LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY(A)
(Approved by A.I.C.T.E & Permanently Affiliated to JNTUGV, Vizianagaram)
Accredited by NBA & NAAC with 'A' Grade
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Department of Electrical and Electronics Engineering

LAB MANUAL

Name of the laboratory: ELECTRICAL MEASUREMENTS & INSTRUMENTATION

Regulation: R20

Subject Code: C312

Branch: Electrical and Electronics Engineering

Year & Semester: III B. Tech- I Semester

INSTITUTE VISION, MISSION
DEPARTMENT VISION, MISSION
PEO & PO/PSO

INSTITUTE

VISION

Produce globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value-based education.

Department of Electrical and Electronics Engineering

VISION

To be a hub for imparting knowledge, skills, and behaviour for exemplary contributions in the field of Electrical and Electronics Engineering.

MISSION

- To impart Technical Education through the state-of-the-art infrastructure facilities, laboratories and instruction.
- To inculcate industry-oriented learning through industrial visits, internships, projects at Industries, MOUs, to make students' technically skills oriented.
- Creating conducive environment for higher education, employment and entrepreneurship through quality education, professional skills and research.
- To promote societal commitment among students by inculcating moral and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates shall have strong foundation in core and allied Electrical and Electronics Engineering, in sciences and mathematics, to become globally competent in designing, modelling and critical problem solving.
PEO2: Graduates shall involve in research activities in the field of electrical and electronics engineering through lifelong learning and provide solutions to engineering problems for sustainable development of society.
PEO3: Graduates shall have good communication skills and socio-ethical values for getting employment or higher studies by excelling in competitive examinations and be able to work in supportive and leadership roles.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop, test, verify and implement electrical and electronics engineering systems and products.
PSO2: Succeed in national and international competitive examinations for successful higher studies and employment.

PROGRAM 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 modelling 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.

COURSE OUTCOMES (COs)

CO1: Analyze the testing of transformer oil (L4).

CO2: Apply suitable method for measuring R, L and C parameters in an electric network (L3)

CO3: Analyze the calibration of various instruments (L4)

CO4: Demonstrate the measurement of frequency and phase difference by using CRO (L2).

CO5: Analyze the measurement of various electrical and non-electrical parameters using appropriate measuring instruments (L4).

COURSE INFORMATION SHEET

AY-2022-23

PROGRAM: **Electrical and Electronics Engineering**	DEGREE: **B. TECH**
COURSE: **Electrical Measurements & Instrumentation Lab**	SEMESTER: **III-I** CREDITS: **1.5**
COURSE CODE: **C312** REGULATION: **R20**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **Core Engineering**	CONTACT HOURS**: 3 hours/Week**.
CORRESPONDING LAB COURSE CODE (IF ANY):	LAB COURSE NAME (IF ANY):

SYLLABUS:

Experiment	DETAILS	HOURS
I	Dielectric oil testing using H.T test kit.	3
II	Measurement of Inductance using Anderson bridge.	3
III	Measurement of Capacitance using a Schering bridge.	3
IV	Measurement of Low Resistance using Kelvin's double bridge.	3
V	Measurement of High resistance and Insulation resistance using Megger.	3
VI	Calibration and testing of single-phase Energy meter.	3
VII	Calibration of dynamometer wattmeter using phantom loading.	3
VIII	Calibration of Voltmeter and Ammeter by using DC Crompton Potentiometer.	3
IX	Measurement of frequency and phase difference by using CRO.	3
X	Measurement of displacement with the help of LVDT.	3
TOTAL HOURS		**30**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T_1	A. K. Sawhney, 'A course in Electrical and Electronics Measurements and Instrumentation' Dhanpati & Co
T_2	J.B. Gupta, 'A Course in Electronic and Electrical Measurements', S.K.Kataria & Sons, Delhi.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
C302	**Electrical Measurements and Instrumentation.**	1.Measurement of unknown parameters, frequency and Phase Difference. 2.Calibration of various Measuring Instruments.	**II-II**

COURSE OBJECTIVES:

1	To understand the testing of transformer oil.
2	To determine the unknown inductance, resistance, capacitance using DC and AC Bridges.
3	To analyze the calibration of various instruments.
4	To understand the measurement of frequency and phase difference by using CRO
5	To understand the measurement of various non-electrical parameters using transducers.

COURSE OUTCOMES:

S. No.	DESCRIPTION	PO (1..12) MAPPING	PSO (1,2) MAPPING
C312.1	Analyze the testing of transformer oil (L4)	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1
C312.2	Apply suitable method for measuring R, L and C parameters in an electric network (L3).	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1
C312.3	Analyze the calibration of various instruments (L4)	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1
C312.4	Demonstrate the measurement of frequency and phase difference by using CRO (L2)	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1
C312.5	Analyze the measurement of various electrical and non-electrical parameters using appropriate measuring instruments (L4)	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1
COURSE OVERALL PO/PSO MAPPING: PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1			

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

S.No.	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
C312.1	3	3	1	2	-	2	2	2	3	2	1	2	3	-
C312.2	3	3	2	2	-	2	2	2	3	2	1	2	3	-
C312.3	3	3	2	2	-	2	2	2	3	2	1	2	3	-
C312.4	3	3	2	2	-	2	2	2	3	2	1	2	3	-
C312.5	3	3	1	2	-	1	2	2	2	2	1	2	3	-
C312*	3	3	2	2	-	2	2	2	3	2	1	2	3	-

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop, test, verify and implement Electrical and Electronics Engineering systems and products.
PO2	Problem Analysis	PO8	Ethics	PSO2	Succeed in national and international competitive examinations for successful higher studies and employment.
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

COs VS POs MAPPING JUSTIFICATION:

SNO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
C312.1	PO 1	3	Understanding the fundamental concepts of dielectric strength of transformer oil is substantially essential to solve fundamental engineering problems.
	PO 2	3	Analyzing the circuit used in the transformer oil test, including the high-voltage transformer and measuring instruments is Substantially useful for problem-solving.
	PO 3	1	The concept of dielectric oil test is slightly necessary to design system components.
	PO 4	2	Conducting experiments and interpreting the results in testing transformer oil involves moderately on investigation skills.
	PO 6	2	Understanding the impact of transformer oil quality on electrical safety contributes moderately to engineer and societal responsibilities.
	PO 7	2	Understanding environmental impact of using and disposing of transformer oil is moderately relevant to sustainability considerations.
	PO 8	2	The Dielectric oil test is Moderately necessary for Professional ethics and responsibilities in engineering practice.
	PO 9	3	The concept of dielectric oil strength is substantially useful for individual and teamwork.
	PO 10	2	Analyzing test results of dielectric oil strength is moderately essential for effective communication in electrical engineering activities.
	PO 11	1	Testing procedure of dielectric oil strength slightly minimizes operational costs and prevents expensive

			failures, ensuring financial sustainability in power systems.
	PO 12	2	The concept of dielectric oil testing is Moderately necessary to engage in independent and lifelong learning.
	PSO 1	3	Testing of dielectric oil strength is substantially essential to design and develop electrical and electronics engineering systems.
C312. 2	PO 1	3	Understanding the fundamental concepts of R, L and C parameters is substantially essential to solve fundamental engineering problems.
	PO 2	3	Analyzing the measurement of R, L and C parameters is Substantially useful for problem-solving.
	PO 3	2	implementing suitable measurement methodologies for electrical parameters is moderately necessary to design system components.
	PO 4	2	Interpreting data related to R, L, and C measurement is moderately essential to investigate the complex engineering problems.
	PO 6	2	Understanding the measurement of electrical parameters on electrical safety contributes moderately to engineer and societal responsibilities.
	PO 7	2	Understanding environmental impact of R, L and C parameter is moderately relevant to sustainability considerations.
	PO 8	2	The measurement of electrical parameters is moderately necessary for Professional ethics and responsibilities in engineering practice.
	PO 9	3	Conducting experiments and analysis of electrical parameters is substantially useful for individual and teamwork.
	PO 10	2	Analysis of R, L and C parameters is moderately essential for effective communication in electrical engineering activities.
	PO 11	1	Measurement of electrical parameters slightly minimizes operational costs and prevents expensive failures, ensuring financial sustainability in power systems.
	PO 12	2	Measurement of electrical parameters is moderately helpful for Continuously upgrading knowledge on modern measurement tools and techniques.
	PSO 1	3	The Knowledge of electrical measurements is substantially required to design and develop electrical and electronics engineering systems.
C312.3	PO 1	3	Understanding calibration techniques for various electrical instruments substantially essential to solve fundamental engineering problems.
	PO 2	3	Analyzing the calibration various measuring instruments is Substantially useful for problem-solving.

	PO 3	2	Implementing the calibration of measuring instruments is moderately necessary to design system components.
	PO 4	2	Interpreting data related to calibration is moderately essential to investigate the complex engineering problems.
	PO 6	2	Understanding the Calibration of measuring instruments on electrical safety contributes moderately to engineer and societal responsibilities.
	PO 7	2	Understanding environmental impact of calibration is moderately relevant to sustainability considerations.
	PO 8	2	The calibration of measuring instruments is moderately necessary for Professional ethics and responsibilities in engineering practice.
	PO 9	3	Conducting experiments and analysis of calibration is substantially useful for individual and teamwork.
	PO 10	2	Analysis of calibration of measuring instruments is moderately essential for effective communication in electrical engineering activities.
	PO 11	1	Calibration of measuring instruments slightly minimizes operational costs and prevents expensive failures, ensuring financial sustainability in power systems.
	PO 12	2	Analysis of calibration is moderately helpful for Continuously upgrading knowledge on modern measurement tools and techniques.
	PSO 1	3	The Knowledge of calibration is substantially required to design and develop electrical and electronics engineering systems.
C312. 4	PO 1	3	Understanding the working principles of a CRO is Substantially useful to solve complex engineering problems.
	PO 2	3	Identifying and analyzing waveform characteristics to determine frequency and phase difference accurately is moderately essential to problem solving.
	PO 3	1	Implementing the measurement of frequency and phase difference is slightly useful to design system components.
	PO 4	2	Interpreting data related to measurement of frequency and phase difference is moderately essential to investigate the complex engineering problems.
	PO 6	1	Understanding the measurement of frequency and phase difference on electrical safety contributes slightly to engineer and societal responsibilities.
	PO 7	2	Understanding environmental impact of frequency and phase difference is moderately relevant to sustainability considerations.
	PO 8	2	The measurement of Frequency and phase difference is Moderately necessary for Professional ethics and responsibilities in engineering practice.

	PO 9	2	Conducting experiment on measurement of frequency and phase difference is moderately useful for individual and teamwork.
	PO 10	2	Frequency and phase difference measurement is moderately essential for effective communication in electrical engineering activities.
	PO 11	1	Understanding accurate frequency and phase measurements slightly helps in project planning, ensuring proper selection of electrical components and minimizing errors, ultimately leading to cost-effective and efficient system design.
	PO 12	2	Understanding the use of a CRO builds foundational skills in signal measurement, encouraging continuous learning to adapt to advancements moderately in modern measurement tools and technologies
	PSO 1	3	Accurate measurement of frequency and phase difference using a CRO is substantially essential for testing and verifying electrical circuits, ensuring proper system design, troubleshooting faults, and validating performance in electrical and electronic systems.
C312.5	PO 1	3	Understand the working of measuring instruments and their role in electrical & non-electrical parameters is Substantially essential to solve complex engineering problems.
	PO 2	3	Identifying different types of instruments used to measure electrical & non-electrical parameters accurately is substantially essential to analyze the engineering problems.
	PO 3	2	Implementing the transducers to convert non-electrical parameters into electrical is moderately necessary to design system components.
	PO 4	2	Interpreting data related to measurement of electrical & non-electrical quantities is moderately essential to investigate the complex engineering problems.
	PO 6	2	Understanding the measurement of electrical & non-electrical electrical parameters on electrical safety contributes moderately to engineer and societal responsibilities.
	PO 7	2	Implementing transducer-based measurements is moderately essential in sustainable engineering practices, such as energy-efficient monitoring systems.
	PO 8	2	The measurement of electrical & non-electrical parameters is Moderately necessary for Professional ethics and responsibilities in engineering practice.
	PO 9	3	Conducting experiments and analysis of measuring instruments is substantially useful for individual and teamwork.

	PO10	2	Analyzing results of electrical & non-electrical quantities is moderately essential for effective communication in electrical engineering activities.
	PO11	1	Effective selection and utilization of C.Ts & transducers slightly helps in cost-efficient system design, resource management, and decision-making in engineering projects.
	PO 12	2	Measurement of electrical & non-electrical parameters is moderately helpful for Continuously upgrading knowledge on modern measurement tools and techniques.
	PSO 1	3	The Knowledge on measurement of electrical & non-electrical parameters is substantially necessary to design and develop electrical and electronics engineering systems.

ADDITIONAL EXPERIMENTS:

SNO	**DESCRIPTION**	**CO Mapping**	**POs & PSOs Mapping**
1	Measurement of 3-Phase Power with Single Wattmeter and 2 No's of C. T	CO5	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1
2	Measurement of % Ratio Error and Phase Angle of given C.T by Comparison.	CO5	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1

WEB SOURCE REFERENCES:

1	https://electricallab.in/electrical-machine-ii-lab/dielectric-strength-of-transformer-oil/#google_vignette
2	http://vlabs.iitkgp.ac.in/asnm/
3	https://www.electricaldeck.com/2021/05/calibration-of-energy-meter.html
4	https://www.electricalengineeringinfo.com/2016/11/measurement-of-phase-and-frequency-lissajous-patterns-of-cro-cathode-ray-oscilloscope.html#google_vignette
5	https://ebooks.inflibnet.ac.in/msp04/chapter/transducers-ii/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑CHALK & TALK	☐ICT TOOLS	☑WEB REFERENCES	☐STUDENT SEMINARS
☐INDUSTRIAL VISITS	☐INTERNSHIPS	☑EXPERENTIAL LEARNING	☐MODEL-BASED LEARNING
☐GUEST LECTURES	☑COLLABORATIVE LEARNING	☐MINI/MAJOR PROJECTS	☐CASE STUDIES/REAL LIFE EXAMPLES

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ END SEM EXAM
☑STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☐STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by

Approved by

PAC Member

Signature of HOD, EEE

Course Code	Course Title	Hrs./Week L: T: P	Credits
R20EEE-PC3104	**Electrical Measurements and Instrumentation Laboratory**	**0:0:3**	**1.5**

Course Objectives:

- To understand the testing of transformer oil.
- To determine the unknown inductance, resistance, capacitance using DC and AC Bridges.
- To analyze the calibration of various instruments.
- To understand the measurement of frequency and phase difference by using CRO.
- To understand the measurement of various non-electrical parameters using transducers.

Course Outcomes:

- Analyze the testing of transformer oil (L4)
- Apply suitable method for measuring R, L and C parameters in an electric network (L3).
- Analyze the calibration of various instruments (L4)
- Demonstrate the measurement of frequency and phase difference by using CRO (L2)
- Analyze the measurement of various electrical and non-electrical parameters using appropriate measuring instruments (L4).

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Lectures/Demonstrations:

1. Concepts relating to Measurements: True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Sensitivity.
2. Errors in Measurements. Basic statistical analysis applied to measurements: Mean, Standard Deviation, Six-sigma estimation.
3. Sensors and Transducers for physical parameters: temperature, pressure, torque, flow. Speed and Position Sensors.
4. Current and Voltage Measurements. Shunts, Potential Dividers. Instrument Transformers.
5. Measurements of R, L and C.
6. Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.
7. Digital Storage Oscilloscope.

Experiments

1. Dielectric oil testing using H.T test kit.
2. Measurement of L using a bridge technique.
3. Measurement of C using a bridge technique.
4. Measurement of Low Resistance using Kelvin’s double bridge.
5. Measurement of High resistance and Insulation resistance using Megger.
6. Calibration and testing of single-phase Energy meter.
7. Calibration of dynamometer wattmeter using phantom loading.
8. Calibration of Voltmeter and Ammeter by using DC Potentiometer.
9. Measurement of frequency and phase difference by using CRO.
10. Measurement of displacement with the help of LVDT.

LIST OF EXPERIMENTS (Performed in the Laboratory)

1. Dielectric oil testing using H.T test kit.
2. Measurement of L using a bridge technique.
3. Measurement of C using a bridge technique.
4. Measurement of Low Resistance using Kelvin's double bridge.
5. Measurement of High resistance and Insulation resistance using Megger.
6. Calibration and testing of single-phase Energy meter.
7. Calibration of dynamometer wattmeter using phantom loading.
8. Calibration of Voltmeter and Ammeter by using DC Potentiometer.
9. Measurement of frequency and phase difference by using CRO.
10. Measurement of displacement with the help of LVDT.

ADDITIONAL EXPERIMENTS

1. Measurement of 3-Phase Power with Single Wattmeter and 2 No's of C.T
2. Measurement of % Ratio Error and Phase Angle of given C.T by Comparison.

INDEX

1. DIELECTRIC STRENGTH OF TRANSFORMER OIL

1. AIM: To measure the dielectric strength of the oil using HT testing kit.

2. APPARATUS REQUIRED:

S. No	Name of the apparatus	Type	Range	Quantity
1	HT testing kit, Input: 230 V,50 HZ, Output :0-60 kV	---	---	1
2	Measuring scale	---	3 mm	1

3. CIRCUIT DIAGRAM:

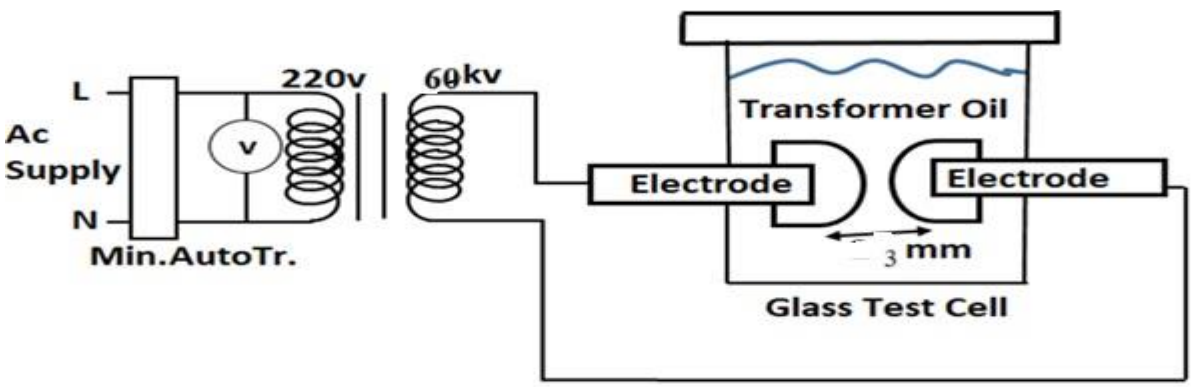


Fig. Dielectric strength of Transformer oil

4.THEORY:

The oil transformer kit is used to determine the dielectric strength of oil these are generally used in transformers. It contains two electrodes of a small gap between there when ever break down voltage occurs there will be a spark is observed at the high voltage side of the transformer. For calibration the gap in between the two electrodes is 4 mm. the voltage that is obtained when flash over occurs is rapidly applied voltage.

Oil test set is basically consists of a double wound high voltage transformer with the H. T .end brought out and terminated on an epoxy insulation. The lower end of the H.T winding is at earth potential and is also brought out. The intermediate circuitry included in series with the primary of H.T transformer, if the current through the test coil exceeds a predetermined value.

The low voltage winding of the main transformer is rated for 230 V or as specified. It is energized

by means of an auto transformer through a fuse link and an intermediate contactor /relay, the provision of an auto transformer enables gradual application of high voltage to the oil under test.
A voltmeter is provided on the panel to indicate the applied high voltage. The voltmeter is connected on the low voltage side of the main transformer but it is calibrated to read H. T voltage directly. When the failure of the test oil occurs, the supply to the voltmeter is maintained although the supply to the H.V transformer is instantly cut off. The voltmeter therefore indicates the voltage at which the oil under test has failed.

The test method consists of subjecting the oil contained in a special apparatus to an AC electric field with continuously increasing voltage till the oil breaks down. The electrodes are made of brass-bronze or stainless steel. The brass is an alloy of copper and zinc and the bronze is an alloy of copper and nickel. The polished electrodes are spherical (12.5-13 mm diameter). The electrodes are mounted 2.5 cm apart with an accuracy of 0.1 mm.

4. PROCEDURE:

Procedure:

1. Study the enclose instruction on Transformer oil testing.
2. Switch on the test kit.
3. Slowly raise the voltage, and keep it at 33 kV for one minute. At the end,

Record whether the oil sample with stood 33 kV for one minute. If it fails earlier, note the time it stood, 33 kV. If it fails at a voltage lower than 33 kV, record that voltage as breakdown voltage.

4.Then raise the voltage till such time there is a breakdown, and record the breakdown voltage.
All the time take care not to exceed the maximum voltage of 60kV.

5. Remove the suspended particles due to breakdown with the help of glass tube provided.

6. Wait for 5 minutes.
7. Repeat step 3 to 6, five times given a total of six observations.
8. Switch off the test kit.

Precaution:

1. Transformer oil should be free from moisture content.
2. Gap should be premises.
3. Nobody should go near the H.T. bushing when the test being conducted.
4. Ignore the first one or two readings, as the air between the electrodes may not ionize.
5. The equipment must be grounded firmly.
6. The electrodes must be cleaned properly before and after use.
7. Do not touch the equipment without grounding it with the grounding rod.
8. Before starting the experiment, make sure the electrodes are properly aligned and zero reading is adjusted.

7. OBSERVATION TABLE:

S. No	Dielectric strength (kV/mm)	
	Manual mode (voltage)	Distance between electrodes
1	20	3 mm
2	18	3 mm
3	17	3 mm

Average Voltage =17.75kv

Dielectric strength=8.85kv/mm

8. RESULT: Hence the dielectric strength of oil is tested using HT testing kit .

Dielectric strength=8.85kv/mm

9.OUTCOME: By conducting this experiment CO1, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

10. QUESTIONS FOR SELF ASSESSMENT:

1. What are the different types of insulating materials?
2. What do you mean by dielectric strength?
3. What is difference between insulator and dielectric?
4. What is difference between breakdown voltage and dielectric strength?
5. What are the different types of insulating oils?
6. What is the dielectric strength of ideal oil?

2. MEASUREMENT OF INDUCTANCE USING ANDERSON BRIDGE

1. AIM:

To measure the unknown self-inductance by using Anderson bridge.

2. APPARATUS:

S. No	Name of the Equipment	Quantity
1	Anderson Bridge Kit	1
2	Headset	1
3	Patch Chords	As Per Requirement

3. CIRCUIT DIAGRAM:

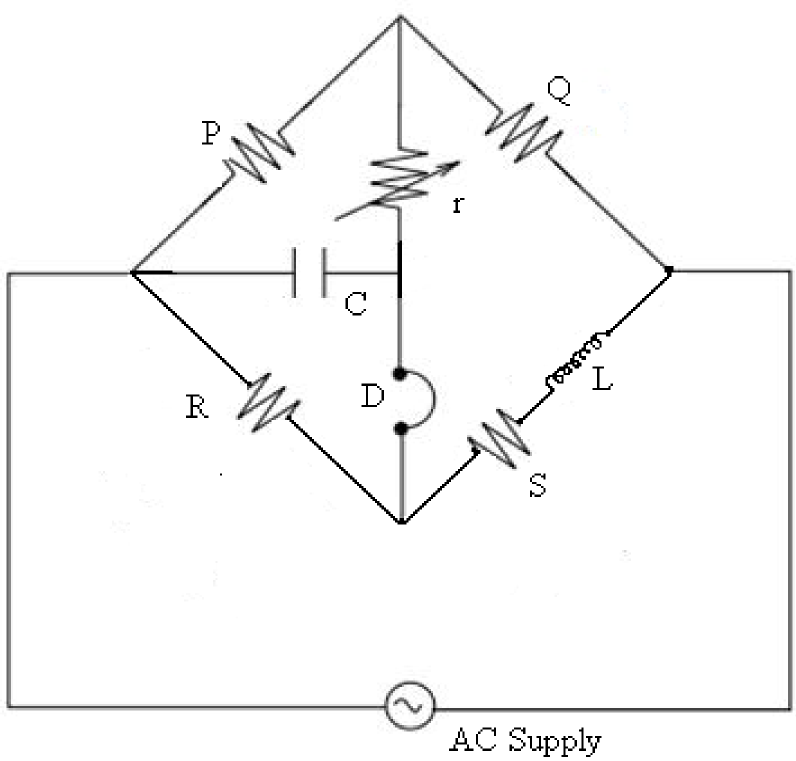


Fig: Anderson Bridge

4. THEORY:

AC bridges are often used to measure the value of unknown impedance (self/mutual inductance of inductors or capacitance of capacitors accurately). A large number of AC bridges are available and Anderson's Bridge is an AC bridge used to measure self-inductance of the coil. It is a modification of Wheatstone Bridge. It enables us to measure the inductance of a coil using capacitor and resistors and does not require repeated balancing of the bridge.

The bridge is balanced by a steady current by replacing the headphone H by moving coil galvanometer and A.C source by a battery. This is done by adjusting the variable resistance, r. After a steady balance has been obtained, inductive balance is obtained by using the A.C source and headphone.

4.1 ADVANTAGES:

1. Fixed capacitor is used in terms of variable capacitor.
2. The bridge is used for accurate determination of inductance in millimeter range.

4.2 DISADVANTAGES:

1. Bridge is more complex
2. Difficult to attain balancing condition.

5. PROCEDURE:

5.1 STEP-I:

1. Connect the circuit to the D.C supply.
2. Switch on the power supply.
3. Now vary the ‘R’ and ‘S’ values one by one until it shows the null deflection in Galvanometer.

5.2 STEP II:

1. Then change the D.C supply terminals to the A.C supply terminals from the unknown port as well as connect the headset to the detector port by disconnecting the galvanometer terminals.
2. Now vary the ‘r’ value to obtain the null beep sound in the headset.
3. Switch off the supply.
4. Disconnect the circuit.

6. PRECAUTIONS:

1. Vary the knobs smoothly.
2. Avoid loose connections.

7. OBSERVATION TABLE:

S.NO	Capacitance C (μF)	Unknown Resistance R (Ω)	Standard Resistance S(Ω)	Resistance r(Ω)	Unknown Inductance L=RC[r+Q+Qr/P] (H)
1.	0.1 μF	52	0.7	4000	0.0468
2.	0.1 μF	77	0	6000	0.1001
3.	0.1 μF	114	0	6000	0.1482
4.	0.2 μF	52	0.5	2000	0.052
5.	0.2 μF	78	1	2600	0.0967
6.	0.2 μF	115	0.9	2900	0.1564

8. MODEL CALCULATIONS:

$L = C[RQ + r(R+S)]$ = 52*0.1*10^{-6}[4000+1000+(1000*4000/1000)] = 0.0468 H

Where C = 0.01μF

$$X_L = 2\pi f L$$

Where f is the frequency and L is the self-inductance of the coil.

9. RESULT:

The unknown inductance is determined by Anderson's bridge.

10. OUTCOME:

By conducting this experiment CO2, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

11. APPLICATIONS:

1. Anderson Bridge is used to measure low quality factor.
2. To calculate the value of inductive reactance (X_L) of the coil at a particular frequency.

12. VIVA QUESTIONS:

1. What are the advantages and disadvantages of this bridge.
2. What is the application of this bridge.

3. MEASUREMENT OF CAPACITANCE USING A SCHERING BRIDGE

1. AIM:

To measure the unknown capacitance by using Schering bridge.

2. APPARATUS:

S. No	Name of the Equipment	Quantity
1	Schering Bridge Kit	1
2	Headset	1
3	Patch Chords	As Per Requirement

3. CIRCUIT DIAGRAM:

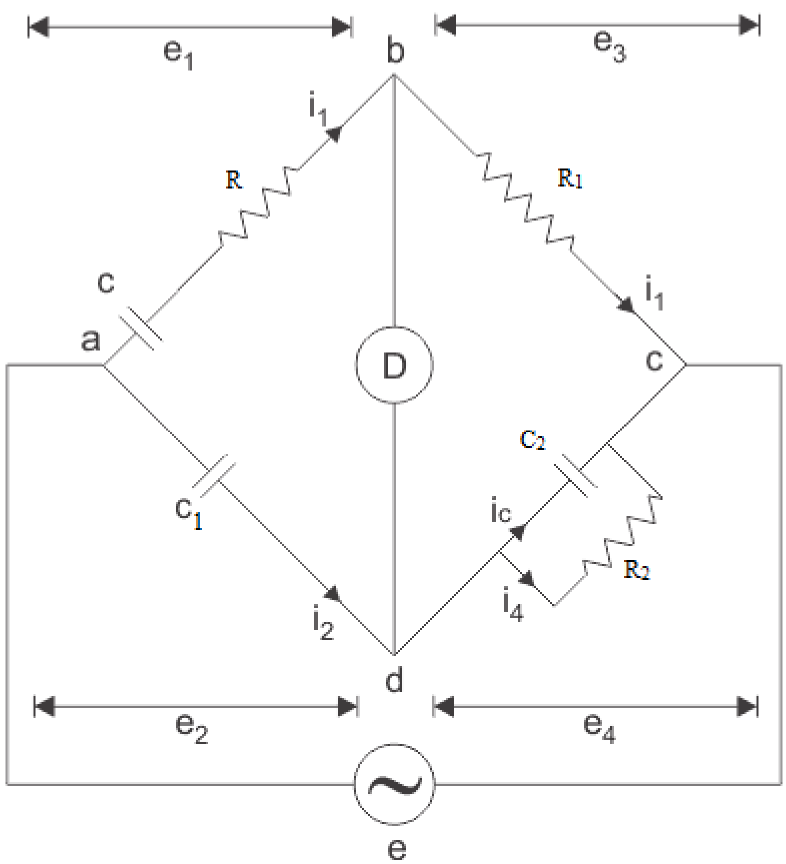


Fig: Schering Bridge

4. THEORY:

This bridge is used to measure to the capacitance of the capacitor, dissipation factor and measurement of relative permittivity.

(a) The bridge arms ab and ad consists of only capacitors as shown the bridge given and impedances of these two arms are quite large as compared to the impedances of bc and cd. The arms bc and cd contains resistor R_1 and parallel combination of capacitor C_2 and resistor R_2 respectively. As impedances of bc and cd are quite small therefore drop across bc and cd is small. The point c is earthed, so that the voltage across bc and dc are few volts above the point c.

(b) The high voltage supply is obtained from a transformer 50 Hz and the detector in this bridge is a vibration galvanometer.

(c) The impedances of arms ab and ad very are large therefore this circuit draws low current hence power loss is low but due to this low current we need a very sensitive detector to detect this low current.

(d) The fixed standard capacitor c_2 has compressed gas which works as dielectric therefore dissipation factor can be taken as zero for compressed air. Earthed screens are placed between high and low arms of the bridge to prevent errors caused due to inter capacitance.

5. PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Switch on the power supply.
3. Now fix the 'R_1' value and then vary the 'R_2' value until obtain the null beep sound in the headset.
4. To find the dissipation factor, apply the 'R' value to get beep sound (or) disturbance and then vary the 'C_2' to reduce (or) minimize that beep sound.
5. Take 'C_1' as standard value i.e., 0.01µfd value.
6. Repeat the above process for different 'R_1' values.
7. Switch off the power supply.
8. Disconnect the circuit.

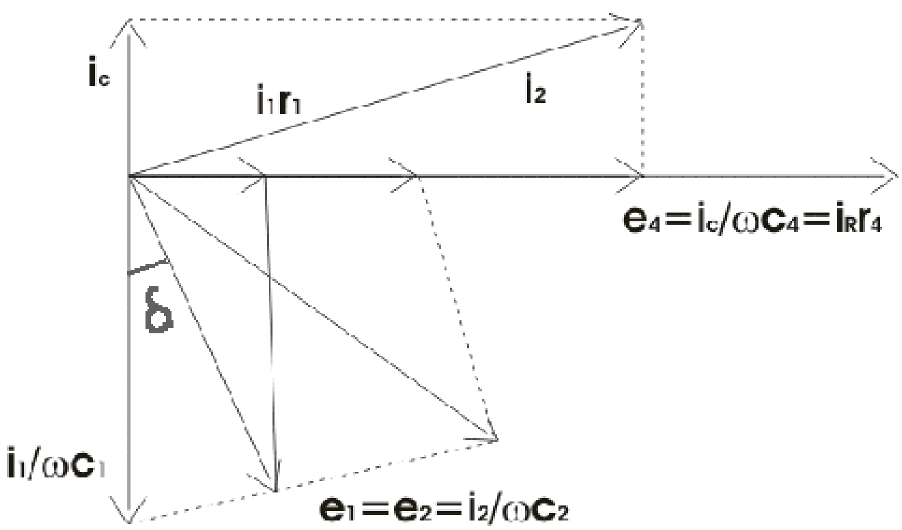
6. PRECAUTIONS:

1. Avoid loose connections.
2. Vary the knobs smoothly.

7. OBSERVATION TABLE:

S. No	Resistance $R_1(\Omega)$	Resistance $R_2(\Omega)$	Standard Capacitance C_1 (µf)	Unknown Capacitance $C=(R_2C_1/R_1)$ µf
1	1000	1000	0.01	0.01
2	1000	2000	0.01	0.02
3	1000	3000	0.01	0.03
4	1000	4000	0.01	0.04
5	2000	2000	0.01	0.01
6	2000	4000	0.01	0.02
7	2000	6000	0.01	0.03
8	2000	8000	0.01	0.04

8. PHASOR DIAGRAM:



9. RESULT:

The unknown Capacitance is determined by Schering bridge.

10. OUTCOME:

By conducting this experiment CO2, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12 are attained

11. APPLICATIONS:

1. It is used for measuring the insulating properties of electrical cables and equipments.
2. It is used in the measurement of the properties of insulators, capacitor bushings, insulating oil and other insulating materials.

12. VIVA QUESTIONS:

1. What are the different types of A.C. Bridges**?**
2. What is meant my Dissipation factor**?**
3. What are the advantages and disadvantages of this bridge?

4.MEASUREMENT OF LOW RESISTANCE USING KELVIN DOUBLE BRIDGE

1.AIM:

To measure the low value of unknown resistance and resistance of connecting leads using a Kelvin's double bridge.

2.APPARATUS REQUIRED:

Sl. No.	Name of the Equipment	Quantity
1	Portable Kelvin's double bridge Kit	1
2	Dry Cells -- (1.5Volts)	2
3	Unknown Resistance	1
4	Galvanometer	1
5	Connecting wires	As required

3.THEORY:

This is a portable bridge with built in taut suspension galvanometer and a 1.5 Volts dry battery (3 cells of 1.5 V each in parallels) This bridge is useful for the measurement of low resistance. Main dial – There are 10 coils of 0.1 ohm each. Slide wire: - 100 divisions of slide wire are equal to 0.1 ohm; each main division is to 0.001 ohm. Each sub – division is to 0.0005 ohm, The reading to the left of zero is to be subtracted from main dial reading and that to the right of zero is to be added to main dial reading. Range switch: - A range multiplier switch furnishers 5 range of X100, X10, x1, x0.1, x0.01. The value of unknown resistance is given by sum of main dial and slide wire reading multiplied by range used.

Method for Measurement of low resistance: -

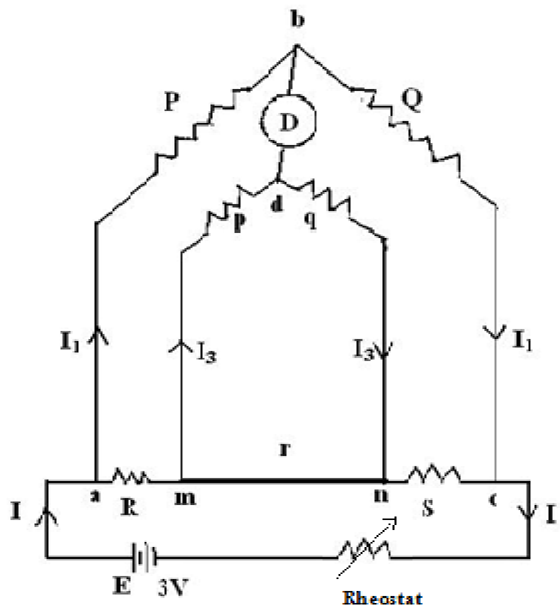
The methods for measurement of low resistance are: -

1. Ammeter Voltmeter method.
2. Kelvin's Double bridge method.
3. Potentiometer method.

Kelvin's Double Bridge

This bridge is a modification of the Wheatstone bridge and provides greatly increased accuracy in measurement of low value resistance an understanding of the Kelvin's bridge arrangement may be obtained by a study of the difficulties that arise in a Wheatstone bridge on accoure of the leads and the contact resistances while measuring low valued resistors. Two actual resistance units of correct ratio be connected between points m and n in the Galvanometer be connected to the function of the resistors. This is the actual Kelvin bridge arrangement. The Kelvin double bridge incorporates the idea of a second set of ratio arms-hence the name double bridge and the use of four terminals resistors for the low resistance arms. The first of ratio arms. P and Q is used to connect the galvanometer to a point C at the appropriate potential between points M and N to eliminate the effect of connecting lead of resistance R between the known resistance, R and the standard resistance S as shown.

4.CIRCUIT DIAGRAM:



5.PROCEDURE:

1. The connections are made as shown in fig.
2. Across the terminals X meant for the unknown resistance, Connected whose shunt resistance can be measured
3. The ratio (P/Q) is adjusted to a particular value.
4. For the ratio, balancing resistance is varied until Galvanometer Shows null deflection.
5. The balance is similarly obtained for different ratios of (P/Q)
6. The resistance since it includes the resistance of the leads.
7. The lead resistance is measured by shorting the leads.
8. To obtain ammeter shunt resistance, the resistance of the leads is subtracted from the total Resistance**.**

6.PRECAUTIONS:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their Ratings
3. Handle the Bridge very carefully

7.MODEL CALCULATIONS;

R= (P/Q) x S

Where R= Unknown Resistance
P= Variable resistance
Q= Variable resistance
S= Standard resistance

8.TABULAR FORM:

RESISTANCE OF THE GIVEN CONNECTING WIRE:

S. No	Multiplier(m)	R (resistance of main dial) (ohms)	r (resistance of slide wire) (cm)	Given Resistance (ohms)	Unknown resistance X=M(R+r)	Error
1	10	80	6.3	1	0.86	0.137
2	100	10	5.6	5	1.56	3.44
3	10	10	10	0.2	0.2	0
4	4	60	10	0.1	0.07	0.07

9.RESULT:

By conducting this experiment, determined the tolerance of resistance and measurement of resistance by using Kelvin's Double Bridge.

10.OUTCOME:

By conducting this experiment CO2, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

11.VIVAQUESTIONS:

1. Why it is called as double bridge.
2. What is the ranges of resistance that can be measured using The bridge.
3. What are the ranges of resistances for low, medium and high resistances?
4. What is sensitivity of bridge?
5. What are the detectors used for DC Bridge.
6. Why the low resistances are four terminal resistances.
7. Why the methods used for medium resistances are not suitable for measurement of low resistances.
8. What are the other instruments to measure the resistance?

4. MEASUREMENT OF HIGH RESISTANCE AND INSULATION RESISTANCE USING MEGGER

1.AIM:

To measure the to measure insulation resistance by megger.

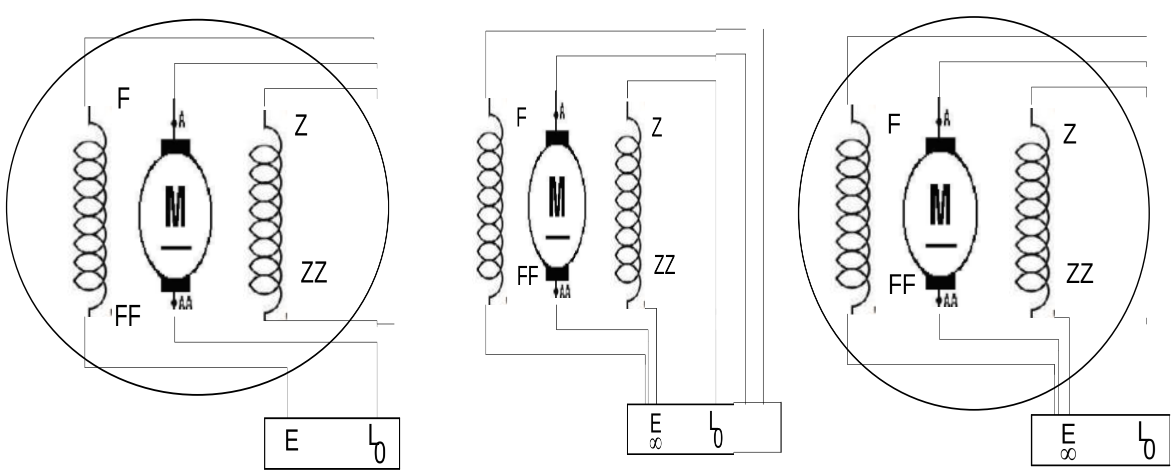
2.APPARATUS REQUIRED:

Sl. No.	Name of the Equipment		Quantity
1	DC compound wound motor	220V, 3KW, 1500rpm	1
2	Megger	Analog	2

3.THEORY:

A dc motor mainly consists of two windings as (a) Armature winding (b) field winding. In case of series dc motor field contain series winding only while shunt motor field contain shunt field winding but in case of compound wound dc motor field winding contain both series and shunt winding since each winding has two terminals in case of compound wound motor. There are three winding 6 terminals which located at top and attached with it.

4.CIRCUIT DIAGRAM:



INSULATION RESISTANCE TEST (BETWEEN WINDING AND BODY):

The aim of this test is that there should be no wire touching of the body. The “E” terminal of megger is connected to the body and 1 terminal should touch the terminal of the generator or motor one by one. Note the reading.

INSULATION RESISTANCE TEST (BETWEEN DIFFERENT TERMINALS):

The aim of this test is to check that the winding which should be insulated from each other are insulated or not. For this test touch the "E" terminal of the megger with shunt field winding F1&F2 terminal and "1" terminal of the megger to armature terminal A1 & A2. If the megger shows "infinite", it means that there is high resistance between two windings. If the megger shows zero it means that the both winding are short circuited with each other. Then test between A1 or A2, C1 or C2, F1 or F2.

5.PROCEDURE:

1. Open all the terminal connection of the dc compound motor
2. now connect the megger to the dc motor terminals to check the terminals and the insulation resistance of the windings
3. if the pointer of the megger deflects towards '0' it is terminals of same winding and if the pointer of megger remains in infinity position, then it is not of same winding
4. now connect the multimeter to check the resistance of different windings and specify them

6.OBSERVATION TABLE:

S.NO	Assumed pair of terminals	Terminal of exact pair	Value if insulating resistance	Types of winding
1	1-3	A1-A2	0.87 ohm	Armature
2	4-6	F1-F2	0.88kohm	Shunt winding
3	2-5	C1-C2	3.4 ohm	Field winding

7.RESULT: Hence determined the insulation resistance by using Megger.

8.OUTCOME: By conducting this experiment CO2, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

6. CALIBRATION AND TESTING OF SINGLE PHASE ENERGY METER

1.AIM: To Calibrate and test the given Single phase energy meter by direct loading.

2. APPARATUS:

S. No	Name	Type	Range	Quantity
1	Single phase Energy Meter	Induction	1500 Rev/KWh	1
2	Wattmeter	UPF	300V/5A	1
3	Voltmeter	MI	(0-300) V	1
4	Ammeter	MI	(0-5) A	1
5	Single Phase Variac	1-Ø	230V/ (0-270) V,10A	1
6	Rheostat	WW	110Ω/5A	1
7	Stop Watch	Digital	-	1
8	Connecting Wires	-	-	As Per Requirement

3. CIRCUIT DIAGRAM:

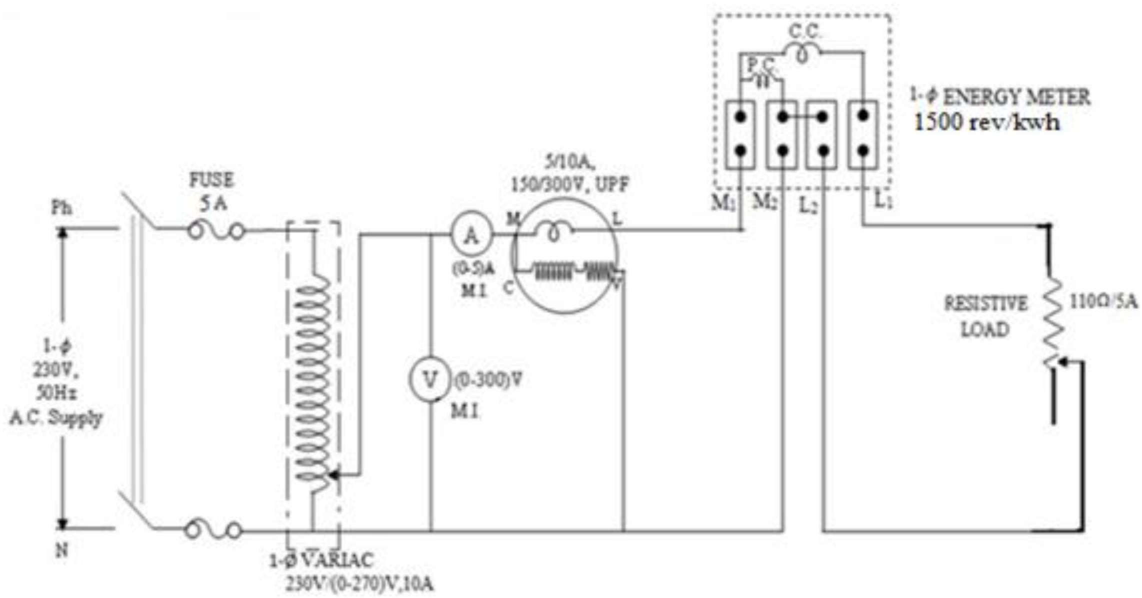


Fig: Calibration & Testing of Single-phase energy meter

4. THEORY:

Induction type of energy meters are universally used for measurement of energy in domestic and industrial AC circuits. Induction type of meters possesses lower friction and higher torque/weight ratio. Also, they are inexpensive and accurate, and retain their accuracy over a wide range of loads and temperature conditions.

There are four main parts of the operating mechanism:

(i) Driving system

(ii) Moving system

(iii) Braking system and

(iv) Registering system.

4.1 Driving System:

The driving system of the meter consists of two electro-magnets. The core of these electromagnets is made up of silicon steel laminations. The coil of one of the electro-magnets is excited by the load current. This coil is called the 'current coil'. The coil of second electromagnet is connected across the supply and, therefore, carries a current proportional to the supply voltage. This coil is called the 'pressure coil'. Consequently, the two electromagnets are known as series and shunt magnets respectively. Copper shading bands are provided on the central limb. The position of these banks is adjustable. The function of these bands is to bring the flux produced by the shunt magnet exactly in quadrature with the applied voltage.

4.2 Moving System:

This consists of an aluminum disc mounted on a light alloy shaft. This disc is positioned in the air gap between series and shunt magnets.

4.3 Braking System:

A permanent magnet positioned near the edge of the aluminum disc forms the braking system. The aluminum disc moves in the field of this magnet and thus provides a braking torque. The position of the permanent magnet is adjustable, and therefore, braking torque can be adjusted by shifting the permanent magnet to different radial positions as explained earlier.

4.4 Registering (counting) Mechanism:

The function of a registering or counting mechanism is to record continuously a number which is proportional to the revolutions made by the moving system. In all induction instruments we have two fluxes produced by currents flowing in the windings of the instrument. These fluxes are alternating in nature and so they produce emfs in a metallic disc or a drum provided for the purpose. These emfs in turn circulate eddy currents in the metallic disc or the drum. The braking torque is produced by the interaction of eddy current and the field of permanent magnet. This torque is directly proportional to the product of flux of the magnet, magnitude of eddy current and effective radius 'R' from axis of disc. The moving system attains a steady speed when the driving torque equal braking torque.

The term testing includes the checking of the actual registration of the meter as well as the adjustments done to bring the errors of the meter with in prescribed limits. AC energy meters should be tested for the following conditions:

1. At 5% of marked current with unity pf.
2. At 100% (or) 125% of marked current.
3. At one intermediate load with unity pf.
4. At marked current and 0.5 lagging pf.

5. PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Keep the single-phase varia at zero-volt position.
3. Now switch on the power supply.
4. Gradually vary the variac to apply the rated voltage (230 volts).
5. For different values of load, note down the readings of the ammeter, voltmeter, wattmeter and time taken for 5 revolutions of the disc.
6. Gradually vary the variac to minimum or zero-volt position.
7. Switch off the power supply.
8. Calculate observed reading, actual reading, %error, %correction.
9. Draw the graph between Load current (vs) % Error.

6. PRECAUTIONS:

1. Avoid loose connections.
2. Be Careful while observing the revolutions with stop watch.
3. Do not apply more current, more than the rated energy meter current.
4. Take readings without error.
5. Live terminals should not be touched.

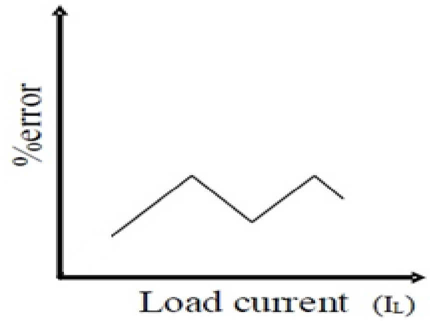
7. OBSERVATION TABLE:

S. No	Supply Voltage (Volts)	Load Current (Amps)	Power (Watts)	Time (sec)	Actual Energy E_1	Indicated Energy $E_2=W*t$	% Error= $(E_2-E_1)/E_1*100$
1	230	1.8	410	52.72	6.28	6.666	4.12
2	230	2.3	540	40.06	6.53	6.666	1.45
3	230	2.8	620	32.65	6.21	6.666	4.2
4	230	3.2	700	27.16	6.34	6.666	3.5
5	230	4.0	860	23.82	6.39	6.666	3.8

Actual Energy = E1

Indicated Energy=E_2=W*t

8. MODEL GRAPH:



9. MODEL CALCULATIONS:

Actual Energy E_1 = No. of revolutions / (energy meter constant (k)

= $(10*10^3)/1500$ = 6.66 Wh.

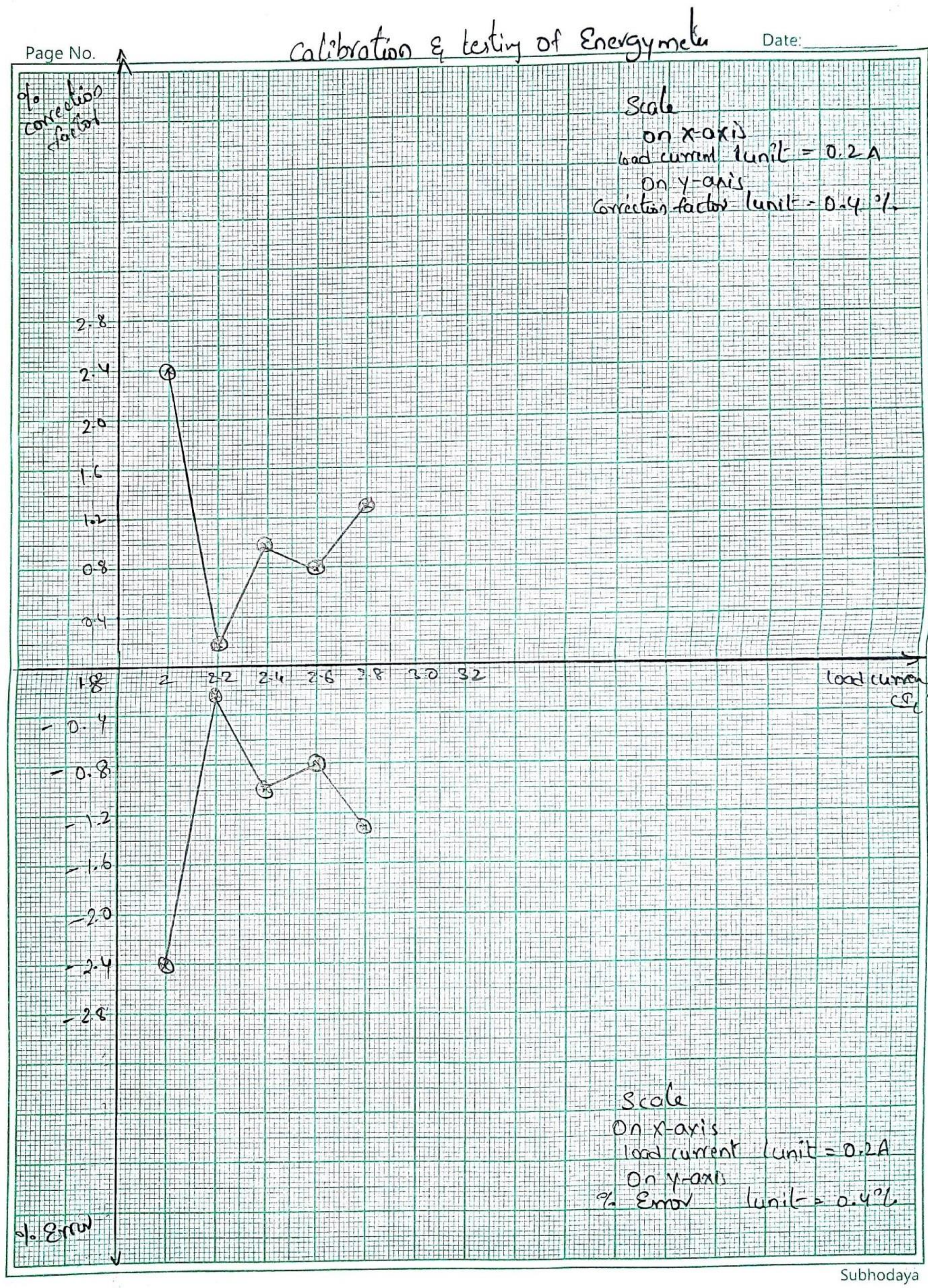
Where, no. of revolutions = 10

Energy meter constant k=1500 rev/KWh

Practical reading E_2 = W *t = (410*52.72)/3600 = 6.28

% Error = $(E_2-E_1)/E_1*100$ = 4.12

%Correction = - % Error = - 4.12


Page No.
Calibration & testing of Energymeter
Date:
% correction factor
Scale
On x-axis
load current 1unit = 0.2 A
On y-axis
Correction factor 1unit = 0.4 %
2.8
2.4
2.0
1.6
1.2
0.8
0.4
1.8
2
2.2
2.4
2.6
2.8
3.0
3.2
load current
-0.4
-0.8
-1.2
-1.6
-2.0
-2.4
-2.8
Scale
On x-axis
load current 1unit = 0.2A
On y-axis
% Error 1unit = 0.4%
% Error
Subhodaya

10. RESULT:

Hence calibrated the given single phase energy meter and tested at different loads and the graph is plotted for % Error Vs I_L and % Correction factor Vs I_L.

11.OUTCOME:

By conducting this experiment CO3, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

12. APPLICATIONS:

Electricity meters measure and display power consumption in residential, industrial, and commercial dwellings, as well as sub-stations in the electric grid. They are evolving rapidly, and different solutions and architectures are required to meet varying regional utility requirements.

13. VIVA QUESTIONS:

1. What is an energy meter?
2. What are the types of energy meter?
3. Which type of energy meters are used in dc circuits?
4. Energy meter is an ______________ (i) integrating instrument (ii) indicating instrument
5. Can the measured percentage error be negative?
6. What do you mean by 'torque adjustment'?
7. What is operating torque?
8. Define braking torque?
9. When does the disc on the spindle rotate with a constant speed?
10. The operating torque is directly proportional to speed, state true or false.

7. CALIBRATION OF DYNAMOMETER UPF WATTMETER USING PHANTOM LOADING

1. AIM:

To Calibrate the given UPF wattmeter by phantom loading.

2. APPARATUS:

S. No	Name of The Equipment	Type	Range	Quantity
1	Single Phase Variac	1-Ø	230V/ (0-270) V 10A	2
2	Ammeter	MI	(0-5) A	1
3	Voltmeter	MI	(0-300) V	1
4	Wattmeter	UPF	300V,5A	1
5	Rheostat	WW	50Ω/5A	1
6	Connecting Wires	-	-	As Per Requirement

3. CIRCUIT DIAGRAM:

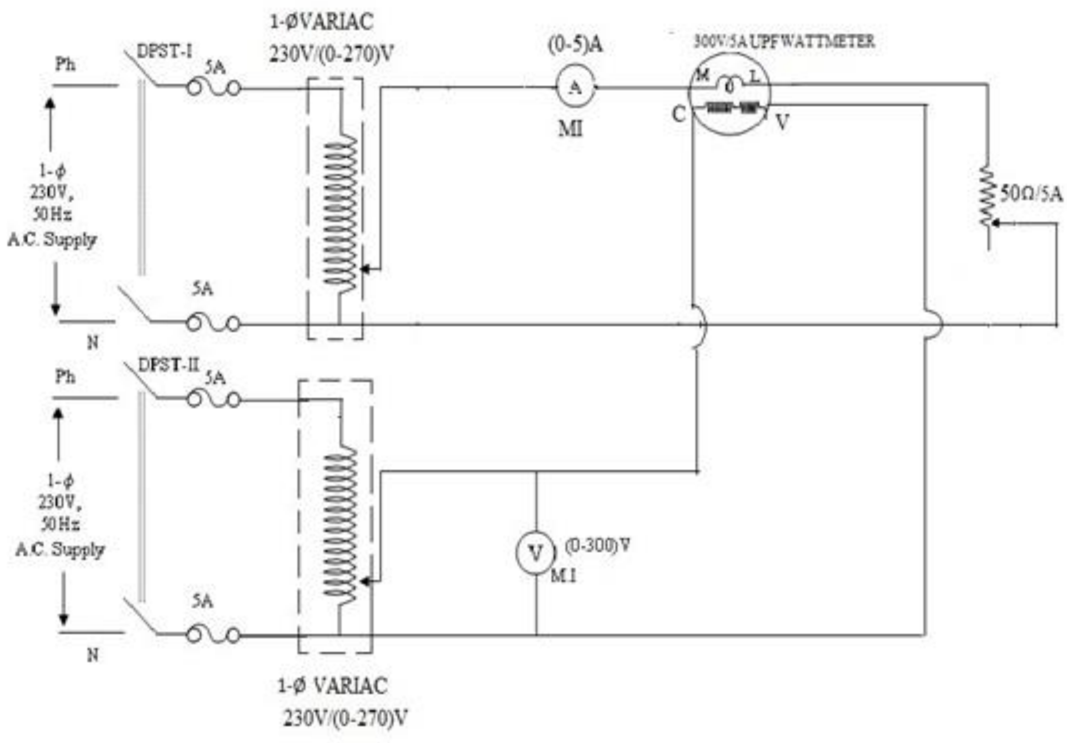


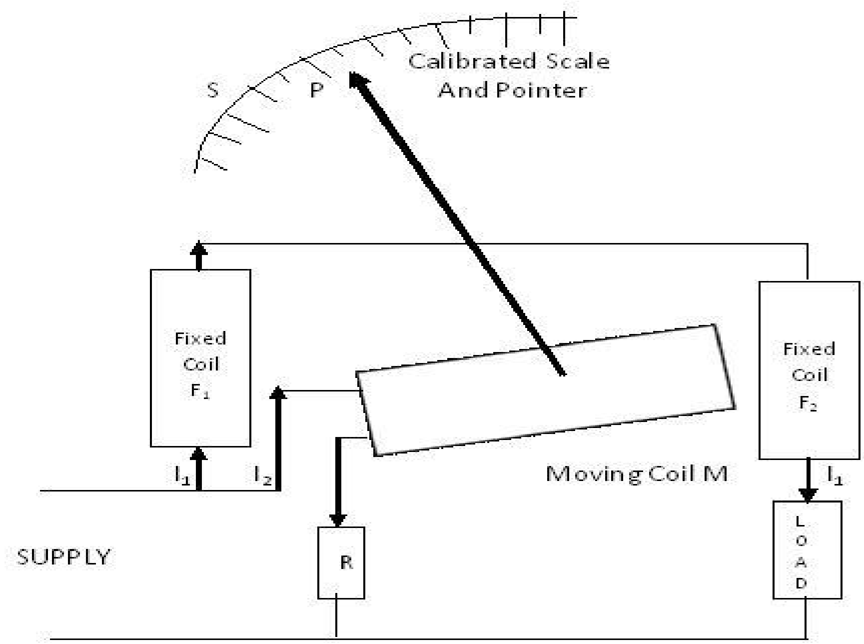
Fig: Calibration of Dynamometer UPF Wattmeter using Phantom Loading

4. THEORY:

When the current rating of a meter under test is high a test with actual loading arrangements would involve a considerable waste of power. In order to avoid this "Phantom" or Fictitious" loading is done.

Phantom loading consists of supplying the pressure circuit from a circuit of required normal voltage, and the current from a separate low voltage supply as the impedance of this circuit very low. With this arrangement the total power supplied for the test is that due to the small pressure coil current at normal voltage, plus that due to the current circuit current supplied at low voltage. The total power, therefore, required for testing the meter with phantom loading is comparatively very small.

An electrodynamometer wattmeter consists of two fixed coils, FA and FB and a moving coil M as shown below.



The fixed coils are connected in series with the load and hence carry the load current. These fixed coils form the current coilof the wattmeter. The moving coil is connected across the load and hence carries a current proportional to the voltage across the load. A highly non-inductive resistance R is put in series with the moving coil to limit the current to a small value. The moving coil forms the potential coilof the wattmeter.

The fixed coils are wound with heavy wire of minimum number of turns. The fixed coils embrace the moving coil. Spring control is used for movement and damping is by air. The deflecting torque is proportional to the product of the currents in the two coils. Theses watt meters can be used for both DC and AC measurements. Since the deflection is proportional to the average power and the spring control torque is proportional to the deflection, the scale is uniform. The meter is free from waveform errors. However, they are more expensive.

5. PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Keep the single phase variac (I & II) in minimum (or) zero-volt position.
3. Switch on the single-phase power supply.
4. Now gradually vary the variac 'II' up to the rated position (230V) without varying the variac 'I'.
5. Then vary the variac 'I' for different current readings up to the rated current (5A) and note down the readings of ammeter, voltmeter and wattmeter.
6. After taking the readings, adjust the variac 'I' and 'II' to its minimum (or) zero-volt position.
7. Finally switch off the single-phase power supply.
8. Calculate the percentage error.

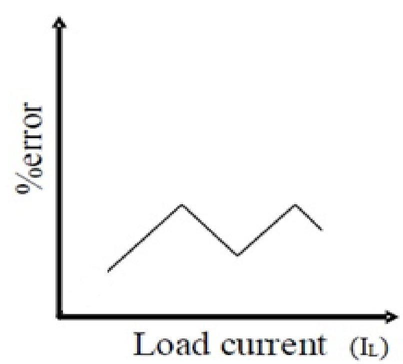
6. PRECAUTIONS:

1. Avoid loose connections.
2. Take readings without the parallax error.

7. OBSERVATION TABLE:

S. No	Supply Voltage (V) Volts	Load Current (I) Amps	Wattmeter (W)Watts	True Power	% Error
1	230	1	144	50	1.88%
2	230	2	232	200	1.6
3	230	2.5	288	312.5	0.784
4	230	3	344	450	0.23
5	230	3.5	400	612.5	0.34
6	230	4	440	800	0.45

8. MODEL GRAPH:

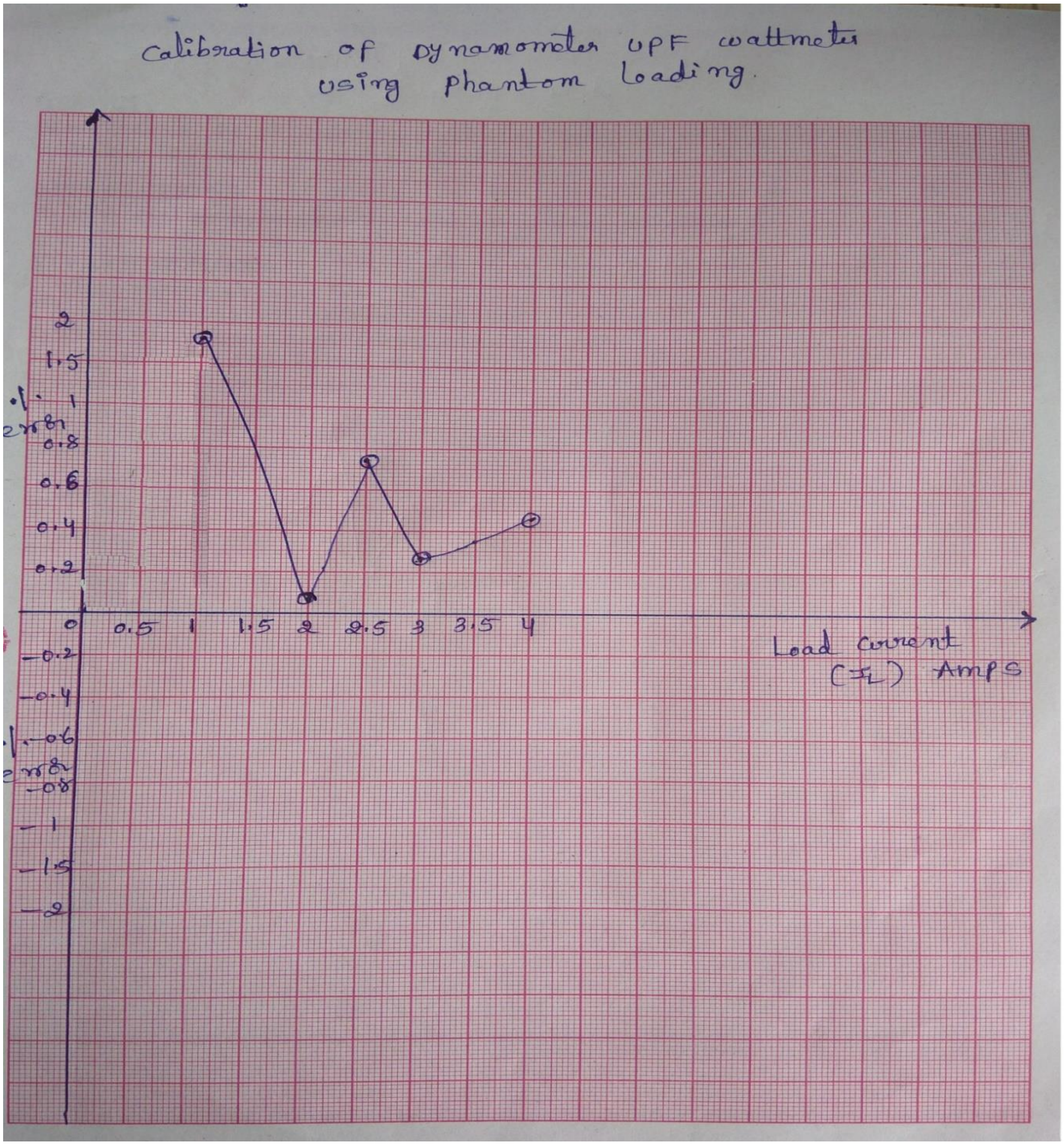


9. MODEL CALCULATIONS:

True Value = 50

Practical Value= Wattmeter Reading=144Watts

%Error = [(True Value-Practical Value)/True Value] *100= (144-50)/50= 1.88%



10. RESULT:

The calibration of UPF wattmeter by phantom loading test is done and the corresponding %Error at different loads are calculated and the graph is plotted.

11. OUTCOME:

By conducting this experiment CO3, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

12. APPLICATIONS:

1. It is used to test the energy meter to avoid power wastage while testing.

13. VIVA QUESTIONS:

1. What is meant by correction factor?
2. Is the load current in UPF wattmeter is high / low?
3. What is the difference between moving coil and fixed coil?
5. State a few errors in dynamometer wattmeter?
6. Applications of UPF wattmeter?

8. CALIBRATION OF PMMC AMMETER AND VOLTMETER USING D.C CROMPTON POTENTIOMETER

1. AIM:

To Calibrate PMMC Ammeter and Voltmeter using DC Crompton potentiometer

2. APPARATUS:

S. No	Name of The Equipment	Type	Range	Quantity
1	DC Crompton potentiometer	DC	-	1
2	Standard Cell	DC	1.0186V	1
3	Volt Ratio Box	-	Output 0-1.5V Input 0-1.5, 15, 30,100,300V	1
4	Regulated power supply (RPS)	DC	(0-30) V	1
5	Ammeter	MC	(0-2) A	1
6	Voltmeter	MC	(0-300) V	1
7	Sensitive galvanometer	Spot reflecting MC type	30-0-30	1
8	Standard resistance	--	0.1Ω,10A	1
9	Battery	--	2V	1
10	DC Supply	--	220V	1
11	Connecting Wires	--	--	As Per Requirement

3. CIRCUIT DIAGRAM:

3.1 CALIBRATION OF VOLTMETER:

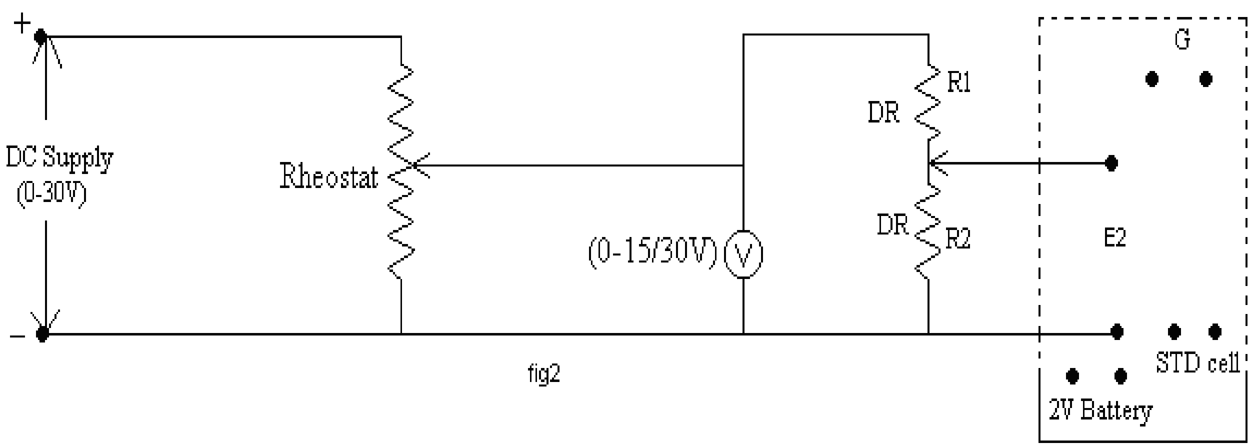


Fig: Calibration of Voltmeter

3.2 CALIBRATION OF AMMETER:

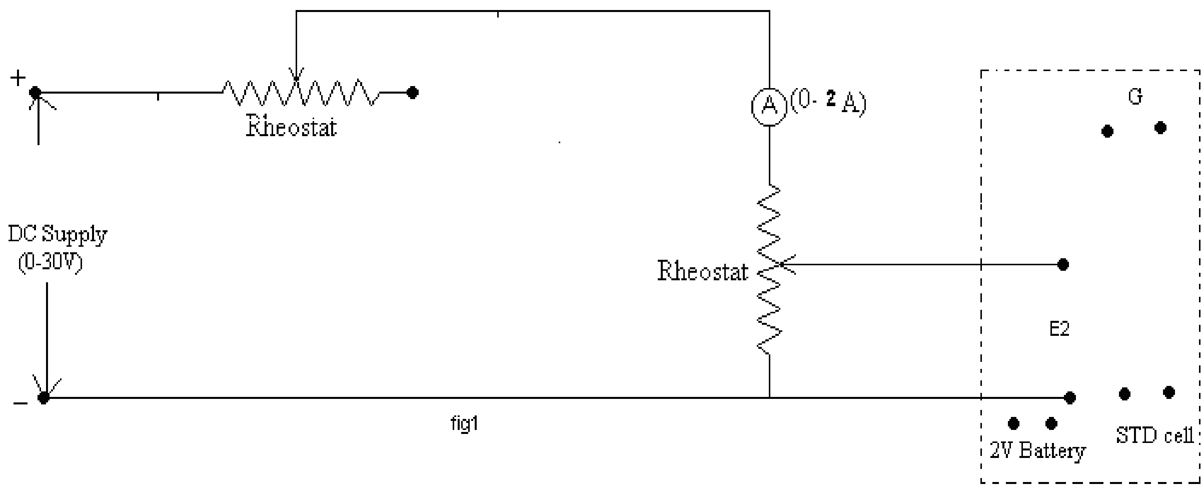


Fig: Calibration of Ammeter

4. THEORY:

A Potentiometer is an instrument designed to measure an unknown voltage by comparing it with unknown voltage. The known voltage may be supplied by a standard cell or any other known voltage –reference source. Measurements using comparison methods are capable of a high degree of accuracy because the result obtained does not depend upon on the actual deflection of a pointer, as is the case in deflection methods, but only upon the accuracy with which the voltage of the reference source is known. Another advantage of the potentiometers is that since a potentiometer makes use of a balance or null condition, no current flows and hence no power is consumed in the circuit containing the unknown emf when the instrument is balanced. Thus, the determination of voltage by a potentiometer is quite independent of the source resistance.

It can also be used to determine current simply by measuring the voltage drop produced by the unknown current passing through a known standard resistance. The potentiometer is extensively used for a calibration of voltmeters and ammeters and has in fact become the standard for the calibration of these instruments. For the above-mentioned advantages, the potentiometer has become very important in the field of electrical measurements and calibration.

Modern laboratory type potentiometers used calibrated dial resistors and a small circular wire of one or more turns, thereby reducing the size of the instrument. The resistance of slide wire is known accurately the voltage drop along the slide wire can be controlled by adjusting the value of working current. The process of adjusting the working current so as to match the voltage drop across a portion of sliding wire against a standard reference source is known as "Standardization".

5. PROCEDURE:

5.1 STANDARDIZATION:

1. Connections are made as per the circuit diagram.
2. Keep the function knob of the potentiometer at STD position. Switch on the 2V Supply
3. Adjust the main dial and slide wire of the potentiometer to read standard cell voltage (1.0186V).
4. Press the Galvano key of the potentiometer and adjust the coarse and fine rheostats until the galvanometer gives null deflection. This completes standardization of the Potentiometer. Once standardization is done the position of R_1 (coarse rheostat) & R_2 (fine rheostat) should not be changed.

5.2 CALIBRATION:

5.2.1 PMMC VOLTMETER:

1. Voltmeter under test is connected across potential divider in such a way that p.d across Voltmeter can be varied.
2. V.R box is used in parallel to potentiometer to reduce voltage to the range of potentiometer
3. Change the function knob to E1 position. Switch on RPS and adjust a suitable voltage on Voltage Ratio Box.
4. Press the Galvano key of the potentiometer and adjust the slide contact and slide wire until the Spot reflecting galvanometer gives null deflection.
5. Note down the readings of voltmeter, and potentiometer slide contact and slide wire readings.
6. Repeat the steps 4 and 5 for different voltages from RPS
7. Reduce the voltage of RPS and RPS to zero. Switch off the supply.
8. Draw the graph between Load current (vs) % Error.

5.2.2 PMMC AMMETER:

1. Ammeter to be calibrated is connected in series with variable resistor R & standard Resistance S.
2. The standard resistance should of such a magnitude that current passed through it doesn’t exceed range of potentiometer.
3. V.R box is used in parallel to potentiometer to reduce voltage to the range of Potentiometer.
4. Keep the rheostat at maximum position and change the function knob to E1 position. Switch ON RPS2) and apply 30 volts.
5. Vary the rheostat gradually and adjust suitable current.
6. Press the Galvano key on the potentiometer and adjust the slide contact and slide wire until the spot reflecting galvanometer gives the null deflection.

7. Note down the readings of ammeter, voltmeter, and potentiometer slide contact and slide wire readings.
8. Repeat the steps 5 to7 for different values of current.
9. Vary the rheostat to maximum position, reduce the voltage of RPS and RPS to zero. Switch off the supply.
10. Draw the graph between Load current (vs) % Error.

6. PRECAUTIONS:

1. Connect the circuit without loose connections.
2. Don't vary the coarse and fine pots, after standardization.

7. OBSERVATION TABLE:

7.1 FOR VOLTMETER:

S. No	Voltmeter reading(V), VTrue	Volt ratio box	V_{act}= (Coarse +Fine) *E2	% Error
1	15	15/1.5=10	14.71	1.93%

7.2 FOR AMMETER:

S. No	Ammeter Reading(A), I_{True}	E_2 Value(V)	I_{act} = E/R	% Error
1	1	95 mv	9.5	5.26%

8. MODEL CALCULATIONS:

8.1 VOLTMETER CALCULATION:

Calibration of voltmeter:
V–R Box ratio = output voltage / input voltage= 15/1.5=10
V_{True}= Voltmeter reading= 15
V_{at}= Reading obtained from potentiometer
= [Coarse voltage + Fine voltage] x Ratio of volt-ratio box= $[1.25+221*10^{-3}]$ *10=14.71V
%Error = [(True value – Practical value) / (True Value)] * 100= (15-14.71/15) *100= 1.93%

8.2 AMMETER CALCULATION:

I_{True}=Ammeter reading= 1A

$I_{Act}= (Coarsevolt + Finevolt) * RatioofVoltRatiobox \Big/ Standard Resistance$ =9.5

%Error = [(True value – Practical value) / (True Value)] * 100= 5.26%

9. RESULT:

Hence the calibration of PMMC Voltmeter and Ammeter is done using DC Crompton potentiometer and also calculated the %Error = 1.93%.

10. OUTCOME: By conducting this experiment CO3, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

11. APPLICATIONS:

1. Calibration of voltmeter and Ammeter.
2. Measurement of resistance.
3. Calibration of Wattmeter.
4. Measurement of unknown E.M.F.

12. VIVA QUESTIONS:

1. What do you mean by a potentiometer?
2. What are the types of potentiometers?
3. What is the working principle of a potentiometer?
4. What is standardization of potentiometer?
5. What is the purpose of connecting a standard battery in the circuit?
6. Application of dc potentiometer?
7. What do you mean by calibration curve of the ammeter?
8. What do you mean by a volt-ratio box?

9. Measurement of Frequency and Phase difference using CRO

1. AIM: To Measure the frequency and phase difference by using CRO.

2. APPARATUS:

S. No	Name	Quantity
1	Cathode ray oscilloscope (CRO)	1
2	Function generator	1
3	Connecting probes	2

3.THEORY:

The cathode ray oscilloscope is an electronic test instrument; it is used to obtain waveforms when the different input signals are given. In the early days, it is called as an Oscillograph. The oscilloscope observes the changes in the electrical signals over time, thus the voltage and time describe a shape and it is continuously graphed beside a scale. By seeing the waveform, we can analyze some properties like amplitude, frequency, rise time, distortion, time interval, and etc.,

- **Measurement of Voltage Using CRO:**

A voltage can be measured by noting the Y deflection produced by the voltage; using this deflection in conjunction with the Y-gain setting, the voltage can be calculated as follows:

V = (no. of boxes in cm.) x (selected Volts/cm scale)

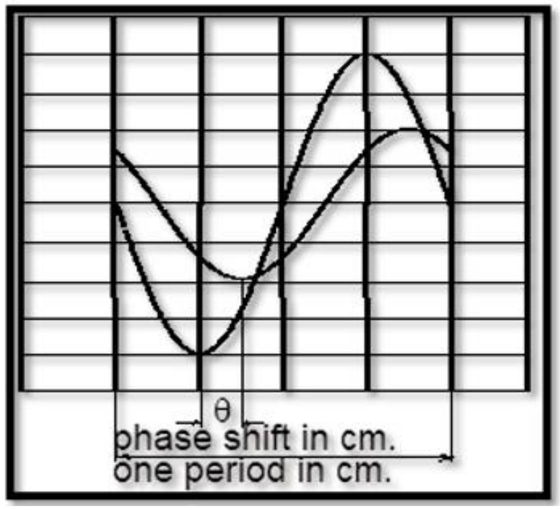
- **Measurement of Frequency Using a CRO:**

  A simple method of determining the frequency of a signal is to estimate its periodic time from the trace on the screen of a CRT. However, this method has limited accuracy, and should only be used where other methods are not available. To calculate the frequency of the observed signal, one has to measure the period, i.e. the time taken for 1 complete cycle, using the calibrated sweep scale. The period could be calculated by

  T = (no. of squares in cm) x (selected Time/cm scale) Once the period T is known, the frequency is given by f(Hz)= 1/T(sec).

- Measurement of Phase:

  The calibrated time scales can be used to calculate the phase shift between two sinusoidal signals of the same frequency. If a dual trace or beam CRO is available to display the two signals simultaneously (one of the signals is used for synchronization), both of the signals will appear in proper time perspective and the amount of time difference between the waveforms can be measured.



The phase shift can be calculated by the formula;

$$\theta = \frac{Phase\ shift\ in\ cm}{One\ period\ in\ cm} * 360°$$

Use of Lissajous Patterns for Frequency Measurements:

If a well calibrated CRO Time base is not available, a signal generator can be used to measure the frequency of an unknown sinusoidal signal. It is connected to the vertical channel (or horizontal) and the calibrated signal source is fed to the horizontal channel (or vertical). The frequency of the signal generator is adjusted so that a steady Lissajous pattern is obtained. The Lissajous pattern can be very involved to analyze. However, for the frequency measurement, all that is needed is the number of tangencies (points at the edge of arcs) along the vertical and horizontal lines. The frequency relationship between the horizontal and vertical inputs is given by;

$$\frac{f_h}{f_v} = \frac{No.of\ tangencies\ (vertical)}{No.of\ tangencies\ (horizontal)}$$

The Lissajous pattern shown in figure is observed on the CRT screen. Find the phase shift between the signals applied to the X and Y inputs of the scope.

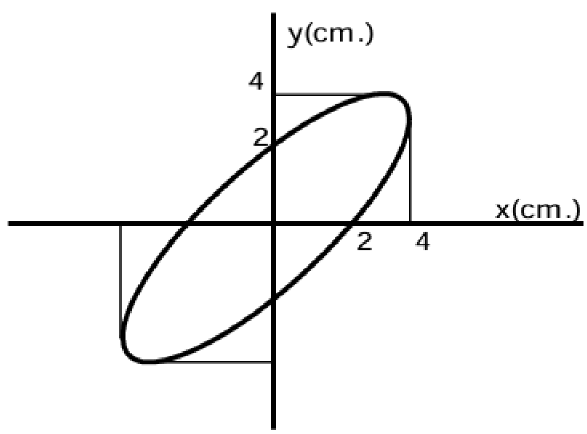
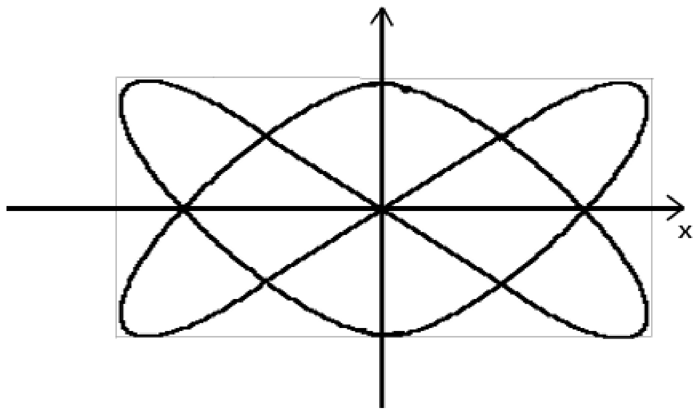


Figure shows a Lissajous pattern observed on the CRT screen. Determine the frequency relationship between the signals applied to the X and Y inputs of the scope.



4. PROCEDURE:

1. Understand the significance of each and every knob on the CRO.
2. From The given function generator feed in a sinusoidal wave and adjust the time base knob and amplitude knob to observe the waveform as a function of time.
3. Measure the time period and Amplitude (peak to peak) of the signal. Find the frequency and verify if the same frequency is given from the function generator.
4. Observe the waveforms simultaneously on the two channels of a CRO.
5. Note down the readings and take the waveforms.

5. OBSERVATION TABLE:

S. No	Applied Frequency (Hz)	No. of Vertical Tangencies	No. of Horizontal Tangencies	Unknown Frequency (Hz)
1.	600	2	1	300
2.	900	3	1	300
3.	400	2	3	600

6. PRECAUTIONS:

All the connections should be tight.

Readings should be taken without parallax error.

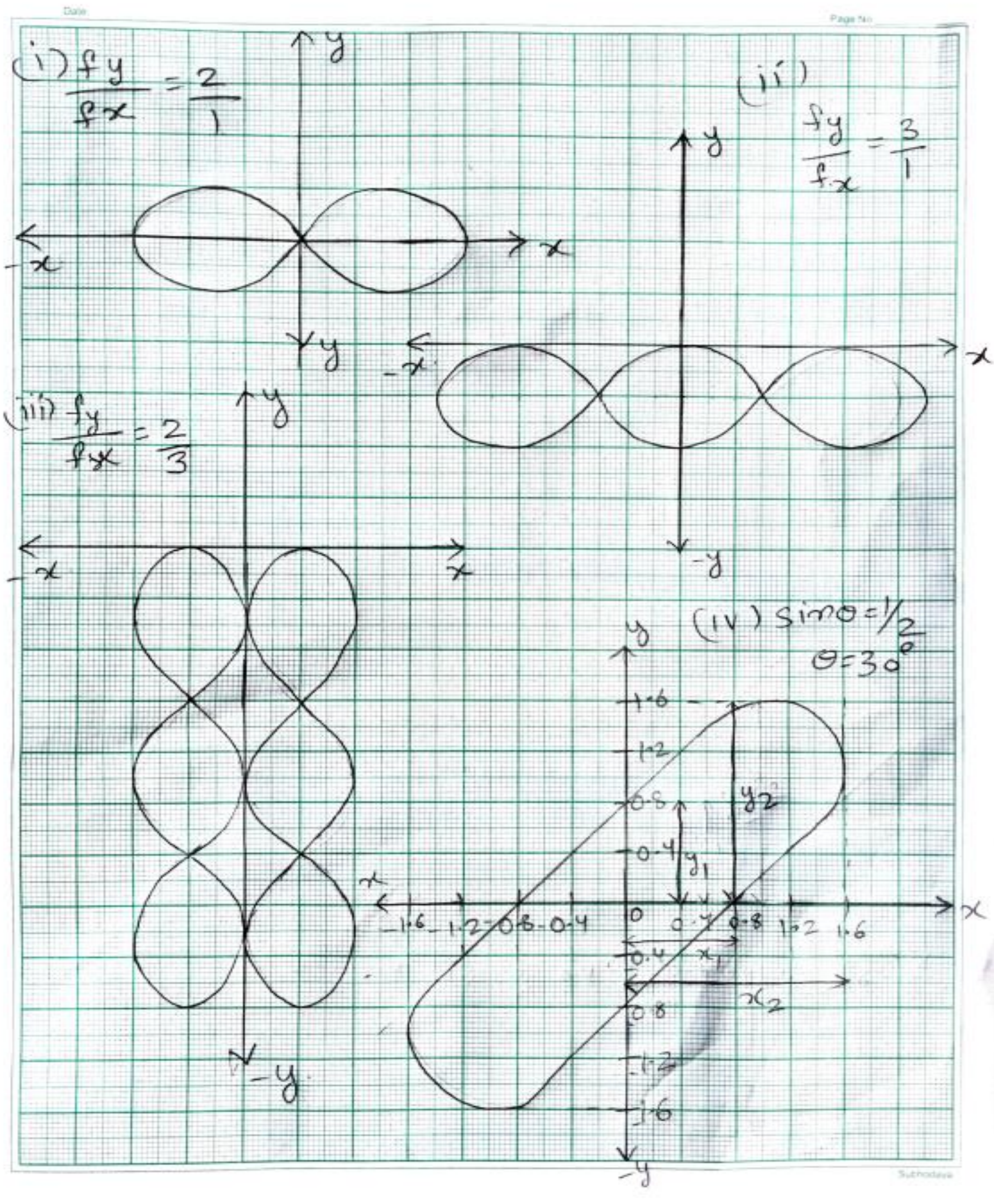
7. MODEL CALCULATIONS:

Frequency of generator = 600Hz

No. of Vertical tangencies = 2

No. of Horizontal tangencies =1

Unknown Frequency = 300 Hz.



(i) fy/fx = 2/1
(ii) fy/fx = 3/1
(iii) fy/fx = 2/3
(iv) sinθ = 1/2
θ = 30°

8. **RESULT**: The different Lissajous patterns was observed on CRO and also measured the phase difference and frequency of a signal.

9. **OUTCOME:** By conducting this experiment CO4, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

10. APPLICATIONS:

1. Measurement of voltage
2. Measurement of Current
3. Measurement of Frequency
4. Measurement of Phase difference
5. To trace and measuring signals of RF, IF and AF in radio and TV.
6. To trace visual display of sine wave.

11. VIVA QUESTIONS:

1. Can you measure signal phase using the CRO
2. How many channels are there in a CRO
3. Can you comment on the wave length of a signal using a CRO.
4. How do you measure the frequency using the CRO

10.Measurement of displacement with the help of LVDT

1. AIM:

To determine the characteristics of LVDT (linear variable differential transformer).

2. APPARATUS:

S. No	Name of The Equipment	Type	Range	Quantity
1	LVDT	1-Ø	230V/ (0-270) V 10A	2
2	Digital displacement indicator	MI	(0-5) A	1
3	calibration jig (micrometer).	MI	(0-300) V	1
4	Wattmeter	UPF	300V,5A	1
5	Rheostat	WW	50Ω/5A	1
6	Connecting Wires	-	-	As Per Requirement

3. THEORY:

Differential transformers, based on a variable Inductance principle, are also used to Measure displacement. The most popular variable-inductance transducer for linear displacement measurement is the Linear Variable Differential Transformer (LVDT). The LVDT illustrated in the fig. consists of three symmetrically spaced coils wound onto an insulated bobbin. A magnetic core, which moves through the bobbin without contact, provides a path for magnetic flux linkage between coils. The position of the magnetic core controls the mutual between the center or primary coil and with the two outside or secondary coils. When an AC carrier excitation is applied to the primary coil, voltages are induced in the two secondary coils that are wires in a series-opposing circuit. When the core is centered between the two secondary coils, the voltage induces between the secondary coils are equal but out of phase by 1800. The voltage in the two coils cancels and the output voltage will be zero. When the core is moves from the center position, an imbalance in mutual inductance between the primary coil and the secondary coil occurs and an output voltage develops. The output voltage is a linear function of the core position as long as the motion of the core is within the operating range of the LVDT.

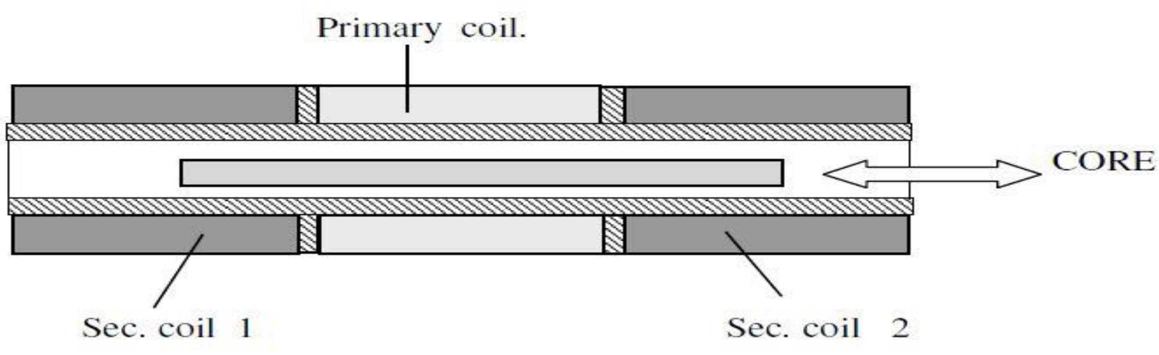
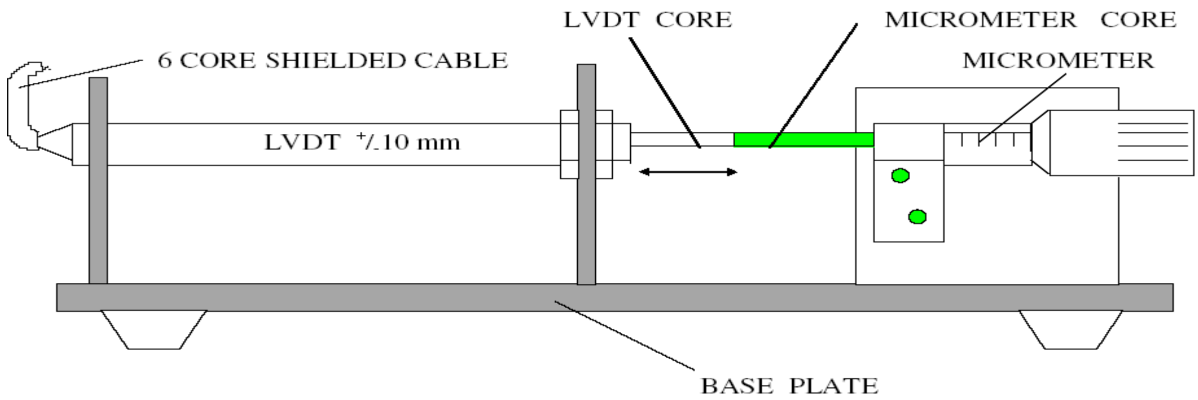
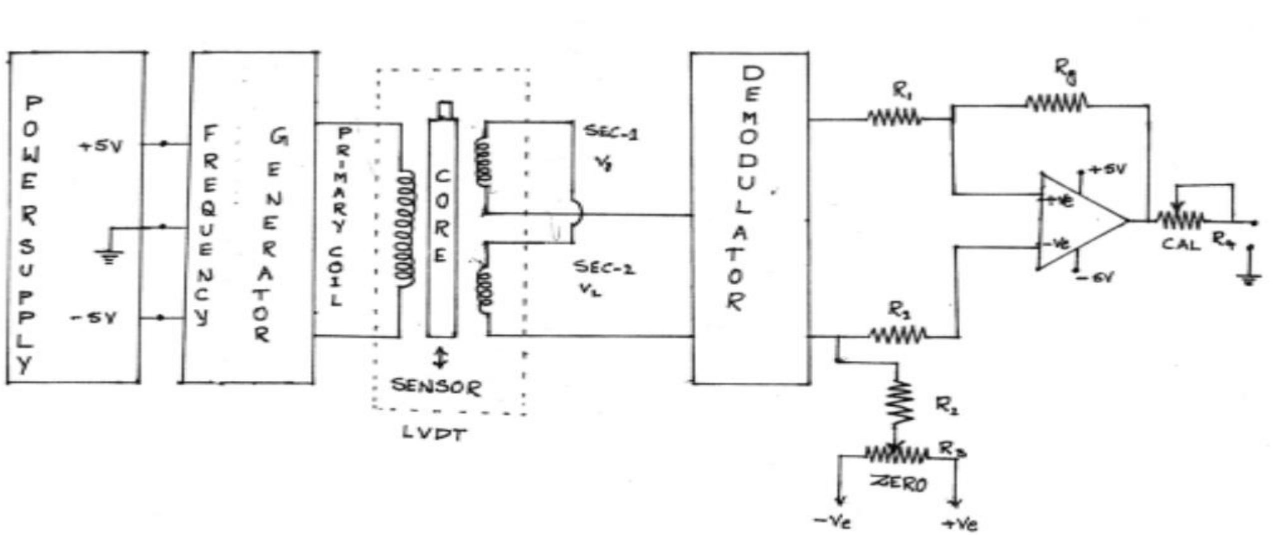


Diagram to shows schematically the working of LVDT.

LVDT WITH CALIBRATION JIG



CIRCUIT DIAGRAM



SPECIFICATION INDICATOR

* Display:31/2-digit seven segment red LED display of range200mV for full scale deflection. to read +/- 1999counts.
* Excitation Voltage:1000 Hz at 1V
* Operating Temperature: +100 C to 550 C
* Zero Adjustment: Front panel through Potentiometer.
* Sensitivity: 0.1mm
* System Inaccuracy: 1%
* Repeatability: 1%
* Connection: Through 6 core shielded cable with Din connector.
* Fuse: 250mA fast glow type.
* Power: 230 V +/- 10 %, 50 Hz.

SENSOR

* Range: +/- 10.0 mm

* Excitation Voltage: 1 to 4 kHz at 1 to 4V
* Linearity: 1%
* Operating Temperature: +100 C to 550 C
* Connection: Through 6 core shielded cable provided along with the sensor of 2M length.
* Calibration Jig: Micrometer of 0 to 25mm length is mounted on the base.

5. PROCEDURE:

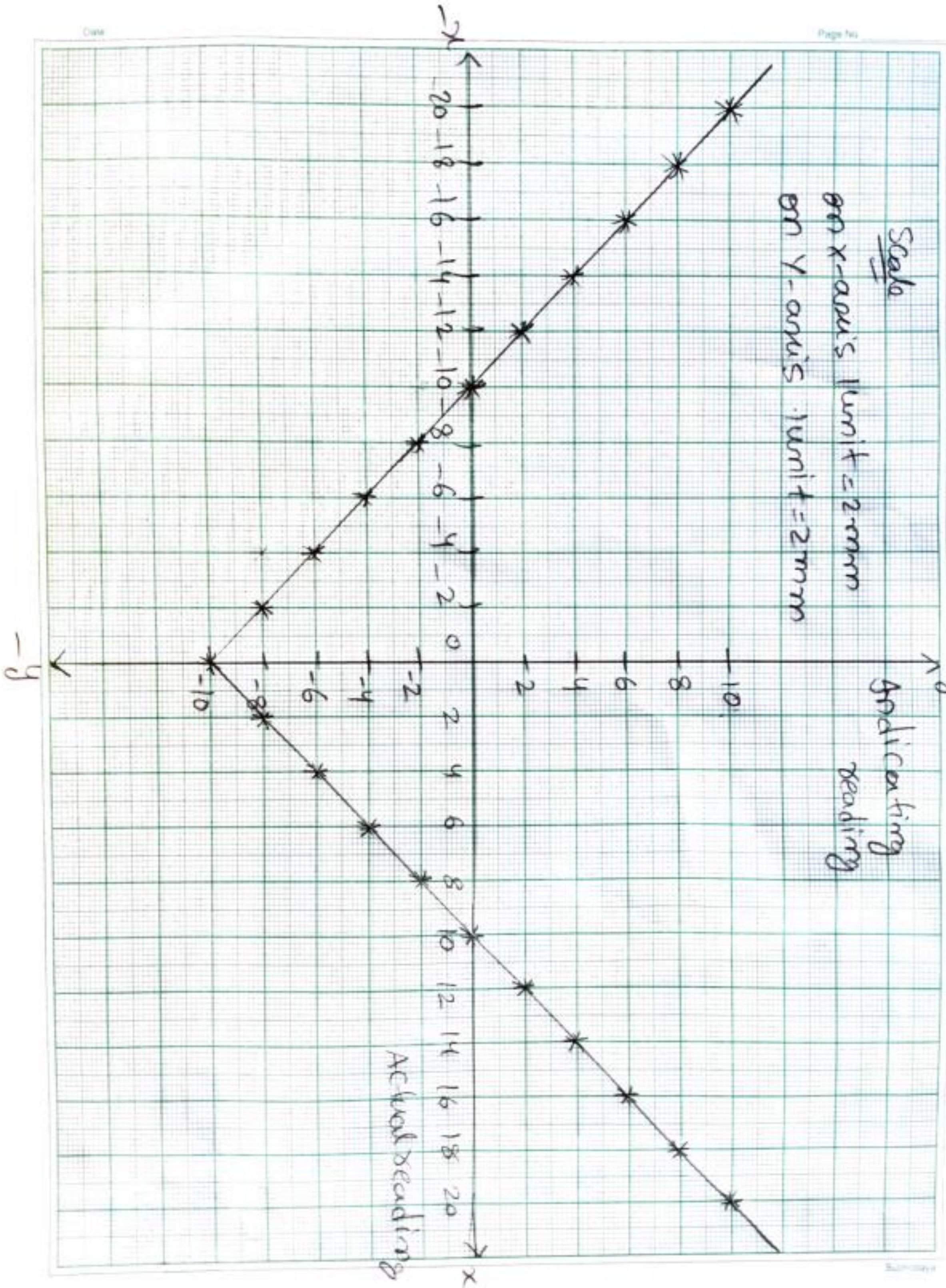
1. Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on the Instrument.
2. Allow the instrument in ON position for 10 minutes for initial warm-up.
3. Rotate the micrometer till it reads “20.0”.
4. Adjust the CAL potentiometer at the front panel so that the display reads “10.0”
5. Rotate the core of micrometer till the micrometer reads “10.0” and adjust the ZERO potentiometer till the display reads “00.0”
6. Rotate back the micrometer core up to 20.0 and adjust once again CAL Potentiometer till the display read 10.0. Now the instrument is calibrated for +/-10.0mm range. As the core of LVDT moves the display reads the displacement in mm.
7. Rotate the core of the micrometer in steps of 1 or 2 mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core the display will read the displacement sensed by the LVDT.
8. Tabulate the readings and plot the graph Actual V/s indicator reading

6. PRECAUTIONS:

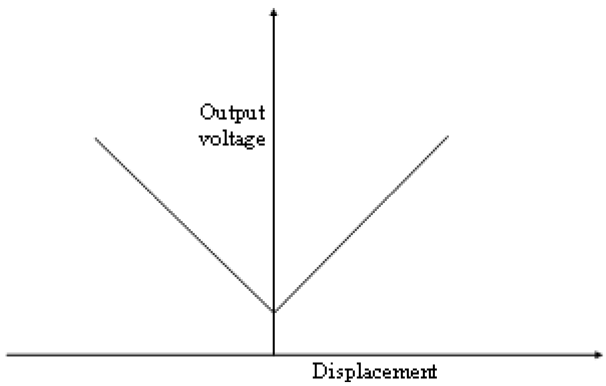
1. Initial zero setting may do properly
2. Move the core gently.
3. While taking readings parallax error has to avoid.

7. OBSERVATION TABLE:

S. No	Actual Micrometer Reading in mm	Indicator reading of LVDT in mm	Error	%Error
1	0	-10	0	0
2	2	-8.1	0.01	1
3	4	-6.2	0.02	2
4	6	-4.1	0.01	1
5	8	-2	0	0
6	10	0	0	0
7	12	1.96	0.01	1
8	14	3.92	0.02	2
9	16	6	0	0
10	18	7.95	0.01	1
11	20	10	0	0


Scale
on x-axis 1unit = 2mm
on Y-axis 1unit = 2mm
Indicating reading
Actual reading

8.MODEL GRAPH:



9.RESULT: Measured the displacement by using the LVDT.

10.OUTCOME: By conducting this experiment CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

ADDITIONAL EXPERIMENTS

1. MEASUREMENT OF 3-PHASE POWER WITH SINGLE WATTMETER AND 2 NO'S OF C.T

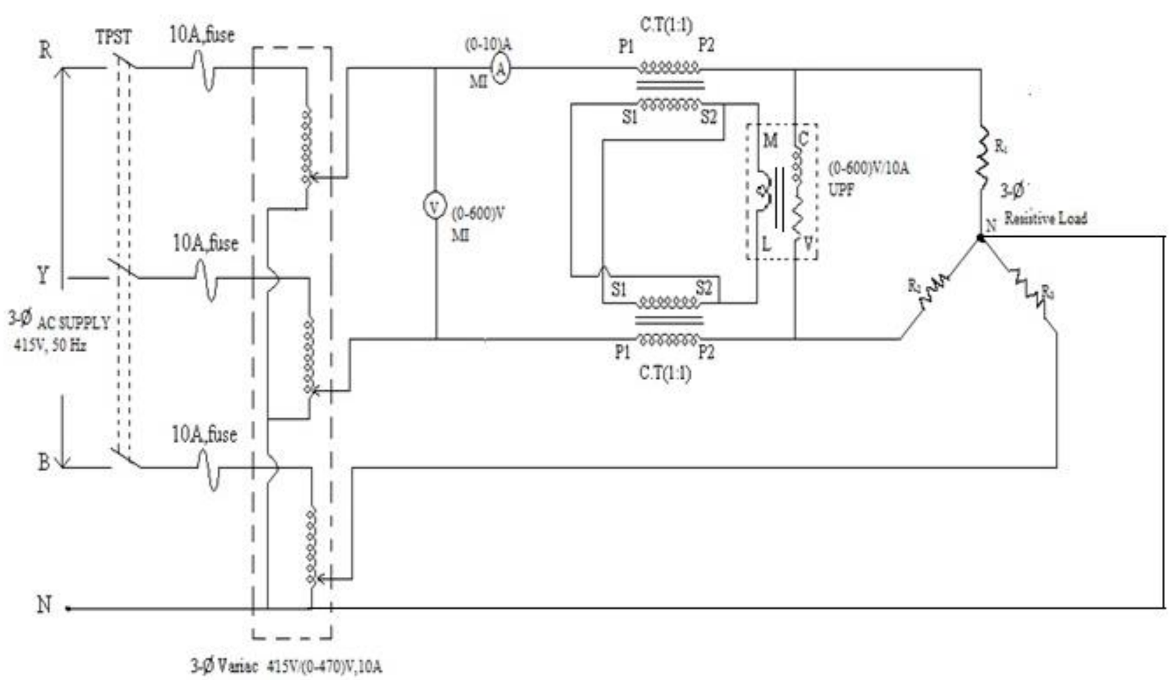
1. AIM:

To measure the 3- Phase power with single wattmeter and 2 No's of C.T.

2.APPARATUS:

S.NO	NAME OF THE EXPERIMENT	TYPE	RANGE	QUANTITY
1	Three Phase Variac	AC	415V/(0-470)V, 15A	1
2	Wattmeter	UPF	600V,10A	1
3	Voltmeter	MI	(0-600) V	1
4	Ammeter	MI	(0-10) A	2
5	Current Transformer	-	1:1,5/5A	2
6	Three Phase Load	Resistive Load	15A	1
7	Connecting Wires	-	-	As Per Requirement

3.CIRCUIT DIAGRAM:



4.THEORY:

To measure 3- phase power using two CT's. Power can be measured in many ways, for a balanced load only one wattmeter is enough to measure the 3- phase power, and for an unbalanced load, two wattmeter method is used to measure the 3- phase power. The primary windings of CT's are connected in series with two phases. The secondary of both the CTs are connected as shown in figure the current coil of wattmeter connected across both secondaries of CT's. The pressure coil is connected between the two phases.

5.PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Keep the three-phase autotransformer at minimum or zero-volt position.
3. Switch on the three-phase power supply.
4. Vary the three phase variac slowly to its rated voltage (415V) and then apply the load in steps for different values and take the readings of the ammeter, voltmeter and wattmeter.
5. Now switch of the loads and adjust the variac to its previous (zero volt) position.
6. Switch off the three phase power supply.

6.FOR BALANCED CONDITION:

To check the balance condition, apply the two-phase loads simultaneously and note down the two ammeter readings then it should show the same value.

TABULAR FORM:

FOR UNBALANCED CONDITION:

S. No	Supply Voltage (V_L)Volts	Current (I_R)Amps	Current (I_Y)Amps	Power (W)Watts
1	385	0.5	0	160
2	385	0.4	0	400
3	385	2.2	0	600
4	385	2.9	0	800
5	385	3.65	0	1000
6	385	0	0.5	200
7	385	0	1.5	400
8	385	0	2.2	600
9	385	0	3	800
10	385	0	3.7	1040
11	385	0	4.4	1360

FOR BALANCE CONDITION:

S. No	Supply Voltage (V_L)Volts	Current (I_R)Amps	Current (I_Y)Amps	Power (W)Watts
1	385	0.5	0.5	400
2	385	1.5	1.5	800
3	385	2.2	2.2	1360
4	385	2.9	2.9	1760
5	385	3.65	3.65	2320

7.MODEL CALCULATIONS:

Three phase power is, P = 3(VICOSΦ)

8.PRECAUTIONS:

1. Avoid loose connections.
2. The secondary of CT should not be kept open.
3. Take readings without error.

9.RESULT:

Three phase active power (P= <u>400</u> W) is calculated using single phase wattmeter and two CT's method at balanced and unbalanced load conditions.

10.OUTCOME: By conducting this experiment CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

11.VIVA QUESTIONS:

1. What is Burden of transformer?
2. Define (C.T&P. T) A. Transformation ratio
   B. Turns ratio
   C. Nominal ratio
   D. RCF
3. Why C.T secondary should not be opened?
4. Comparison between C.T & P.T

2.MEASUREMENT OF % RATIO ERROR AND PHASE ANGLE OF GIVEN CT BY COMPARISON.

1.AIM:

To determine the percentage ratio error and the phase angle error of the given current transformer by comparison with another current transformer whose error are known.

2.APPARATUS:

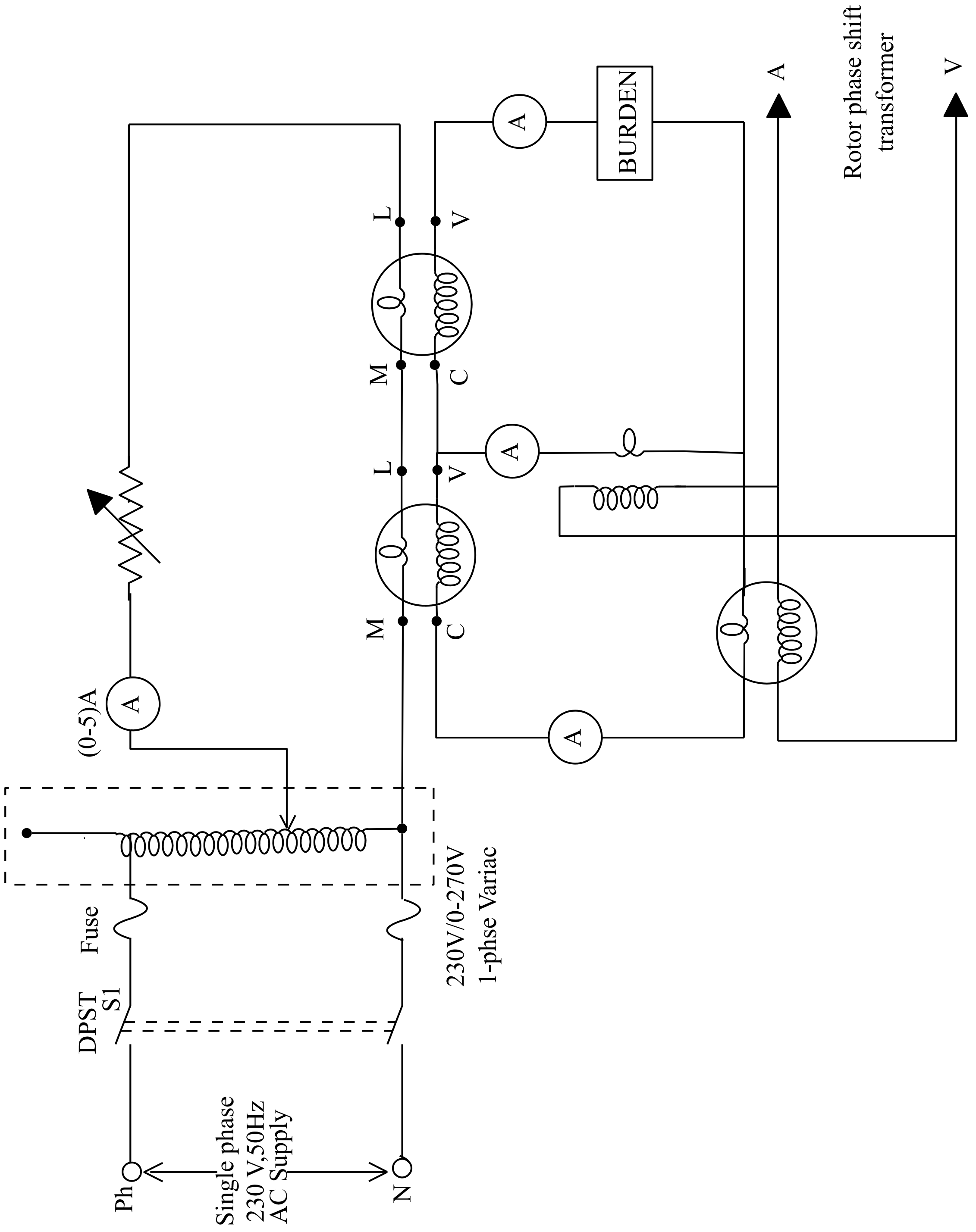
S.NO	Name of the Apparatus	Type	Range	Quantity
1	Voltmeter	M.I	(0-600) V	1
2	Ammeter	M.I	(0-5) A	1
3	Wattmeter	LPF, UPF	300V, 5A	2
4	Current transformer	--	10A/5A	2
5	1-Ø Auto transformer	--	230V/ (0-270) V, 10A	1
6	Rheostat	WW	50Ω/5A	2
7	Burden box		230V/ (0-270) V	1
8	Connecting wires	--	--	As per requirement

3.THEORY:

Silsbee method is a comparison method. There are two types of Silsbee's methods. They are deflection and null methods. Only Deflection method is described here. The ratio and phase angle of test Transformer are determined in terms of that of standard transformers having the same nominal ratio.

The two transformers are connected with their primaries in series. An additional adjustable burden is put in the secondary circuit of the transformer under test. An ammeter is included in the secondary circuit of the standard transformer so that the current may be set to desired value. W_1 is the wattmeter whose current coil is connected to carry the secondary current of the standard transformer. The current coil of wattmeter W_2 carries a current ΔI which is the difference between secondary currents of the standard and test transformers. The voltage circuits of the wattmeter are supplied in the parallel from a phase shifting transformer at constant voltage V.

4.CIRCUIT DIAGRAM:



5.PROCEDURE:

1. Connect the circuit as per circuit shown.'
2. Using the auto T/ F, the current through the primary in gradually increased.
3. The difference b/ w C.T secondary's ΔI should be zero, if it is not zero then connection to any one of C.T secondaries are reversed.
4. The current I_p through C.T primaries is made equal to a fixed value using auto T/F.
5. By operating the phase shifter, W1 is made zero. The readings of ammeter and W_2 are noted.
6. Now, W_1 is adjusted to maximum value by rotating phase shifting T/ F and ammeter and W_2 readings are noted.
7. Above procedure is repeated for different primary current.

6.PRECAUTIONS:

1. Avoid loose connections.
2. Readings to be taken without parallax error.

7.TABULAR FORM:

S. No	V(v)	I(A)	I_{ss} (A)	W1q(W)	W_{2q} (W)	W_{1P}(W)	W_{2P}(W)	θ_1	θ_2	R_x	θ_x
1	230	2	2	0	8	220	8	-17^0	-117^0	-0.0466	1.25^0
2	230	0.5	0.5	0	4	100	4	-15^0	-105^0	-0.0884	5^0

8.RESULT:

By conducting this experiment obtained the percentage ratio error=0.0466 and phase angle error=1.25 at I =2(Amps), W_{1q}=0 (watts), W_{2q}=8 (watts), W_{1p}=220 (watts), W_{2p}=8 (watts).

9.OUTCOME: By conducting this experiment CO5, PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1 are attained.

10.VIVA QUESTIONS:

1. Why the C.T & P.T are called instrument transformers?
2. Why we have to close the secondary of a C.T always?
3. What are the different errors in C. T's?
4. What is the procedure to conduct Silsbee's method?
5. Is there any another method to test the C.T?
6. What are the advantages & disadvantages in Silsbee's method?