Electrical Measurements and Instrumentation

LABORATORY MANUAL

B.TECH.(EEE)   SEMESTER –III

Subject Code: BEE 352

Session: 2024-25, odd 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

Table of Contents

Vision and Mission of the Institute

Vision:

"Dronacharya Group of Institutions, Greater Noida aims to instill core human values and facilitating competence to address global challenges by providing Quality Technical Education."

Mission:

M1: Enhancing technical expertise through innovative research and education, fostering creativity and excellence in problem-solving.

M2: Cultivating a culture of ethical innovation and user-focused design, ensuring technological progress enhances the well-being of society.

M3: Equipping individuals with the technical skills and ethical values to lead and innovate responsibly in an ever-evolving digital landscape.

Vision and Mission of the Department

Vision

To be a Centre of Excellence in Globalizing Education and Research in the field of Electrical and Electronics Engineering.

Mission

M1: To empower technocrats with state-of-art knowledge to excel as eminent electrical engineers with multi-disciplinary skills.

M2: To emphasize social values and leadership qualities to meet the industrial needs, societal problems and global challenges.

M3: To enable the technocrats to accomplish impactful research and innovations.

Programme Educational Objectives (PEOs)

PEO 1. To foster strong knowledge in basic sciences and electrical engineering that enable technocrats to have successful careers.

PEO 2. Imbibed with the state of art knowledge to adapt ever transforming technical scenario.

PEO 3. Inspire engineers to provide innovative solutions to real-world challenging problems by applying electrical and electronics engineering principles.

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 engineering practice.

PO 9: Individual and teamwork: 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)

PSO1: Graduates will be capable to gain knowledge in diverse areas of electrical and electronics engineering and apply that to a successful career, entrepreneurship and higher education.

PSO2: Enhance the competence of graduates to design and analyze systems used in advanced power applications, renewable energy, electrical drives in allied technical fields.

PSO3: Graduate will use advance tools to analyze, design and develop electrical and electronic systems for feasible operation and meet the industry requirements.

University Syllabus

1. Calibration of AC voltmeter and AC ammeter.
2. Measurement of inductance using Maxwell's Bridge.
3. Measurement of capacitance using Schering Bridge.
4. Measurement of low resistance using Kelvin's Double Bridge.
5. Measurement of Power using CT and PT.
6. Measuring displacement using LVDT.
7. Measuring temperature using thermocouple.
8. Measuring pressure using piezoelectric pick up.
9. Measurement of speed of DC motor by photoelectric pick up.
10. Speed measurement using Hall Effect sensor.
11. PC based data logging of temperature sensor using LabVIEW/ MATLAB.
12. Signal conditioning of analog signal using LabVIEW/ MATLAB.

Course Outcomes (COs)

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

CO1 : Understand the importance of calibration of measuring instruments

CO2 : Demonstrate the construction and working of different measuring instruments.

CO3: Demonstrate the construction and working of different AC and DC bridges, along with their applications.

CO4: Ability to measure electrical engineering parameters like voltage, current, power & phase difference in industry as well as in power generation, transmission and distribution sectors.

CO5: Capability to analyze and solving the variety of problems in the field of electrical measurements.

CO-PO Mapping

	PO 1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2
CO1	2	3	2	3	3	2	3	2	3	2	3	2
CO2	2	2	3	2	2	3	2	3	2	3	2	2
CO3	2	3	2	3	3	3	3	2	2	3	2	2
CO4	2	2	3	3	3	3	2	2	2	3	2	2
CO5	2	3	1	3	3	2	3	2	2	3	2	2
Course Correlation mapping	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**2**	**2**	**3**	**2**	**2**

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

CO-PSO Mapping

	PSO1	PSO2	PSO3
CO1	2	3	2
CO2	2	3	2
CO3	2	3	2
CO4	2	3	2
CO5	2	3	2
Course Correlation mapping	**2**	3	**2**

Course Overview

Electrical measurement and instrumentation include installing, operating, and maintaining equipment that measures various electrical parameters such as voltage, current, power, resistance, inductance, capacitance, and impedance.
Instrumentation also encompasses sophisticated devices to monitor and control electrical systems. Electric current is measured by these devices to provide readings that will determine the health of an electrical system so that corrective measures can be taken if a problem is detected.
There are a wide variety of instruments available on the market today. Some of the most common types include:

- Ammeters - Used to measure electric current in a circuit.
- Voltmeters - Used to measure potential difference (voltage) between two points in a circuit.
- Ohmmeters - Used to measure resistance in a circuit.
- Multimeters - A combination instrument that can measure multiple electrical parameters such as voltage, current, and resistance.
- Clamp meters - A type of multimeter that can be placed around an electrical conductor, such as a wire or cable to measure parameters such as current or voltage without disconnecting the conductor from the circuit.

The principle of electrical measurement is based on the concept of an electric circuit. An electric circuit is a closed loop of conductors through which electric current can flow. The current in a circuit is caused by the flow of electrons from one atom to another. The electrons flow from the negative terminal of a battery or power source through the conducting wires of the circuit to the positive terminal.
The voltage of the power source and the circuit's resistance determines the current's strength in a circuit. The higher the voltage, the more electrons will flow through the circuit. The resistance of a circuit limits the flow of electrons and thus determines how much current will flow through it.
Electrical measurements are measured by measuring a circuit's voltage or current. The most common type of voltmeter is an analog voltmeter, which uses a moving needle to indicate voltage on a scale. A digital voltmeter (DVM) uses electronic displays to show voltage readings. Current can be measured using an ammeter, which measures the current flow through a given point in a circuit.

List of Experiments mapped with COs

S. No	Aim of the	COs
1	Calibration of AC voltmeter and AC ammeter.	CO1
2	Measurement of inductance using Maxwell's Bridge.	CO3
3	Measurement of capacitance using Schering Bridge.	CO3
4	Measurement of low resistance using Kelvin's Double Bridge.	CO3
5	Measurement of Power using CT and PT	CO3
6	Measuring displacement using LVDT.	CO3
7	Measuring temperature using thermocouple	CO4
8	Measuring pressure using piezoelectric pick up.	CO5
9	Measurement of speed of DC motor by photoelectric pick up.	CO3
10	Speed measurement using Hall Effect sensor.	CO1
11	PC based data logging of temperature sensor using LabVIEW/ MATLAB	CO5
12	Signal conditioning of analog signal using LabVIEW/ MATLAB	CO5

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.

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.

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 firewood 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 the 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.

Precautions (In case of Fire)

1. Turn the equipment off. If the 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.

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 as how to explore.	Student fails to define the problem adequately	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 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 qualityof conclusions drawn is not up to the mark	Cannot analyse the data or observations for any kind of conclusions	Lacks required knowledge to propose viable conclusions and solutions
AC5: Lab record assessment	Well-organized and confident presentation of record & able to correlate the theoretical concepts with the concerned	Presentation of record acceptable	Presentation of record lacks clarity and organization	No efforts exhibited

	lab results with appropriate reasons.			

LAB EXPERIMENTS

Experiment No.1

Aim: To study and perform Calibration of ac voltmeter and ac ammeter

OBJECTIVE: Introduction to various Supply Systems, Ammeter, Voltmeter, Wattmeter, Energy meter, Tachometer, Rheostat, Loading Devices, Transformer.

Apparatus Required: Demonstration of various instruments like Ammeter, Voltmeter, Wattmeter, Energy Meter, Tachometer, Rheostat, Various Capacitors, Various Resistors, AC and DC Power Supply.

Theory

AMMETER

Ammeter is employed for measuring of current in a circuit and connected in series in the circuit. As ammeter is connected in series, the voltage drop across ammeter terminals is very low. This requires that the resistance of the ammeter should be as low as possible. The current coil of ammeter has low current carrying capacity whereas the current to be measured may be quite high. So for protecting the equipment a low resistance is connected in parallel to the current coil and it is known as shunt resistance

Analog Ammeter

VOLTMETER

(a) Voltmeter is employed to measure the potential difference across any two points of a circuit. It is connected in the parallel across any element in the circuit. The resistance of voltmeter is kept very high by connecting a high resistance in series of the voltmeter with the current coil of the instrument. The actual voltage drop across the current coil of the voltmeter is only a fraction of the total voltage applied across the voltmeter which is to be measured.

Analog voltmeter

Result: We have studied and perform the Calibration of ac voltmeter and ac ammeter.

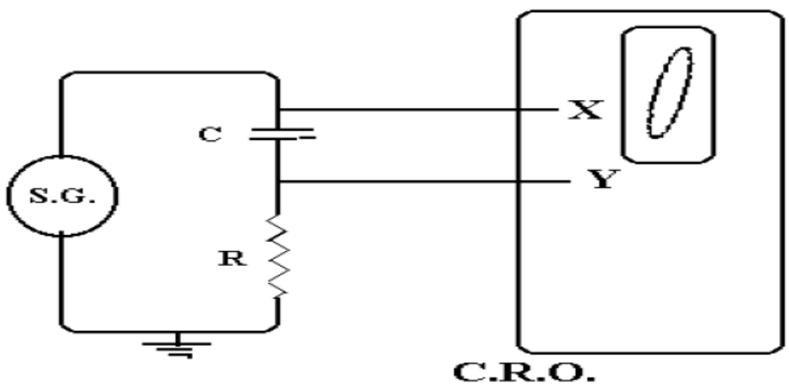
Experiment No. 2

Aim: Measurement of form factor of a rectified sine wave and determine source of error if r.m.s.value is measured by a multi-meter.

Apparatus Used: Signal generator, CRO, capacitor, variable resistor and connecting terminals.

Theory: When an AC current is sent through an R-C circuit, the current direction is same in both the elements, R and C. But the voltage directions are different. The voltage across the resistor is in the direction of current and the voltage across the condenser lags behind the current by 90^0. Because of this, the resultant voltage also lags behind the current by some angle (Φ) called phase difference. Since the current can’t be measured directly by a CRO, the voltage across the resistor is given to CRO, which represents the current direction. So the phase difference is the angle between the voltage across the resistor and the resultant voltage.

Circuit Diagram:



Observation Table:

Table

Resistance (R) = Ω Capacitance (C) = μF

S.No.	Applied Frequency f (Hz)	Angular Frequency $\omega = 2\pi f$ (Rad/sec)	Theoretical Phase $\Phi_1 = Tan^{-1}(\frac{1}{\omega C R})$	A (mm)	B (mm)	Practical Phase $\Phi_2 = Sin^{-1}(\frac{A}{B})$
1.						
2.						
3.						
4.						
5.						
6.						

Procedure: The connections are made as shown in the circuit and as said in the description. The time base (X-plates) band switch is kept in external mode. The gain band switch of Y-plates is kept in desired range, so as to get complete maximum size ellipse on the screen. The maximum deflection (B) from the mean position and the deflection (A) at t = 0, from the mean position are measured using the divisions on the screen. The experiment is repeated by varying the frequency (f) of the signal generator in equal steps. The values of f, A and B are noted in the table. The values of resistance and capacitance are also noted.

Precautions: 1.The size of the ellipse should be maximum, to minimize the error of measurement.
2. The time base (X-plates) band switch should be kept in external mode.

Results: The calculated value of Φ1 and Φ2 are equal

Experiment No. 3

Aim: To determine the unknown value of inductance by comparing with a variable standard self inductance using Maxwell's Inductance bridge.

Apparatus Used:

S. No.	Name of the apparatus	Quantity
1.	Transformer 230/15v	1 NOS
2.	Bread board	1 NOS
3.	Resistors	4 NOS
4.	Variable Resistor	1 NOS
5.	Inductors	2 NOS
6.	Digital Multimeter	1 NOS

Theory: This bridge circuit measures an inductance by comparison with a variable standard self inductance.

The connections and the phasor diagrams for balance conditions are shown below.

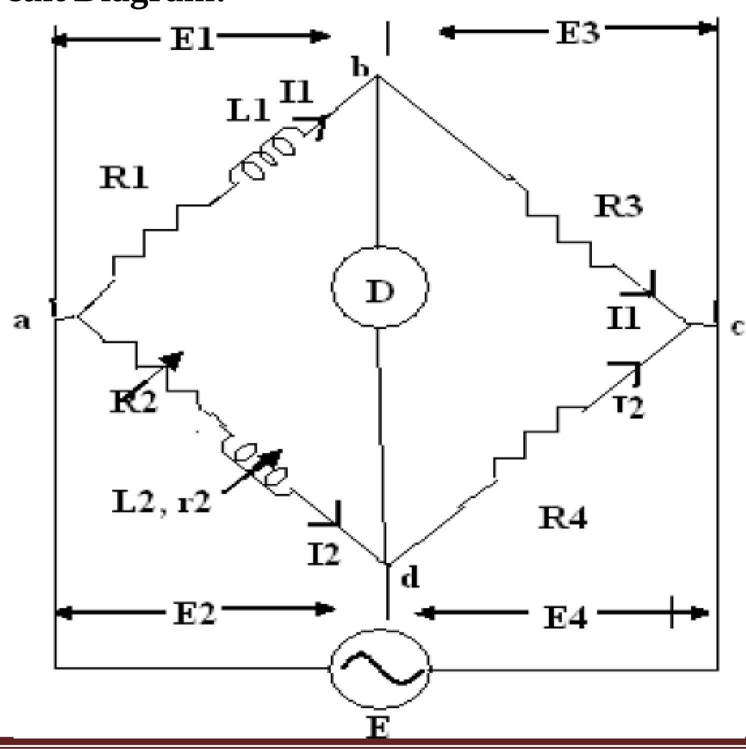
Let, L1 = unknown inductance of resistance R1,

L2 = variable inductance of fixed resistance r2,

R2 = variable resistance connected in series with inductor L2,

R3, R4 = known non-inductive resistances.

Circuit Diagram:



At balance, L1 = R3L2/R4 , R1= R3(R2+r2)/R4.

Procedure:

1. Connect the circuit as shown in the figure.
2. Connect the unknown inductance in L1.
3. Connect the multimeter between ground and output of imbalance amplifier.
4. Vary R2, from minimum position, in clockwise direction.
5. If the selection of R2 is correct the balance point can be obtained at minimum position.
6. Vary R2 for fine balance adjustment.

Observation Table:

S. No.	R2	R3	C1	L1= R3L2 / R4	True value of L1
1					
2					
3					

Result: Actual and practical values of Inductances are found to be nearly equal.

Experiment No. 4

Aim: Measurement of inductance by Hay's bridge **Apparatus Used:**

S. No.	Name of the apparatus	Quantity
1	Lab trainer kit	1
2	Multimeter	1
3	Unknown inductor	1

Theory: The Hay's Bridge differs from Maxwell's bridge by having resistor R1 in series with standard capacitor C1 instead of in parallel. It is immediately apparent that for large phase angles, R1 should have a very low value. The Hay's circuit is therefore more convenient for measuring high Q coils. The balance equations are again derived by substituting the values of theimpedance of the bridge arms into the general equation for bridge balance. On separating real and imaginary terms, the balance equations are:

$$R1Rx + Lx/C1 = R2R3 \text{ --------------(1)}$$

$$Rx/\omega C1 = \omega LxR1 \text{ --------------- (2)}$$

Both equations 1 & 2 consist of L & R. By solving the above equations

$$Rx = \frac{\omega^2 C_1^2 R_1 R_2 R_3}{1+\omega^2 C_1^2 R_1^2} \text{ ....(3)}$$

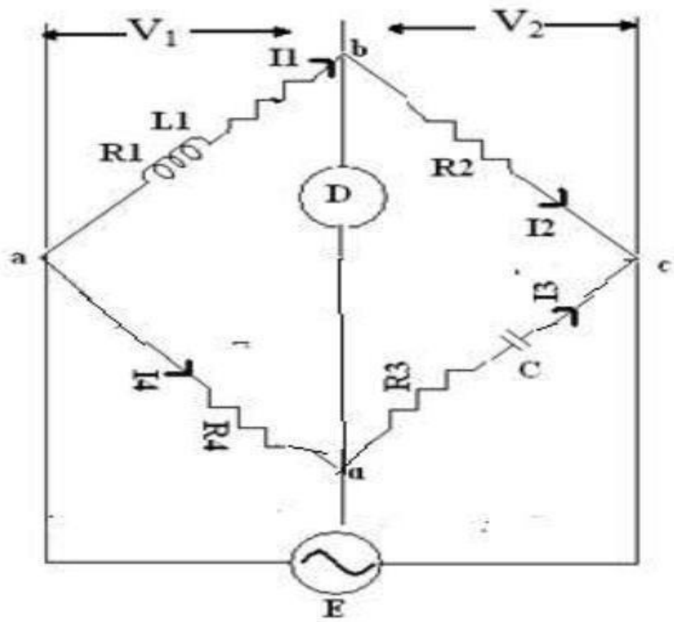
$$Lx = \frac{R_2 R_3 C_1}{1+\omega^2 C_1^2 R_1^2} \text{ ------- (4)}$$

The expressions for the unknown inductance & resistance are consists of frequency term under balanced condition when two phase angles are equal, their tangents are also equal. Hence,

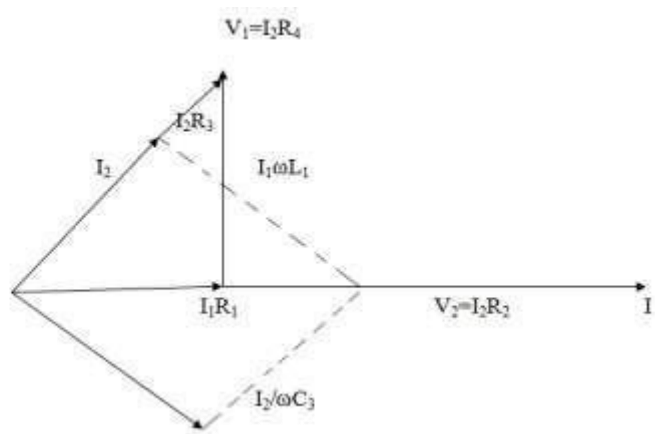
$$\tan\theta L = \tan\theta C \text{ (or) } Q = \frac{1}{\omega C_1 R_1} \text{ -------(5)}$$

Substituting (5) in (4)

Circuit Diagram:



Phasor Diagram:



Procedure:

1. Switch ON the trainer & check the power supply.
2. Connect the unknown value of inductance (high Q) in arm marked Lx.
3. Vary R2 for fine balance adjustment.
4. The balance of bridge can be observed by using head phone. Connect the output of the bridge at the input of the detector.
5. Connect the head phone at output of the detector, alternately adjust R1 and proper selection of R3 for a minimum sound in the head phone.
6. Finally disconnect the circuit and measure the value of R1 at balance point using any multimeter. By substituting R1, R3 and C1 the unknown inductance can be obtained.

Observation Table:

S.No.	R2 (KΩ)	R3 (Ω)	C1 (μF)	Lx (mH)	L mH
1					
2					
3					

Result: After balancing the bridge, the values of R1 R3 and C1 are measured and found that the calculated value of Lx is almost equal to the actual value.

Experiment No. 5

Aim: Measurement of inductance by Anderson's bridge

Apparatus Used:

S. No.	Name of the apparatus	Quantity
1.	Transformer 230/15v	1 NOS
2.	Bread board	1 NOS
3.	Resistors	6 NOS
4.	Variable Resistor	1 NOS
5.	Inductors	2 NOS
6.	Capacitors	1 NOS
7.	Digital Multimeter	1 NOS

Theory: In this bridge, the self inductance is measured in terms of a standard capacitor. This method is applicable for precise measurement of self-inductance over a very wide range of values. Figure below show the connections and the phasor diagram of the bridge for balanced conditions. Let L1 = self inductance to be measured, R1 = resistance of self-inductor, r,R2,R3,R4 = known non-inductive resistance r1 = resistance connected in series with self-inductor,

At, balance, I1 =I3 and I2 = IC +I4.

Now, I1R3 = IC/jωC therefore, IC = I1jωCR3.

Writing the other balance equations.

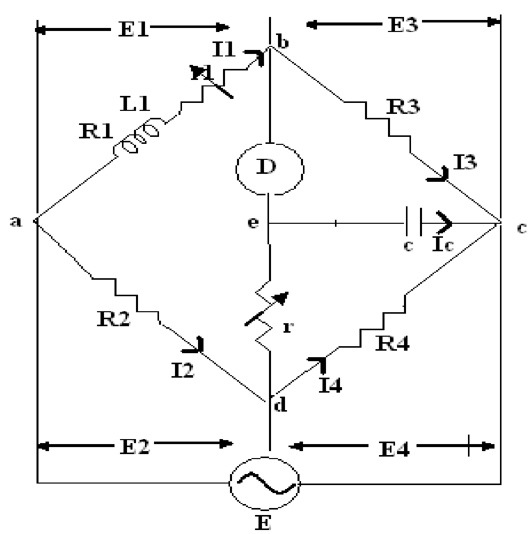
I1(r1+R1+jωL1) = I2R2 + ICr and IC(r+1/jωC) = (I2-IC) R4

By substituting IC value and equating real and imaginary parts

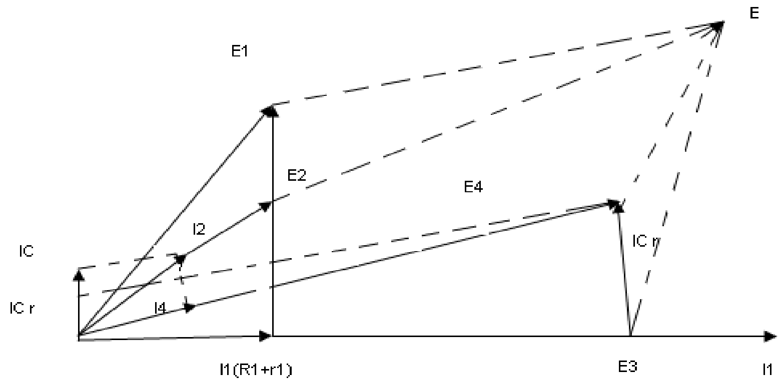
R1 = R2R3/R4 – r1

L1 = C R3/R4{ r(R4+R2)+R2R4}

Circuit Diagram:



Phasor Diagram:



Procedure:

1. Connect the circuit as shown in the figure.
2. Connect the unknown inductance in L1.
3. Select any value of r.
4. Connect the multimeter between ground and output of imbalance amplifier.
5. Vary r1 and r, from minimum position, in clockwise direction.
6. Calculate the inductance L1 by substituting known values.

Observation Table:

S. No.	Actual value of L in mH	R in ohms	Practical value of L in mH

Results: The unknown inductance is determined using the Anderson's bridge.

Experiment No. 6

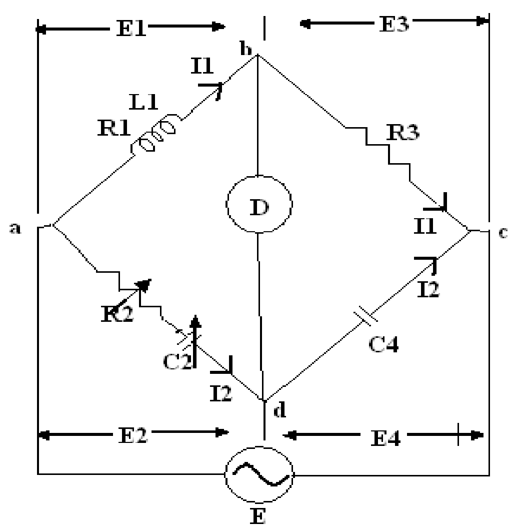
Aim: Measurement of capacitance by Owen's bridge

Apparatus Used:

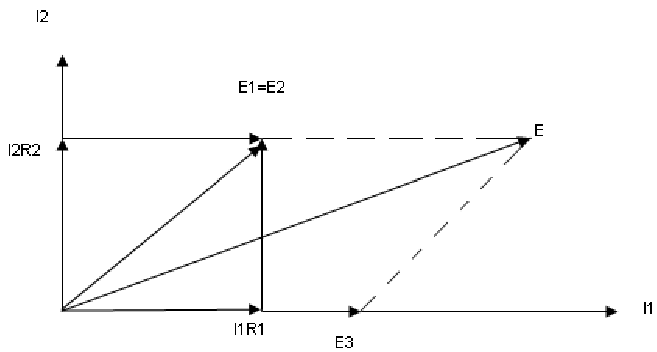
S. No.	Name of the apparatus	Quantity
1.	Transformer 230/15v	1 NOS
2.	Bread board	1 NOS
3.	Resistors	2 NOS
4.	Variable Resistor	1 NOS
5.	Inductors	1 NOS
6.	Capacitors	2 NOS
7.	Digital Multimeter	1 NOS

Theory: This bridge is used for measurement of an inductance in terms of capacitance.
Let L1 = unknown self-inductance of resistance R1, R3 = fixed non-inductive resistance, R2 = variable non-inductive resistance, C4 = fixed standard capacitor, C2 = variable standard capacitor.
At balance, $(R1+j\omega L1)(1/j\omega C4) = (R2 + 1/j\omega C2)\ R3$.
Separating the real and imaginary terms, we obtain: $L1 = R2R3C4$ and $R1 = R3C4/C2$.

Circuit Diagram:



Phasor Diagram:



Procedure:

1. Connect the circuit as shown in the figure.
2. Connect the unknown inductance in L1.
3. Select any value of R1, R4 and C3..
4. Connect the multimeter between ground and output of imbalance amplifier.
5. Vary R1 and R4, from minimum position, in clockwise direction.
6. If the bridge does not balance change the value of C3.
7. Calculate the inductance L1 by substituting known values.

Observation Table:

S.NO	R2	R4	C3	L1= R2C3R4	True value of L1

Result: Actual and practical values of Inductances are found to be nearly equal.

Experiment No. 7

Aim: Measurement of capacitance by Schering bridge

Apparatus Used:

S. No.	Name of the apparatus	Quantity
1.	Transformer 230/15v	1 NOS
2.	Bread board	1 NOS
3.	Resistors	2 NOS
4.	Variable Resistor	1 NOS
5.	Inductors	1 NOS
6.	Capacitors	3 NOS
7.	Digital Multimeter	1 NOS

Theory: Schering bridge is one of the most important of the a.c. bridge. It is extensively used in measurement of capacitance.

At balance, $\{r1+ 1/(j\omega C1)\}\ \{R4/(1+j\omega C4R4)\} = R3/(j\omega C2)$

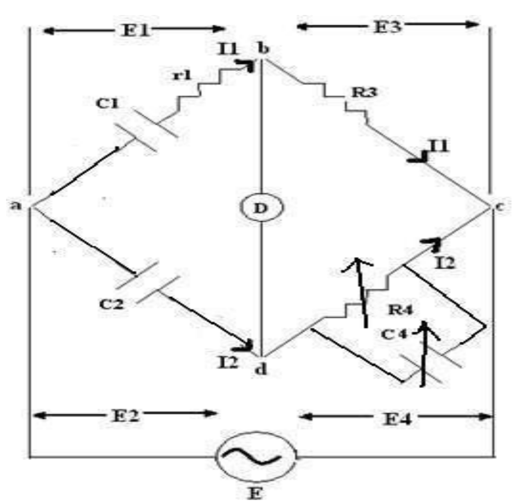
$\{r1+ 1/(j\omega C1)\}\ R4 = R3/(j\omega C2) * \{(1+j\omega C4R4)\}$

$r1R4 - \{(jR4)/(\omega C1)\} = \{ (-jR3)/(\omega C2)\} + \{(R3R4C4)/(C2)\}$

Equating real and imaginary terms,

$r1 = R3C4/C2$ and $C1 = C2R4/R3$

Circuit Diagram:



Procedure:

1. Connect the circuit as shown in the figure.
2. Select any value of C1.
3. Connect the multimeter between ground and output of imbalance amplifier.
4. Vary R4 and C4, from minimum position, in clockwise direction.
5. If the selection of C1 is correct the balance point can be obtained at minimum position.

64

6. If that is not the case, select another C1.

7. Calculate the Capacitance by substituting known values.

Observation Table:

S.NO	C4	C1	C2	R3	R4

Result: Hence the balanced condition of schering bridge is obtained and unknown value of capacitance is found.

Experiment No. 8

Aim: Measurement of low resistance by Kelvin's double bridge

Apparatus Used: Power Supply, Resistance Box, DPIC etc.

Theory: The kelvin double bridge incorporates the idea of a second set of ratio arms - hence the name double bridge- and the use of four terminal resistors for the low resistance arms. Fig.1. shows the schematic diagram of kelvin bridge. The first ratio arms is P and Q. The second set of ratio arms p and q is used to connect the galvanometer to a point d at the appropiate potential between points m and n to eliminate the effect of connecting lead resistance r between the unknown resistance R and the standard resistance S.

The ratio p/q is made equal to P/Q. Under balance conditions there is no current through the galvanometer which means that the voltage drop between a and b, E_{ab} is equal to voltage drops E_{amd} between a and c.

$$E_{ab} = \frac{P}{P+Q} E_{ac} \quad and \quad E_{ac} = I\left[R + S + \frac{(p+q)r}{p+q+r}\right]$$

$$and \quad E_{amd} = I[R + \frac{p}{p+q}\left\{\frac{(p+q)r}{p+q+r}\right\}] = I[R + \frac{pr}{p+q+r}]$$

for zero galvanometer deflection, $E_{ab}=E_{amd}$

$$\frac{PI}{P+Q}[R + S + \frac{(p+q)r}{p+q+r}] = I[R + \frac{pr}{p+q+r}]$$

$$or \; R = \frac{P}{Q}S + \frac{qr}{p+q+r}[\frac{P}{Q} - \frac{p}{q}] \; ------------(1)$$

now if $\frac{P}{Q} = \frac{p}{q}$ Eq (1) becomes, $R = \frac{P}{Q}S$ ---------(2)

Eq (2) is the usual working equation for the kelvin bridge. It indicates that the resistance of connecting lead, r, has no effect on the measurement, provided that the two sets of ratio arms have equal ratios.

Circuit Diagram:

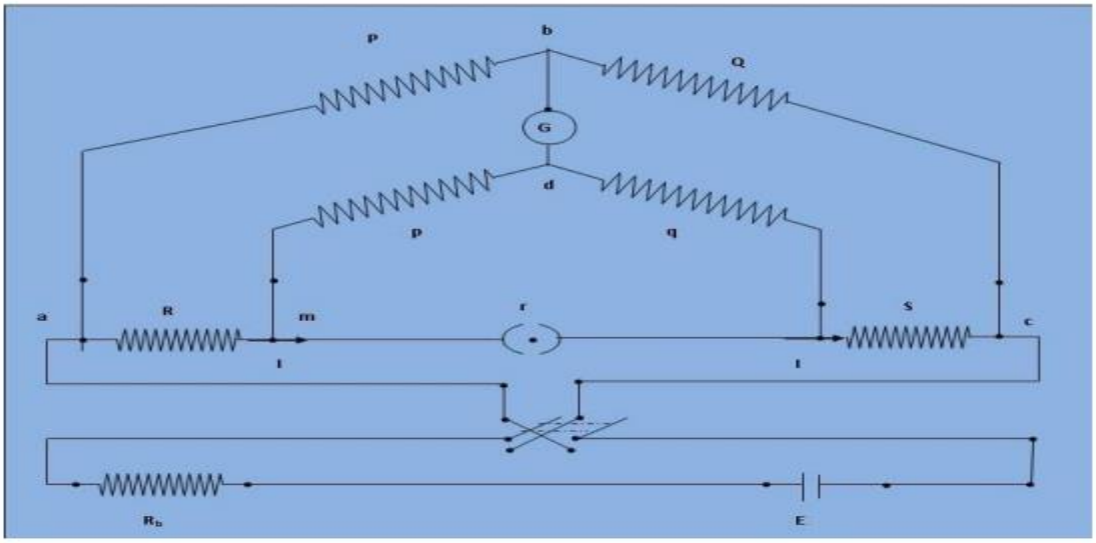


Fig. 1. The circuit diagram of Kelvin Double Bridge.

Procedure:

1. Connect the circuit as shown in the Fig. 1.
2. Set the value of the resistances A and a at by setting the plugs at the marked positions and the values of B, b at by setting the dial. Open the Key K. The bridge will act as a wheatstone bridge. A null deflection Galvanometer will ensure the relationship .
3. Close the key K. Adjust the rheostat to obtain 2A current in the circuit.
4. Keeping the resistances A, a at, very B, b to obtain the Galvanometer null.Note the value B, b at balance position from the dial.
5. Reverse the direction of current by operating the two-way switch 's' and obtain the balance.
6. Set the values of A, a at 1 and position and repeat step 5 and step 4.
7. Repeat step 5 through step 6 for different line currents 3A, 4A and 5A.

Result: We have performed the Kelvin's double bridge and measured precision of four-terminal low resistances.

Experiment No. 9

Aim: Measurement of voltage, current and resistance using dc potentiometer

Apparatus Used:

S. No.	Apparatus Name	Quantity
1	Adjustable DC Power Supply	1
2	Digital Multimeter	1
3	10 kΩ potentiometer	1
4	100 kΩ potentiometer	1

Theory: A potentiometer is a three terminal resistive device. The outer terminals present a constant resistance which is the nominal value of the device. A third terminal, called the wiper arm, is in essence a contact point that can be moved along the resistance. Thus, the resistance seen from one outer terminal to the wiper plus the resistance from the wiper to the other outer terminal will always equal the nominal resistance of the device. This three terminal configurationis used typically to adjust voltage via the voltage divider rule, hence the name potentiometer, or *pot* for short. While the resistance change is often linear with rotation (i.e., rotating the shaft 50% yields 50% resistance), other schemes, called *tapers*, are also found. One common non-linear taper is the logarithmic taper. It is important to note that linearity can be compromised (sometimes on purpose) if the resistance loading the potentiometer is not significantly larger in value than the potentiometer itself.

If only a single outer terminal and the wiper are used, the device is merely an adjustable resistor and is referred to as a rheostat. These may be placed in-line with a load to control the load current, the greater the resistance, the smaller the current.

Circuit Diagram:

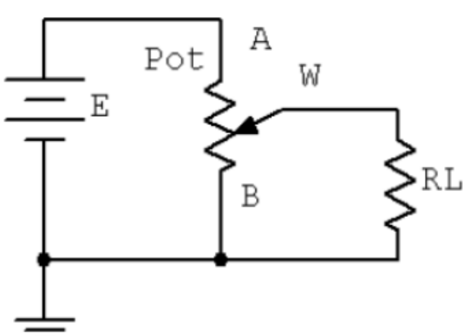


Figure 1

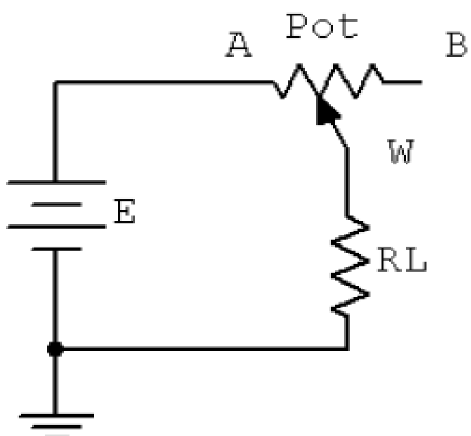


Figure 2

Procedure:

1. Using a 10 k pot, first rotate the knob fully counter-clockwise and using the DMM, measure the resistance from terminal A to the wiper arm, W. Then measure the value from the wiper arm to terminal B. Record these values in Table 1. Add the two readings, placing the result in the final column.
2. Rotate the knob 1/4 turn clockwise and repeat the measurements of step 1. Repeat this process for the remaining knob positions in Table 1. Note that the results of the final column should all equal the nominal value of the potentiometer.
3. Construct the circuit of Figure 2 using E = 10 volts, a 10 k potentiometer and leave RL open. Rotate the knob fully counter-clockwise and measure the voltage from the wiper to ground. Record this value in Table 2. Continue taking and recording voltages as the knob is rotated to theother four positions in Table 2.
4. Set RL to 47 k and repeat step 3.
5. Set RL to 4.7 k and repeat step 3.
6. Set RL to 1 k and repeat step 3.
7. Using a linear grid, plot the voltages of Table 2 versus position. Note that there will be four curves created, one for each load, but place them on a single graph. Note how the variance of the load affects the linearity and control of the voltage.
8. Construct the circuit of Figure 3 using E = 10 volts, a 100 k potentiometer and RL = 1 k. Rotate the knob fully counter-clockwise and measure the current through the load. Record this value in Table 3. Repeat this process for the remaining knob positions in Table 3.
9. Replace the load resistor with a 4.7 k and repeat step 8.

Observation Table:

Table 1

Position	RAW	RWB	RAW + RWB
Fully CCW			
1/4			
1/2			
3/4			

Table 2

Position	VWB Open	VWB 47k	VWB 4.7k	VWB 1k
Fully CCW				
1/4				
1/2				
3/4				
Fully CW				

Table 3

Fully CCW	Fully CCW	Fully CCW
Fully CCW		
1/4		
1/2		
3/4		
Fully CW		

Result: We have measured the value of voltage, current and resistance using dc potentiometer.

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Please spare some time to provide your valuable feedback.