

SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF MEDICAL ELECTRONICS

LABORATORY MANUAL



MD3361 – Sensors and Measurements Laboratory

Regulation –2023

III Semester

B.E. Medical Electronics

Academic Year 2025 – 26 (Odd Semester)

Prepared by

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SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF MEDICAL ELECTRONICS

VISION OF THE INSTITUTE

- Educate to excel in social transformation

MISSION OF THE INSTITUTE

- To contribute to the development of human resources in the form of professional engineers and managers of international excellence and competence with high motivation and dynamism, who besides serving as ideal citizen of our country will contribute substantially to the economic development and advancement in their chosen areas of specialization.
- To build the institution with international repute in education in several areas at several levels with specific emphasis to promote higher education and research through strong institute-industry interaction and consultancy.

VISION OF THE DEPARTMENT

- To provide quality education for improving the healthcare and well-being of human kind.

MISSION OF THE DEPARTMENT

- **M1:** To inculcate students with fundamental knowledge, interdisciplinary problem-solving skills and confidence required to excel in Medical Electronics
- **M2:** To up skill the students with the current technological trends and carryout quality research to meet the expectation of healthcare service sectors.
- **M3:** To instil creativity, responsibility, commitment and leadership qualities with professional ethics and moral values.

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DEPARTMENT OF MEDICAL ELECTRONICS

PROGRAM OUTCOMES

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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.
4. **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.
5. **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.
6. **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.
7. **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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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.
12. **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

By the completion of Medical Electronics program, the student will have following Program specific outcomes

1. Ability to apply the knowledge of engineering in solving the healthcare problems.
2. Ability to propose indigenous clinical solution through the application of their domain areas and emerging ICTs

SYLLABUS

MD3361

SENSORS AND MEASUREMENTS LABORATORY

L T P C
4 0 2 4

COURSE OBJECTIVES:

- To study the purpose, methods, errors associated with the measurements.
- To learn the principle of transduction, classifications and the characteristics of different transducers
- To understand the knowledge of the different bridges used for the measurements.
- To identify the concepts of display and recording devices.
- To explore the types of biosensors.

LIST OF EXPERIMENTS:

1. Characteristics of thermistor and thermocouple
2. Characteristics of LDR, Photo Diode and Photo transistor
3. Characteristics of RTD and LVDT
4. Measurement of unknown Resistance using Kelvin Double Bridge and Wheatstone bridge.
5. Measurement of unknown Capacitance using Schering Bridge
6. Measurement of unknown Inductance using Maxwell's & Hay's Bridge
7. Characteristics of strain gauge.
8. Demonstration of CRO
9. Characteristic of A/D and D/A converter

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On completion of the course, student will be able to

CO1: Measure various electrical parameters with accuracy, precision, resolution.

CO2: Understand the basic principles of sensors and transducers.

CO3: Select appropriate light sensors for measurement of physical phenomenon

CO4: Use AC and DC bridges for relevant parameter measurement.

CO5: Employ multimeter, CRO and different types of recorders for appropriate measurement.

CONTENTS

S. No	NAME OF THE EXPERIMENT
1	Characteristics of thermistor and thermocouple
2	Characteristics of LDR, Photo Diode and Photo transistor
3	Characteristics of RTD and LVDT
4	Measurement of unknown Resistance using Kelvin Double Bridge and Wheatstone bridge.
5	Measurement of unknown Capacitance using Schering Bridge
6	Measurement of unknown Inductance using Anderson Bridge
7	Characteristics of strain gauge.
8	Demonstration of CRO
9	Characteristics of A/D and D/A converter

LIST OF EXPERIMENTS

Exp. No.	Name of the Experiment
	CYCLE-I
1	Characteristics of thermistor and thermocouple
2	Characteristics of LDR, Photo Diode and Photo transistor
3	Characteristics of RTD and LVDT
4	Measurement of unknown Resistance using Kelvin Double Bridge and Wheatstone bridge.
5	Measurement of unknown Capacitance using Schering Bridge
	CYCLE-II
6	Measurement of unknown Inductance using Anderson Bridge
7	Characteristics of strain gauge.
8	Demonstration of CRO
9	Characteristics of A/D and D/A converter
	ADDITIONAL EXPERIMENTS
10	Calibration of a) Ammeter. b) Voltmeter. (experiment beyond syllabus)

Exp No.:1(a)

CHARACTERISTICS OF THERMISTOR

Date:

Aim:

To determine the characteristics of thermistor.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Thermistors	---	1
2.	Digital Multimeter	---	1
3.	Thermometer	Max. 100 °C	1
4.	Water Bath	---	1

Pre-Lab Exercise:

1. What is thermistor?
2. Name the different temperature transducers.
3. Give naming convention of thermistor.
4. What are the materials used for constructing thermistor?
5. What is meant by temperature coefficient of resistance?

Theory:

Thermistors are semiconductors with high negative temperature coefficient of resistance. The high sensitivity of the thermistor makes it useful for precision temperature measurement. Oxides of titanium and nickel are among the materials used. They are very sensitive with temperature coefficients that range from -2 to -6Ω /°C. They are capable of detecting minute changes in temperature. Their resistance at 25°C ranges from 100Ω to 100KΩ with 5000Ω being a very common value. Their linearity is the poorest of those of all temperature sensors. The usual range of thermistors is from -200°C to 1000°C. A single thermistor cannot be used over such a large range.

For Thermistor

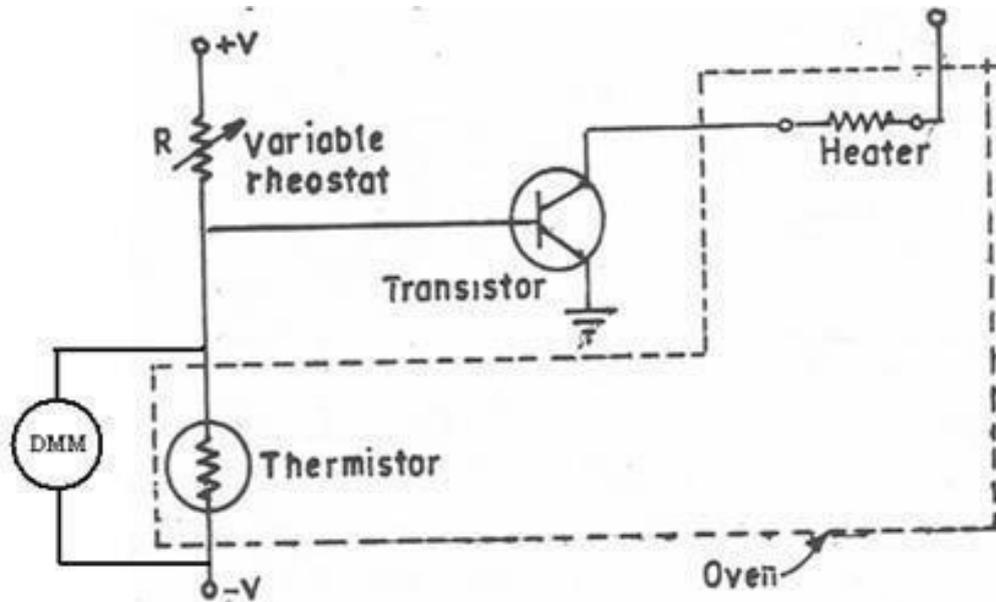
$$R_T = R_0 e^{\beta [(1 / T) - (1 / T_0)]}$$

R_T - Resistance of thermistor at T deg K

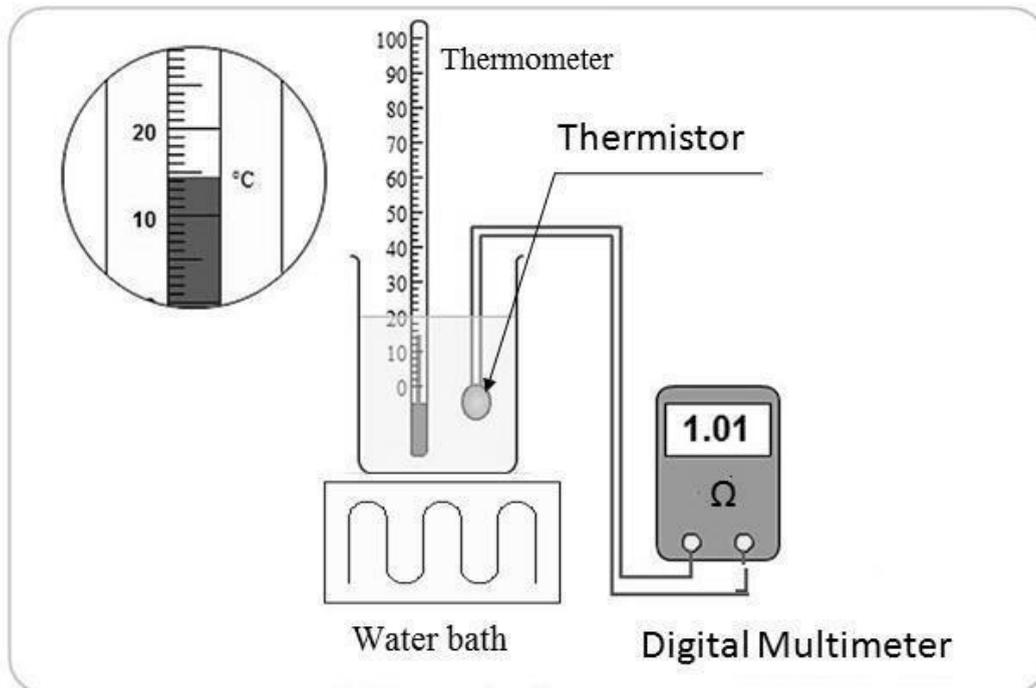
R_0 - Resistance at room temperature

β - Thermistor constant

Circuit Diagram:



Experiment setup:



Procedure:

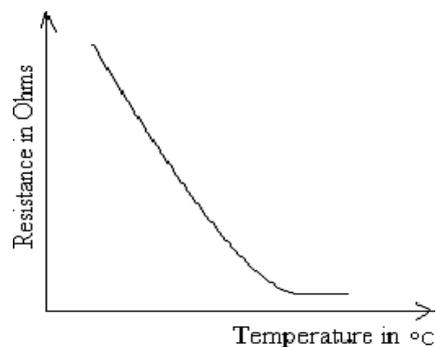
1. Immerse the thermistor & thermometer into the waterbath.
2. Connect the leads from the thermistor to the multimeter.
3. Switch ON the waterbath.
4. Measure the temperature using the thermometer of water and the corresponding resistance of thermistor using multimeter.
5. For every 5 °C rise, the reading on the thermistor and thermometer are noted until the temperature reaches the max. temperature(100°C).

Graph: Plot the graph between Temperature (X-axis) and Output Resistance (Y-axis).

Tabular Column:

S.No.	Temperature (°C)	Output Resistance (kΩ)

Model graph:



Post-Lab Exercise:

1. What is the temperature range of thermistor?
2. Is temperature coefficient of resistance is positive or negative for thermistor? Justify your answer.
3. What is the difference between RTD and thermistor?
4. What about resolution and sensitivity of thermistor?
5. What are the advantages of thermistor over other temperature transducers?
6. What are the applications of thermistor?

Result:

Thus the characteristics of thermistor is determined and the graph is plotted.

Exp No.:1(b)

CHARACTERISTICS OF THERMOCOUPLE

Date:

Aim:

To study the characteristics of Thermocouple.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Thermocouple	---	1
2.	Digital Multimeter	---	1
3.	Thermometer	Max. 100°C	1
4.	WaterBath	---	1

Pre-Lab Exercise:

1. State the principle employed in thermocouple.
2. Is thermocouple is active or passive transducer? Justify your answer.
3. What are the materials used for fabricating thermocouple?
4. What are the different types of thermocouples?
5. What is the function of signal conditioning circuit?

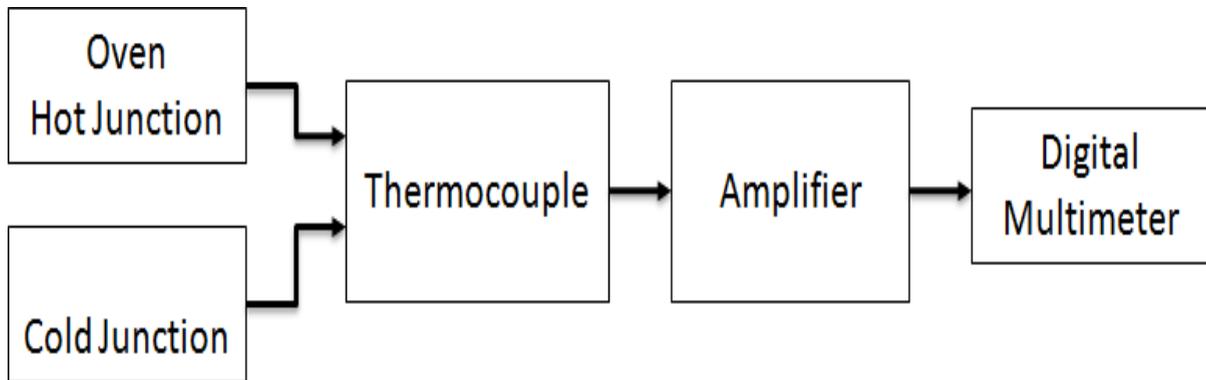
Theory:

Thermocouple is a temperature transducer based on seebeck effect. It is the most common and widely used single device for temperature measurement in industrial applications. Its measurements cover the temperature range of 0°F to 4000°F. Thermocouple is a self-generating transducer and it has a pair of dissimilar metallic conductors. If this dissimilar metallic conductor are connected in a circuit with one junction at T_1 and the other at T_2 , an emf is developed due to difference in temperature. The relation between E, T_1 and T_2 is called the Seebeck effect. Commonly used materials in the thermocouple are Platinum, Rhodium, Chromel, Alumel, Copper–Constantan and Iron–Constantan. The range of chromel•constantan is 700 to 1200°C.

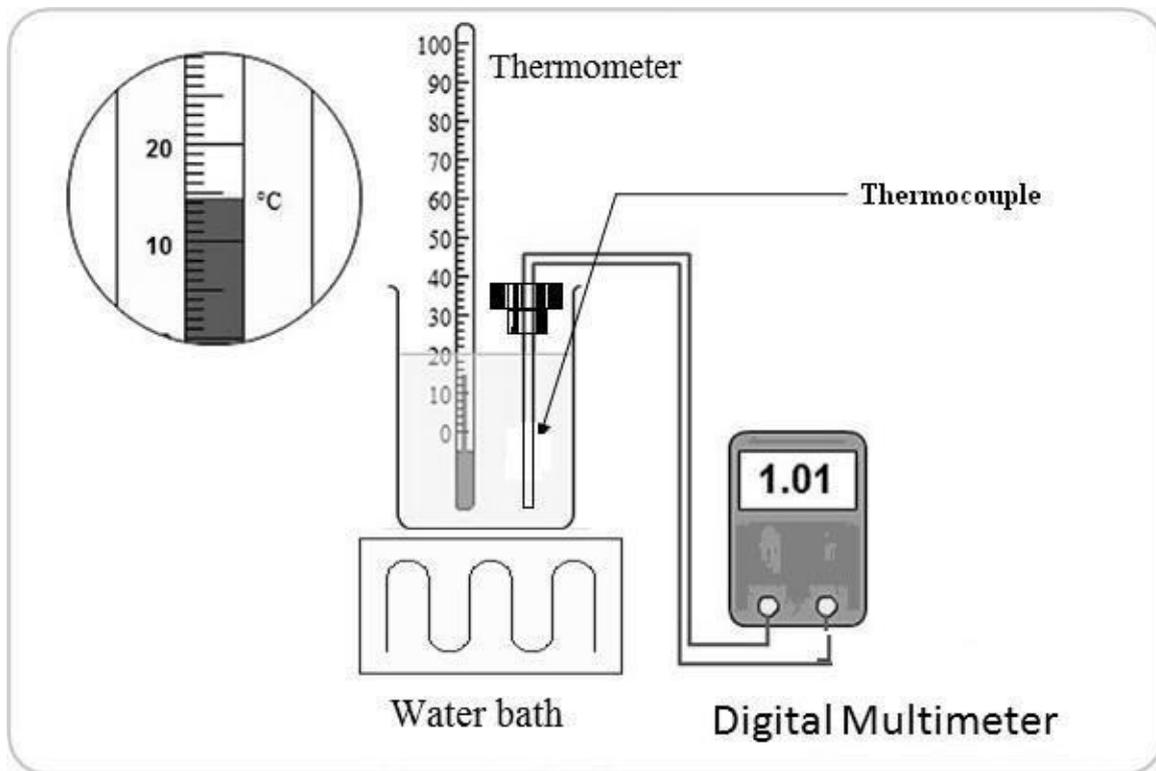
The cold junction of thermocouple is taken as the reference junction and its temperature is kept constant. The hot junction is kept at the place where temperature is to be measured. In lab, it is possible to keep the temperature of cold junction constant but in industries it is not possible. So the variation in thermos emf of thermocouple due to variation in cold junction temperature is to be compensated for exact temperature measurement. Here the compensation is made using Wheatstone bridge in which RTD is placed at one of its arms. Thermocouple output is connected to the non-inverting terminal of operational amplifier. The gain of the amplifier is set to be 10. The bridge excitation comes from a separate D.C. Supply. Finally about 50mV of excitation is made available to the bridge. As the ambient temperature goes changing, the RTD's resistance also changes and small output voltage is developed across the bridge. The bridge output is fed to the inverting input of the amplifier. With higher ambient temperature thermocouple transducer tends to produce lower output voltage.

The RTD bridge circuit automatically takes care of this tendency of the thermocouple by applying a small voltage of proper polarity to the inverting terminal of the amplifier. That is how cold junction compensation is achieved. Condenser connected across the terminals of IC suppresses any unwanted disturbances coming to amplifier. The output of operational amplifier is connected to a pot (MAX.) on the panel and is useful for carrying out the calibration operation. Offset Null Pot is useful for zero adjustment.

Block Diagram:



Experiment Setup:



Procedure:

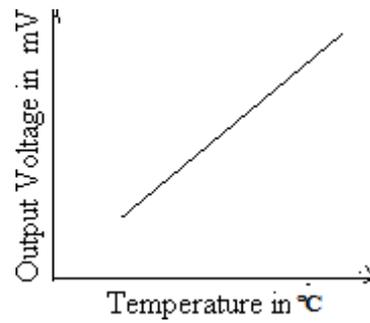
1. Immerse the thermocouple & thermometer into the waterbath.
2. Connect the leads from the thermocouple to the respective meter.
3. Switch ON the waterbath.
4. Measure the temperature of water using thermometer and the corresponding output voltage of thermocouple using multimeter.
5. For every 5°C rise, the reading of the thermocouple are noted until the temp reaches the maximum temperature (100 °C). Tabulate the readings.

Graph: Plot the graph between temperature (X-axis) and thermocouple Output voltage (Y-axis).

Tabular column:

S. No.	Thermometer Reading (°C)	Thermocouple Output voltage (mV)

Model Graph:



Post-Lab Exercise:

1. What is the temperature range of thermocouple?
2. Thermocouple is suitable for _____ range of temperature measurement.
3. Why cold junction compensation is needed?
4. Why signal conditioning circuit is needed at the output of thermocouple?
5. State the industrial applications of Thermocouples.
6. What are the advantages and disadvantages of thermocouple?
7. Compare the performance of thermistor with thermocouple.

Result:

Thus the characteristics of thermocouple is studied and its characteristic curve is plotted.

Date:

Aim:

To study the characteristics of Light Dependent Resistor (LDR).

Apparatus Required:

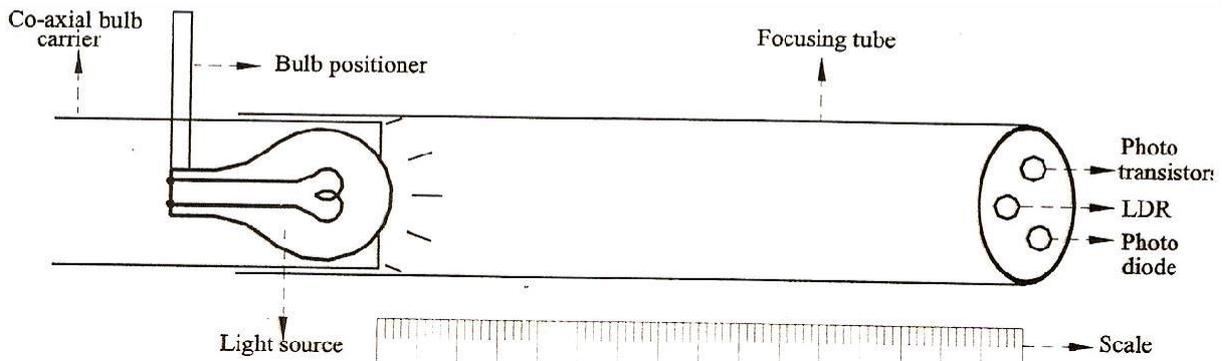
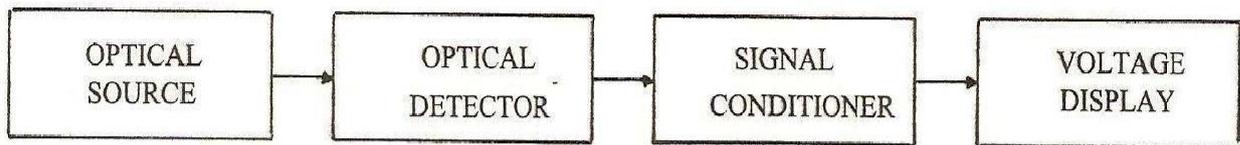
S. No.	Components / Equipments	Specification	Quantity
1.	LDR Trainer Kit	---	1
2.	Digital Multimeter	---	1

Theory:

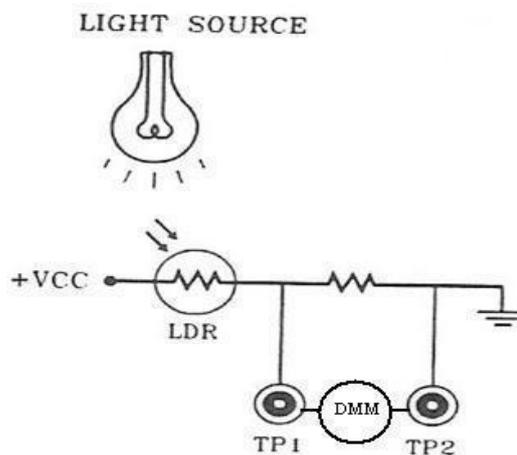
LDR is a photosensitive material whose resistance changes when light falls on it. The resistance of LDR is linearly proportional to the light intensity on it. It is made of non-reflective material usually a semiconductor. If radiation falls upon a semiconductor its conductivity increases. The radiant energy supplied to the semiconductor. This increases the number of current carriers. These increased current carriers decrease the resistance of the material and hence this device is called a LDR or Photoresistor. Due to this property LDR is used in many applications. Cadmium sulphide cell, Lead sulphide cell and selenium cells are used for the manufacturing of LDR. But cadmium sulphide due to their high dissipation capacity and their excellent sensitivity are mostly preferred.

Block Diagram:

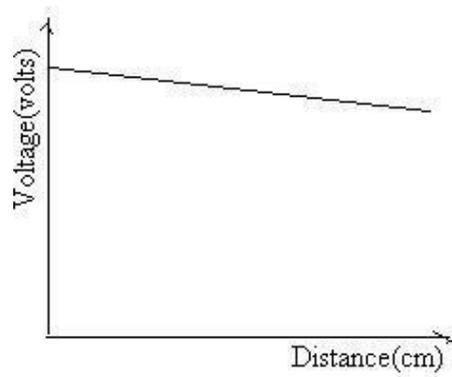
GENERAL BLOCK DIAGRAM OF OPTICAL TRANSDUCER



Circuit Diagram:



Model Graph



Result:

Thus the characteristic of LDR were obtained.

Post Lab Questions:

1. Name some resistive transducers.
2. What is the principle of LDR?
3. What are the applications of LDR?
4. State the advantages of LDR.
5. State the disadvantages of LDR

Exp No.:2(b)

CHARACTERISTICS OF PHOTODIODE

Date:

Aim:

To determine the characteristics of photodiode.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Ammeter	(0-25) mA	1
2.	Voltmeter	(0-30) V	1
3.	Power Supply	(0-30)V	1
4.	Light source	Few Watts	1
5.	Resistors	1K Ω	1
6.	Photodiode	IPL 34C	1
7.	Bread Board	---	1
8.	Connecting wires	---	Few

Pre-Lab Exercise:

1. What is the difference between ordinary diode and photodiode?
2. Why it is called as photodiode?
3. State the principle of "Photo conductive effect".
4. What are the materials used for fabricating photo diode?

Theory:

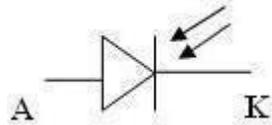
Both Photo diode and Photo transistor operates based on the principle of "Photo conductive effect". When radiation is incident on a semiconductor, it absorbs some light, as a result its conductivity varies directly with the intensity of light and its resistances varies inversely with the intensity of light. This effect is called as Photo conductive effect.

Photo diode:

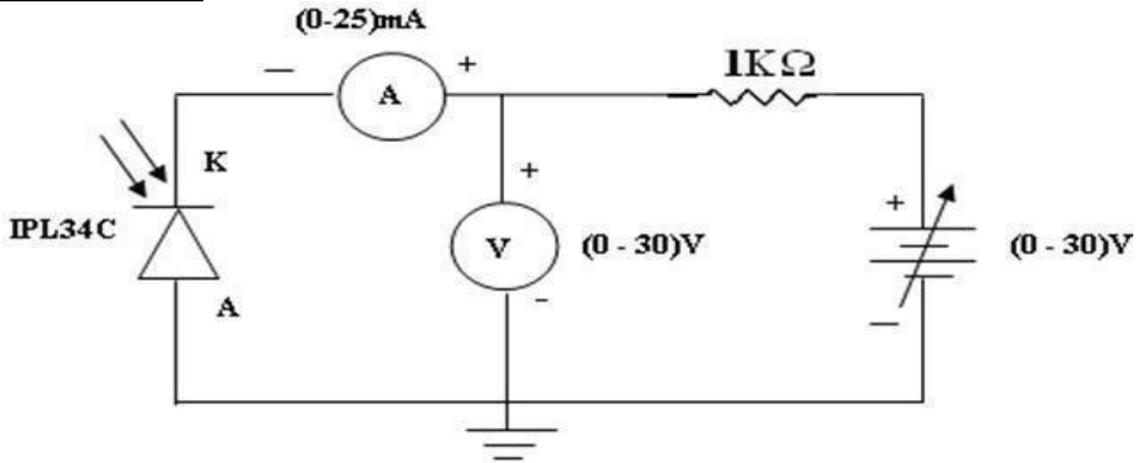
It is a semiconductor PN-junction device whose region of operation is limited to the reverse biased region. Photo diode is connected in reverse biased condition .The depletion region width is large under normal condition, it carries small reverse current due to the minority charge carriers in μA . If the Photo diode is forward biased, the current flowing through it is in mA. The applied forward biased voltage takes the control of the current instead of the light. The change in current due to light is negligible and cannot be noticed. The resistances of forward biased diode are not affected by the light. Hence to have significant effect of light on the current and to operate photo diode as a variable resistor, it is always operated (or) connected in reverse bias. When there is no light, it is called as dark current because there is no current flow due to infinite resistance. When there is a light, more current flows due to very less resistance. Under reverse bias current control due to light only instead of applied voltage.

Photodiode is used in cameras, medical devices, safety equipment, optical communication devices, position sensors, bar code scanners, automotive devices and surveying instruments

Symbol of Photodiode:



Circuit Diagram:



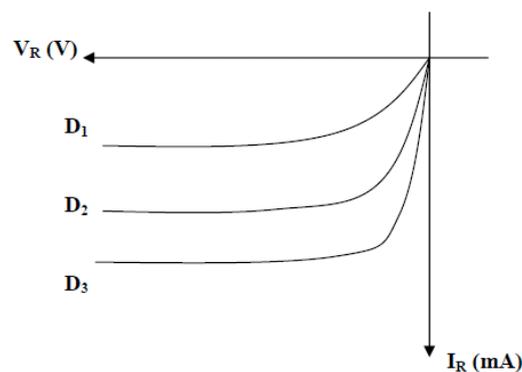
Procedure:

1. Connections are given as per the circuit diagram.
2. Place the photo diode at a particular distance from the illumination.
3. Voltage is varied using R.P.S insteps of 1V and corresponding current is noted.
4. Readings are tabulated for various distances and the graph is drawn between voltage and current

Tabular Column:

$D_1 =$ (cm)		$D_2 =$ (cm)	
V_R (V)	I_R (mA)	V_R (V)	I_R (mA)

Model Graph:



Post-Lab Exercise:

1. How photodiode works?
2. What is the function of the photodiode?
3. Why the Photo diode is always operated in reverse bias?
4. Define dark current in photodiode.
5. State the applications of photodiode.

Result:

Thus the characteristics of photodiode is determined and the graph is plotted for various distances of light source.

Exp No.:2(c)

CHARACTERISTICS OF PHOTO TRANSISTOR

Date:

Aim:

To determine the characteristics of photo transistor.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Ammeter	(0-50) mA	1
2.	Voltmeter	(0-30) V	1
3.	Power Supply	(0-30)V	1
4.	Light source	Few Watts	1
5.	Resistors	1K Ω	1
6.	Photo transistor	L14G3	1
7.	Bread Board	---	1
8.	Connecting wires	---	Few

Pre-Lab Exercise:

1. State the principle of "Photo conductiveeffect".
2. What is the difference between photodiode andphototransistor?
3. What is the difference between ordinary transistor and phototransistor?
4. Why it is called as photo transistor?
5. What are the materials used for fabricatingphototransistor?

Theory:

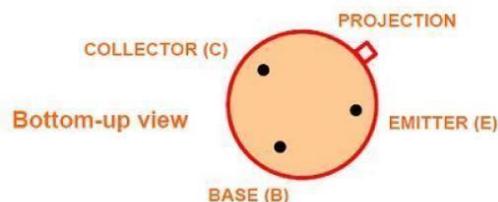
Both Photo diode and Photo transistor operates based on the principle of" **Photo conductive effect**". When radiation is incident on a semiconductor, it absorbs some light, as a result its conductivity varies directly with the intensity of light and its resistances varies inversely with the intensity of light. This effect is called as **Photo conductiveeffect**.

The photo transistor has a light sensitive collector to base junction .A lens is used in transistor package to expose to an incident ligh. When no light is incident, a small leakage current flow from collector to emitter called *ICEO* , due to small thermal generation .This is very small current, of the order of nA this is called a dark current.

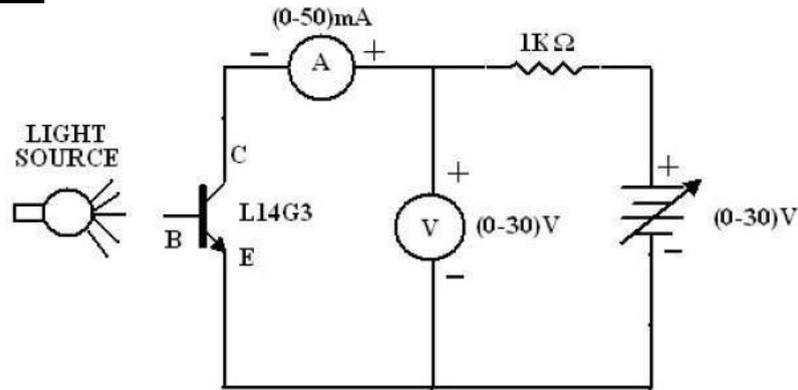
When the base is exposed to the light, the base current is produced which is proportional to the light intensity. As light intensity increases, the base current increases exponentially. Similarly the collector current also increases corresponding to the increase in the light intensity.

Photo transistor can be both a two lead (and) three lead devices. For two lead devices, the base is not electrically available and the device use is totally light dependent

Photo transistor Terminal Convention:



Circuit Diagram:



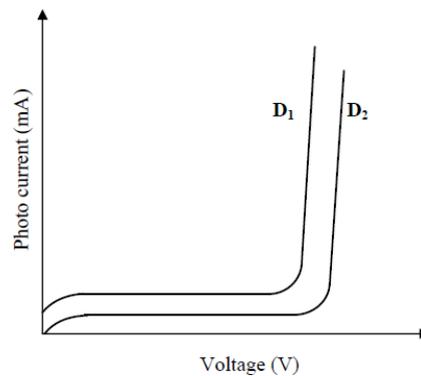
Procedure:

1. Connections are given as per the circuit diagram.
2. Phototransistor is placed at a particular distance from the illumination.
3. Voltage is varied using RPS in steps of 1 volts and corresponding current is noted.
4. Readings are tabulated for various distances and the graph is drawn between voltage and current

Tabular Column:

S.No.	Voltage (V)	Photo Current (mA)	
		D ₁ = (cm)	D ₂ = (cm)

Model Graph:



Post-Lab Exercise:

1. What is the difference between photodiode and photo transistor?
2. How many terminals are there in photo transistor?
3. How photo transistor works?
4. How photo transistor is fabricated?
5. State the applications of phototransistor.

Result:

Thus the characteristics of photo transistor is determined and the graph is plotted for various distances.

ExpNo.:3(a)
Date:

CHARACTERISTICS OF RTD

Aim:

To Analyse characteristics of Resistance Temperature Detector (RTD).

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	RTD	PT100	1
2.	Digital Multimeter	---	1
3.	Thermometer	Max. 100 C	1
4.	WaterBath	---	1
5.	Stop Clock	---	1

Pre-Lab Exercise:

1. Expand RTD
2. What is the principle of RTD?
3. What are the requirements of a conductor to be used in RTD?
4. RTD has _____ temperature coefficient.
5. What are the materials used for constructing RTD?
6. RTD is suitable for _____ temperature measurement application.

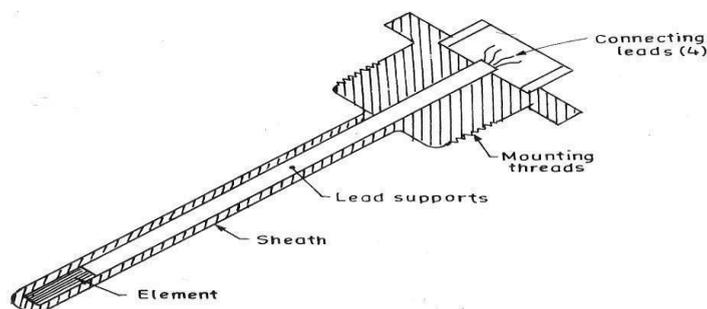
Theory:

The principle of operation of RTD is based on the fact that electrical resistance of many metals increases almost directly to the temperature and gives high degree of accuracy. These characteristics are well known as Co-efficient of resistance and is defined by the approximate formula $R_t = R_o (1 + \alpha t)$

Where, α - Temperature Co-efficient of resistance and R_o - Resistance of wire at 0°C.

RTD is connected to one of the arms of a bridge circuit. The other two arms are connected by constant resistance. An adjustment and a fixed resistance are attached to the adjacent arm of the bridge. When the RTD is at 0°C the helical potentiometer is set to 0 position by adjusting the MIN control on the panel. The bridge output is given to the meter which also initially indicates zero. The resistance of the RTD changes due to the temperature change. The resistance of the adjacent arm is changed by the introduction of corresponding amount of known resistance until balance is achieved. The change in the resistance of RTD can be measured by noting the revolution of the helical pot.

Generalized Diagram:

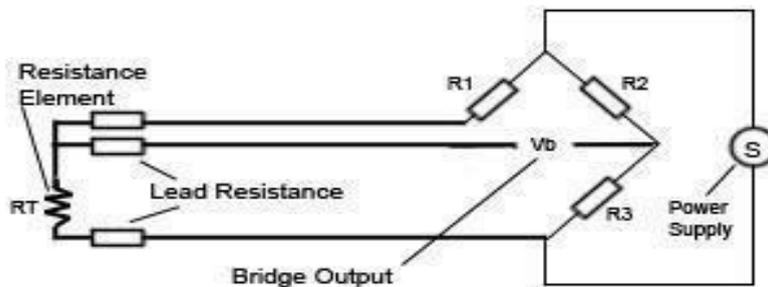


3- Wire RTD configuration:

In order to minimize the effects of the lead resistances, a three-wire configuration can be used. Using this method the two leads to the sensor are on adjoining arms. There is a lead resistance in each arm of the bridge so that the resistance is cancelled out, so long as the two lead resistances are accurately the same.

In a three-wire circuit two constant current sources are used, in order to compensate for the disadvantages described above for the two-wire circuits. Similar to the two-wire circuit the current source IK_2 is used to measure the temperature dependent resistance R_T including the lead and terminal contact resistances. The additional current source IK_1 together with a third lead is used to separately compensate the lead and terminal contact resistances. Assuming the exact same lead and terminal contact resistances for all three leads, the effect on the accuracy of the temperature measurements can be eliminated. But practice has shown that it is not always possible to assure that the terminal contact resistances are always identical.

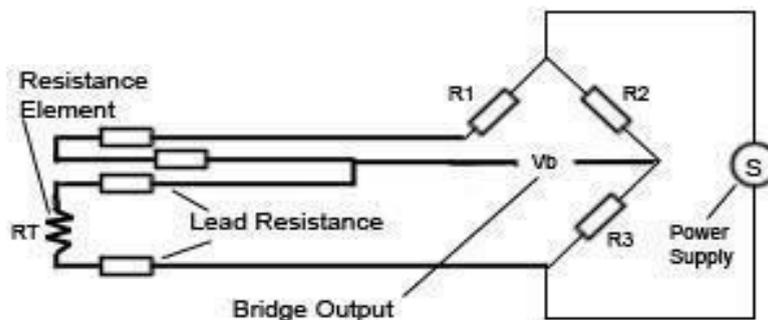
3-Wire RTD Sensor using Bridge Circuit:



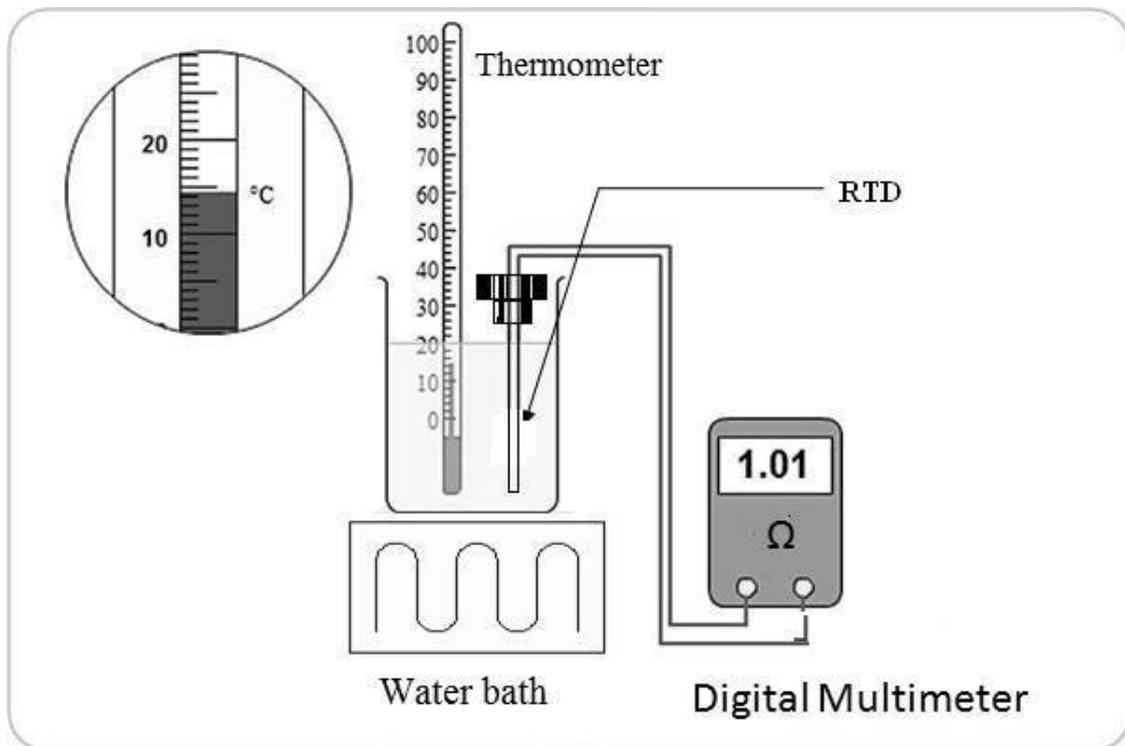
4- Wire RTD Configuration:

The four-wire resistance thermometer configuration increases the accuracy and reliability of the resistance being measured: the resistance error due to lead wire resistance is zero. In the diagram above a standard two-terminal RTD is used with another pair of wires to form an additional loop that cancels out the lead resistance. The above wheatstone bridge method uses a little more copper wire and is not a perfect solution. Below is a better configuration, four wire kelvin connection. It provides full cancellation of spurious effects; cable resistance of up to 15Ω can be handled. With the 4-wire configuration, the instrument will pass a constant current (I) through the outer leads, 1 and 4. The voltage drop is measured across the inner leads, 2 and 3. So from $V = IR$ we learn the resistance of the element alone, with no effect from the lead wire resistance. This offers an advantage over 3-wire configurations only if dissimilar lead wires are used, and this is rarely the case.

4- Wire RTD sensor using Bridge Circuit:



Experiment setup:



Procedure:

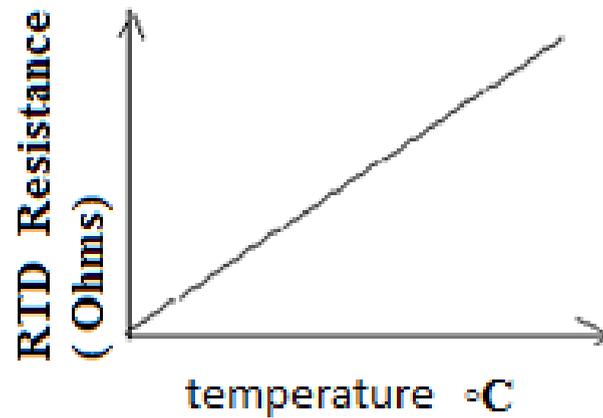
1. Connect the leads from the RTD to the respective meter.
2. The water bath heater is switched ON.
3. Immerse the RTD in water bath .when the water temperature rises note the resistance of RTD for the corresponding temperature
4. Start the stop clock and tabulate the resistance of RTD for every 5seconds.

Graph: Draw the graph between temperature (X – axis) and RTD resistance in ohms(Y – axis).

Tabular Column:

S.No.	Temperature °C	RTD Resistance (Ohms)

Model Graph:



Post-Lab Exercise:

1. What is meant by Pt-100?
2. RTD has _____ temperature coefficient.
3. What are the limitations of RTD?
4. What are the advantages of RTD over thermocouple?
5. How error due to lead resistance is corrected in RTD?
6. What are advantages of four wire RTD over three wire RTD?
7. State the industrial applications of RTD.
8. Compare the performance of thermistor, thermocouple and RTD.

Result:

Thus the characteristics of RTD is analyzed and its characteristic curve is drawn.

Exp No.:3 (b)

CHARACTERISTICS OF LVDT

Date:

Aim:

To study the operation and characteristics of Linear Variable Differential Transformer (LVDT) and to perform displacement measurement from it.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	LVDT Trainer Kit	---	1
2.	Digital Multimeter	---	1

Pre-Lab Exercise:

1. Expand LVDT.
2. What are primary and secondary transducers?
3. Give example for primary and secondary transducer.
4. Is LVDT is _____ (Resistive / Capacitive/ Inductive) transducer.
5. Explain working principle of LVDT.

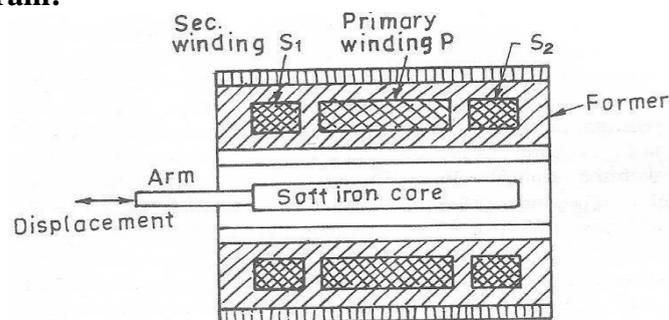
Theory:

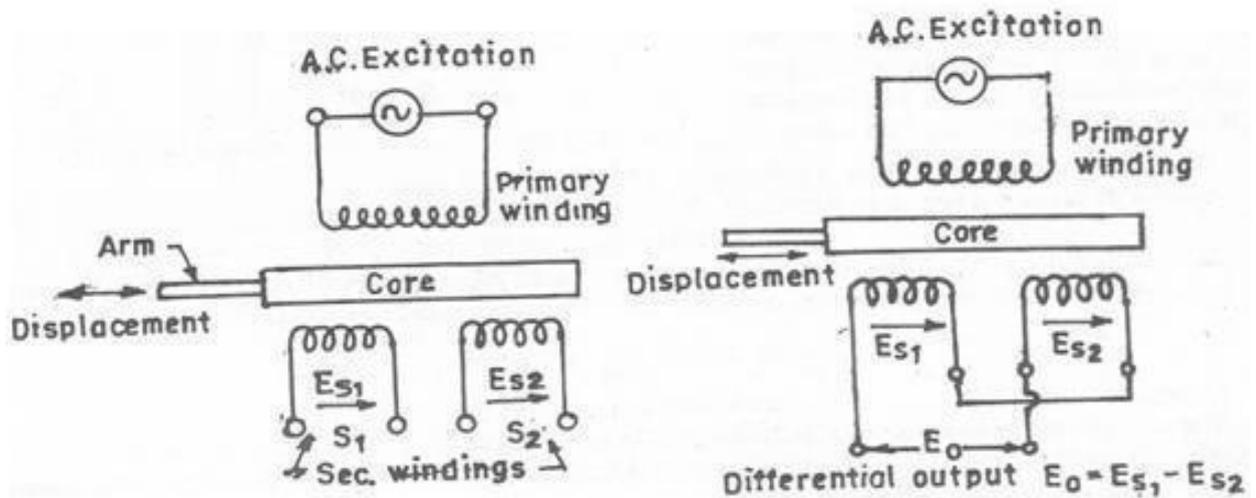
LVDT is the most commonly and extensively used transducer, for linear displacement measurement. The LVDT consists of three symmetrical spaced coils wound onto an insulated bobbin. A magnetic core, which moves through the bobbin without contact, provides a path for the magnetic flux linkage between the coils. The position of the magnetic core controls the mutual inductance between the primary coil and with the two outside or secondary coils. When an AC excitation is applied to the primary coil, the voltage is induced in secondary coils that are wired in a series opposing circuit. When the core is centered between two secondary coils, the voltage induced in the secondary coils are equal, but out of phase by 180° . The voltage in the two coils cancels and the output voltage will be zero.

Circuit Operation:

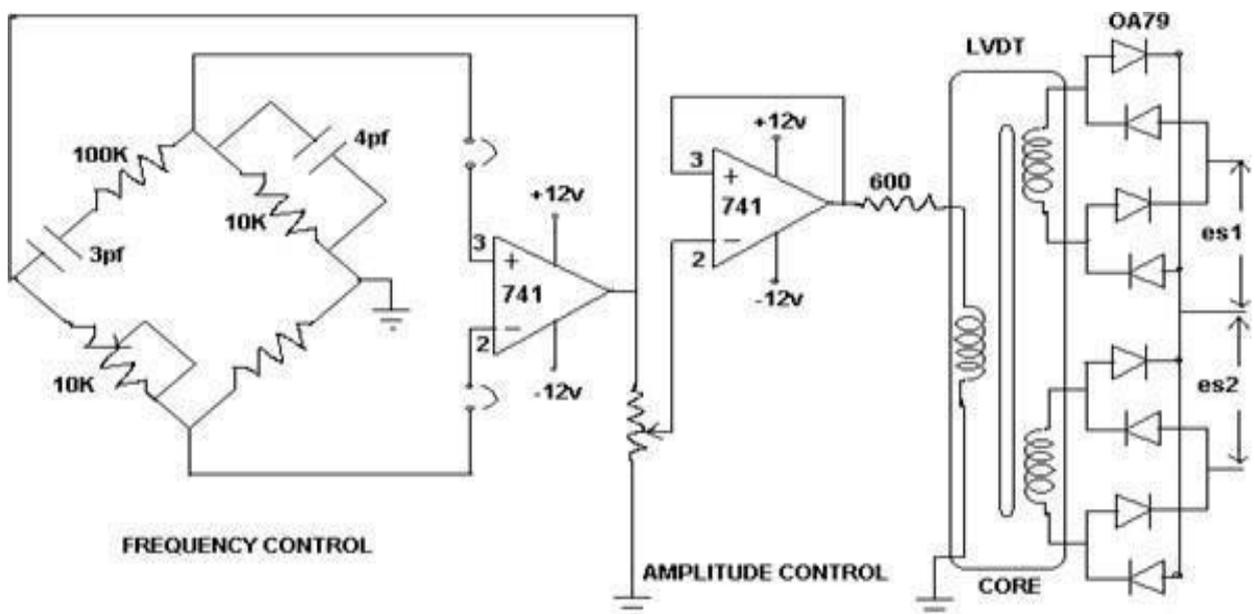
The primary is supplied with an alternating voltage of amplitude between 5V to 25V with a frequency of 50 cycles per sec to 20 K cycles per sec. The two secondary coils are identical & for a centrally placed core the induced voltage in the secondary's E_{s1} & E_{s2} are equal. The secondary's are connected in phase opposition. Initially the net o/p is zero. When the displacement is zero the core is centrally located. The output is linear with displacement over a wide range but undergoes a phase shift of 180° . It occurs when the core passes through the zero displacement position.

Generalized Diagram:





Trainer kit Diagram:



Procedure:

1. Connect the multimeter at the output terminal of the LVDT kit.
2. Switch ON the LVDT kit.
3. Move the core to different positions using screw gauge and measure the secondary voltages E_{s1} & E_{s2}
4. Tabulate the readings & calculate the output voltage (E_0).

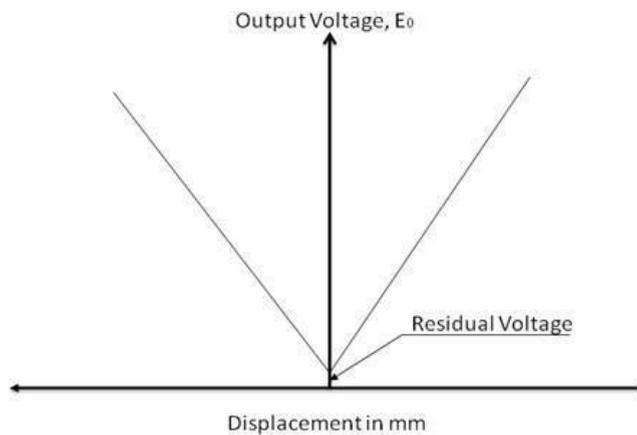
Graph: Plot the graph between core displacement (X-axis) and Output Voltage (Y-axis).

Tabular column:

Screw Guage Reading	Core displacement (mm)	LVDT Output (mV)
		$E_0 = (E_{S1} - E_{S2})$
0	-10	
2	-8	
4	-6	
6	-4	
8	-2	
10	0	
12	2	
14	4	
16	6	
18	8	
20	10	

Note : -ve Sign indicates the direction of displacement.

Model graph:



Post-Lab Exercise:

1. Explain how LVDT is used for displacement measurement?
2. What are the other applications of LVDT?
3. Why $E_0 = E_{S1} - E_{S2}$?
4. What causes residual voltage at null displacement?
5. What are the different types of displacement transducers?
6. What is Null voltage?
7. What are the advantages of LVDT?

Result:

Thus the operation and characteristics of LVDT was studied and its characteristic is plotted.

Exp No.: 4(a) MEASUREMENT OF RESISTANCE USING KELVIN'S DOUBLE BRIDGE

Date:

Aim:

To find the unknown value of low resistance using Kelvin's Double Bridge.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Resistors	1KΩ	4
2.	Unknown Resistors	Different value	4
3.	Decade Resistance Box	---	1
4.	Power Supply	---	1
5.	Digital Multimeter	---	1
6.	Bread Board	---	1
7.	Connecting wires	---	Few

Pre-Lab Exercise:

1. What are the methods of measuring low resistance?
2. Why this bridge is called Kelvin's double bridge?
3. Kelvin's double bridge is suitable for-----resistance measurement.
4. Kelvin's double bridge is the modified form of-----

Theory:

Kelvin's double bridge is a modification of Kelvin's bridge and provides more accuracy in measurement of low resistances. It incorporates two sets of ratio arms and the use of four terminal resistors for the low resistance arms, as shown in circuit diagram.

R_x is the resistance under test and S is the resistor of the same higher current rating than one under test. Two resistances R_x and S are connected in series with a short link of low value of resistance r as possible. P, Q, p, q are four known non inductive resistances, one pair of each (P and p, Q and q) are variable. A sensitive galvanometer G is connected across dividing points PQ and pq . The ratio P/Q is kept the same as p/q , these ratios have been varied until the galvanometer reads zero.

Balance Equation:

$$E_{ab} = \frac{P}{P+Q} E_{ac} \text{ and } E_{ac} = I \left[R + S + \frac{(p+q)r}{p+q+r} \right] \text{-----(1)}$$

$$\text{and } E_{amd} = I \left[R + \frac{p}{p+q} \left\{ \frac{(p+q)r}{p+q+r} \right\} \right] = I \left[R + \frac{pr}{p+q+r} \right] \text{-----(2)}$$

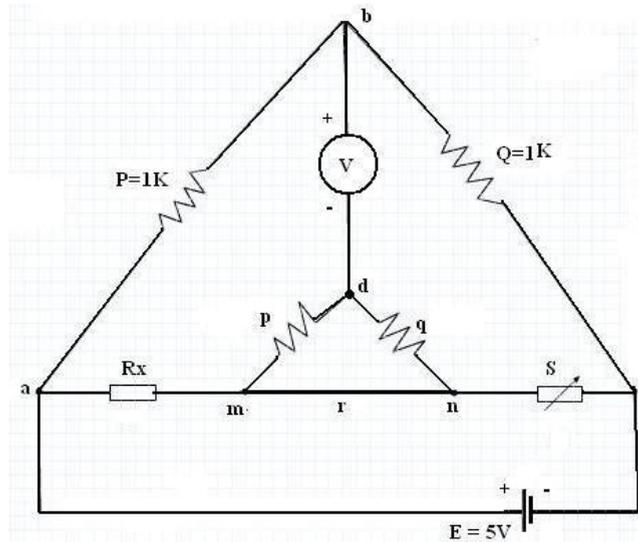
For zero galvanometer deflection, $E_{ab} = E_{amd}$

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

$$\text{or } R = \frac{P}{Q} S + \frac{qr}{p+q+r} \left[\frac{P}{Q} - \frac{p}{q} \right] \text{-----(3)}$$

$$\text{Now, if } \frac{P}{Q} = \frac{p}{q} \text{ Equation (3) becomes, } R = \frac{P}{Q} S \text{-----(4)}$$

Circuit Diagram:



Formulae used:

$$\% \text{ Error} = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

$$R_x = \frac{P}{Q} \cdot S$$

Procedure:

1. Connections are given as per the circuit diagram.
2. Switched ON the supply.
3. Check the initial zero balance condition.
4. The bridge becomes unbalanced when unknown resistance R_x Is connected.
5. The bridge is balanced by varying standard resistance.
6. Unknown resistance R_x is calculated using balance equation.
7. The above steps are repeated for various values of unknown resistance R_x .

Tabular Column:

S.No	P (Ω)	Q (Ω)	S (Ω)	Unknown Resistance R_x (Ω)		% Error
				True	Measured	

Model Calculation:

Post-Lab Exercise:

1. What are the advantages of kelvin's double bridge?
2. What are the limitations of kelvin's double bridge?
3. Explain how Kelvin's double bridge can be used for measuring low resistance?
4. What is the advantage of Kelvin's double bridge over Wheatstone's bridge?
5. Derive the balance equation of Kelvin's double bridge.

Result:

Thus the given unknown resistors value is measured using Kelvin's double bridge.

Exp No.:4(b) MEASUREMENT OF RESISTANCE USING WHEATSTONE'S BRIDGE

Date:

Aim:

To measure the value of unknown resistance in the medium resistance range using Wheatstone's Bridge.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Resistors	1KΩ	2
2.	Unknown Resistors	Different value	4
3.	Decade Resistance Box	---	1
4.	Power Supply	0-30V	1
5.	Digital Multimeter	---	1
6.	Bread Board	---	1
7.	Connecting wires	---	Few

Pre-Lab Exercise:

1. What are called resistance bridges?
2. Name the bridge used for medium range and high range of resistance measurement.
3. How unknown resistance can be measured using Wheatstone bridge?
4. What is called as decade resistance box?
5. When the bridge is said to be balanced?

Theory:

The medium range of resistance is from 1KΩ to some mega ohms. The wheatstone bridge operates upon null indication principle. This means the indication is independent of the calibration of the null indicating instrument or any of its characteristics. For this reason, very high degree of accuracy can be achieved using Wheatstone bridge. Accuracy of 0.1% is quite common with a wheatstone bridge as opposed to accuracies of 3% to 5% with ordinary ohmmeter for measurement of medium resistances. The bridge has 4 resistance arms, consisting of resistances R₁, R₂, R₃ and R_x together with a source of emf and a null detector usually a galvanometer G or other sensitive current meter. The current through the galvanometer depends on the potential difference between the points B and D. the bridge is said to be balanced when there is no current through the galvanometer or when the potential difference across the galvanometer is zero.

For bridge balance, $I_1 R_1 = I_2 R_2$ -----(1)

For the galvanometer current to be zero, the following condition also exists:

$$I_1 = I_3 = \frac{E}{R_1 + R_3} \text{ -----(2)}$$

$$I_2 = I_4 = \frac{E}{R_x + R_2} \text{ -----(3)}$$

E = emf of the battery.

Combining equations (1), (2) and (3) and simplifying, we obtain

$$\frac{R_1}{R_1 + R_2} = \frac{R_x}{R_x + R_3} \text{ -----(4)}$$

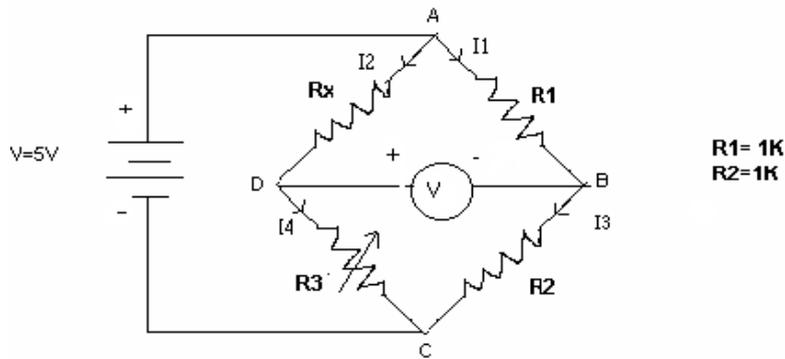
From which, $R_2 R_x = R_1 R_3$ -----(5)

Equation (5) is the well known expression for the balance of Wheatstone bridge. If three of the resistances are known, the fourth may be determined from equation (5)

$$R_x = R_1 \frac{R_2}{R_3}$$

Where R_x is the unknown resistance R_3 is called the ‘standard arm’ of the bridge and R_1 and R_2 are called the ‘ratio arms’.

Circuit Diagram:



Formulae:

$$\% \text{ Error} = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

$$R_x = R_1 \frac{R_2}{R_3}$$

Procedure:

1. Connections are given as per the circuit diagram.
2. Supply is switched ON.
3. Check the zero balance initial condition.
4. When the unknown resistance R_x is connected, the bridge becomes unbalanced.
5. The bridge is balanced by varying the DRB(R_3).
6. The value of unknown resistance is calculated by the given formulae.
7. The above steps are repeated for different value of unknown resistances.
8. Calculate the % error using the given formula.

Tabular Column:

S. No	Resistance R_3 (k Ω)	Unknown Resistance R_x		% error
		True (k Ω)	Measured(k Ω)	

Post-Lab Exercise:

1. What are the applications of Wheatstone bridge?
2. What are standard arm and ratio arm in wheat stone bridge?
3. What is the relationship among the resistors under balanced condition?
4. What are the detectors used for DC bridges?
5. What do you meant by sensitivity?
6. What is the relationship between sensitivity and accuracy of Wheatstone bridge?
7. Why Wheatstone bridge is not suitable for low resistance measurement?

Result:

Thus the Wheatstone bridge is constructed and the unknown resistors were determined.

Exp No.:5 MEASUREMENT OF CAPACITANCE USING SCHERING'S BRIDGE**Date:****Aim:**

To measure the value of unknown capacitance using Schering's bridge & dissipation factor.

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Resistors	1KΩ, 1KΩ, 560Ω, 5.6KΩ	Each one
2.	Decade Resistance Box		
3.	Decade Conductance Box	---	1
4.	Digital Multimeter	---	1
5.	CRO	---	1
6.	Bread board	---	1
7.	Connecting wires	---	Few

Pre-Lab Exercise:

1. Name the bridges used for capacitance measurement.
2. Why Schering's Bridge is called as AC bridge?
3. State the two conditions for balancing an AC bridge?
4. What kind of input should be applied to Schering's Bridge?

Theory:

In this bridge the arm BC consists of a parallel combination of resistor & a Capacitor and the arm AC contains capacitor. The arm BD consists of a set of resistors varying from 1Ω to 1 MΩ. In the arm AD the unknown capacitance is connected. The bridge consists of a built in power supply, 1 kHz oscillator and a detector.

Balance Equations:

Let C_1 = Capacitor whose capacitance is to be measured.

R_1 = a series resistance representing the loss in the capacitor C_1 .

C_2 = a standard capacitor.

R_3 = a non-inductive resistance.

C_4 = a variable capacitor.

R_4 = a variable non-inductive resistance in parallel with variable capacitor C_4 .

At balance,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\left(r_1 + \frac{1}{j\omega C_1} \right) \left(\frac{R_4}{1 + j\omega C_4 R_4} \right) = \frac{1}{j\omega C_2} \cdot R_3$$

$$\left(r_1 + \frac{1}{j\omega C_1} \right) R_4 = \frac{R_3}{j\omega C_2} (1 + j\omega C_4 R_4)$$

$$r_1 R_4 - \frac{jR_4}{\omega C_1} = -j \frac{R_3}{\omega C_2} + \frac{R_3 R_4 C_4}{C_2}$$

Equating the real and imaginary terms, we obtain

$$r_1 = R_3 \frac{C_4}{C_2} \quad \text{and}$$

$$C_1 = C_2 \frac{R_4}{R_3}$$

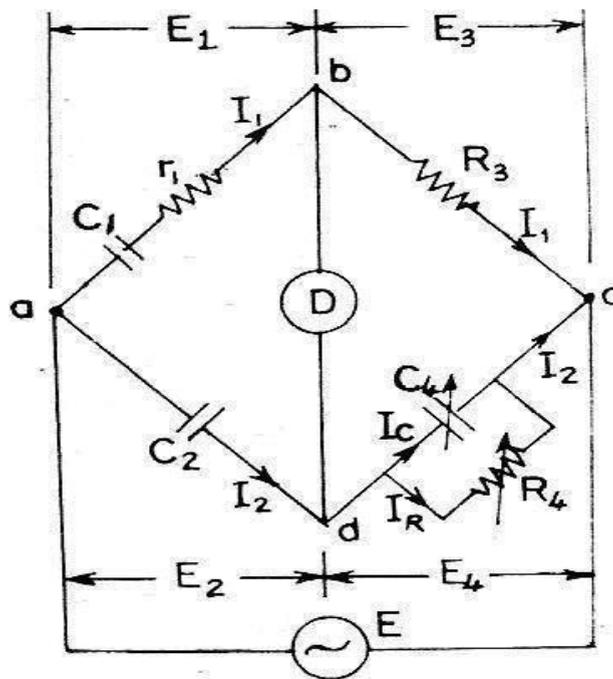
Two independent balance equations are obtained if C_4 and R_4 are chosen as the variable elements.

Dissipation Factor:

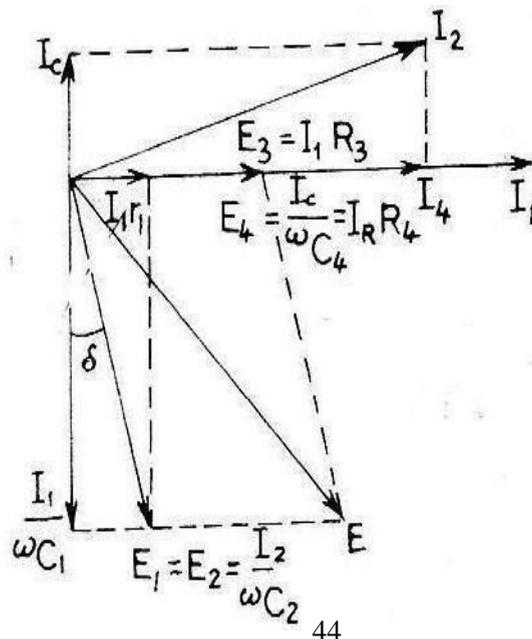
The dissipation factor of a series RC circuit is defined as a co-tangent of the phase angle and therefore by definition the dissipation factor is

$$D_1 = \tan \delta = \omega C_1 r_1 = \omega \left(\frac{C_2 R_4}{R_3} \right) \times \left(\frac{R_3 C_4}{C_2} \right) = \omega C_4 R_4$$

Circuit Diagram:



Phasor Diagram:



Formulae Used:

$$\% \text{ Error} = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

$$r_1 = R_3 \frac{C_4}{C_2} \quad , C_1 = C_2 \frac{R_4}{R_3} \quad \& \quad D_1 = \omega C_4 R_4 \text{ where } C_4 = C_x \& R_4 = R_x$$

Procedure:

1. Switch on the trainer board and connect the unknown in the arm marked C_x.
2. Observe the sine wave at the output of oscillator and patch the ckt by using the wiring diagram.
3. Observe the sine wave at secondary of isolation transformer on CRO. Select some value of R₂.
4. Connect the CRO between ground and the output point of im balance amplifier.
5. Vary R₁(500 ohms potentiometer) from minimum position in the clock wise direction.
6. If the selection of R₂ is correct, the balance point (DC line) can be observed on CRO. (That is at balance the output waveform comes to a minimum voltage for a particular value of R₁ and then increases by varying R₁ in the same clockwise direction). If that is not the case, select another value of R₂.
7. Capacitor C₁ is also varied for fine balance adjustment. The balance of the bridge can be observed by using loud speaker.
8. Connect the loud speaker at the output of the detector. Alternatively adjust R₁ and proper selection of R₂ for a minimum sound in the loud speaker.
9. Tabulate the readings and calculate the unknown capacitance and dissipation factor.

Tabular Column:

S.No.	C ₁ (pF)	C ₃ (μF)	R ₁ (Ω)	R ₂ (Ω)	R _x (Ω)	C _x (μF)		Dissipation factor (D ₁)
						True value	Measured Value	

Model Calculation:**Post-Lab Exercise:**

1. Explain how Schering's Bridge is used for measuring capacitance?
2. What do you mean by dissipation nfactor?
3. Give the relationship between Q and D.
4. Derive the balance equations.
5. What are the limitations of Schering's bridge?

Result:

Thus the unknown capacitance & dissipation factor were measured using Schering's Bridge.

ExpNo.:6 MEASUREMENT OF SELF INDUCTANCE USING ANDERSON'S BRIDGE**Date:****Aim:**

To measure the unknown self-inductance of the coil using Anderson's Bridge.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	Resistors	1KΩ, 1KΩ, 560Ω, 5.6KΩ	Each one
2.	Unknown Resistors	Different value	4
3.	Decade Inductance Box	---	1
4.	Digital Multimeter	---	1
5.	CRO	30 MHz	1
6.	Bread Board	---	1
7.	Connecting wires	---	Few

Pre-Lab Exercise:

1. Name the bridges used for inductance measurement.
2. Is Anderson's bridge is AC or DC bridge?
3. What are the detectors used in AC bridges?
4. Input must be given to Anderson's bridge.

Theory:

The unknown inductance can be measured using the Anderson's bridge trainer. To measure any other value of inductance, the resistance r & r_1 have to be correspondingly changed either by increasing or decreasing the resistance. The resistance in any of the arms of the bridge is increased by externally connecting some resistance in series or decreased by connecting in parallel for which the provision has been given in the trainer. The bridge consists of a built in power supply, 1 kHz oscillator & a detector.

Balance Equations:Let L_1 =self-inductance to be measured R_1 =resistance of self-inductor r_1 =resistance connected in series with self-inductor R, R_2, R_3, R_4 = known non-inductive resistances C =fixed standard capacitorAt balance $I_1=I_3$ and $I_2=I_c+I_4$

$$I_1 R = I_c \times \frac{1}{j\omega C} \quad \therefore I_c = I_1 j\omega C R$$

Writing the other balance equations

$$I_1(r_1 + R_1 + j\omega L_1) = I_2 R_2 + I_c r \quad \text{and} \quad I_c \left(r + \frac{1}{j\omega C} \right) = (I_2 - I_c) R_4$$

Substituting the value of I_c in the above equations, we have

$$I_1(r_1 + R_1 + j\omega L_1) = I_2 R_2 + I_1 j\omega C R_3 r \quad \text{or} \quad I_1(r_1 + R_1 + j\omega L_1 - j\omega C R_3 r) = I_2 R_2 \quad \text{-----(1)}$$

$$j\omega CR_3 I_1 (r + \frac{1}{j\omega C}) = (I_1 - I_1 j\omega CR) R \text{ or } I_1 (j\omega CR r + j\omega R R + R) = I R \quad \text{----- (2)}$$

From equations (1) and (2), we obtain

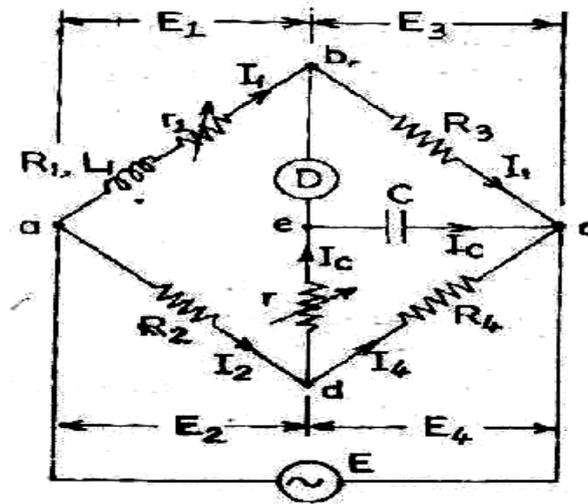
$$I_1 (r_1 + R_1 + j\omega L_1 - j\omega CR_3 r) = I_1 \left(\frac{R_2 R_3}{R_4} + \frac{j\omega CR_2 R_3 r}{R_4} + j\omega CR_3 R_2 \right)$$

Equating the real and imaginary parts

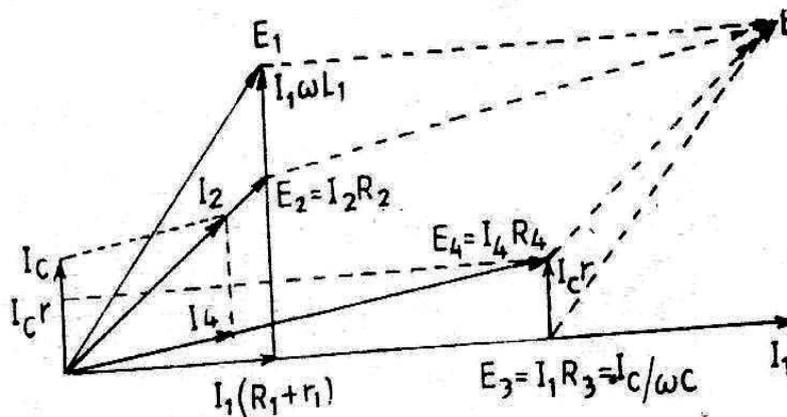
$$R_1 = \frac{R_2 R_3}{R_4} - r_1 \quad \text{----- (3)}$$

$$\text{and } L_1 = C \frac{R_2}{R_4} [r(R_4 + R_2) + R_2 R_4] \quad \text{----- (4)}$$

Circuit Diagram:



Phasor Diagram:



Formula used:

$$\% \text{ Error} = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

$$L_1 = C \frac{R_2}{R_4} [(R_4 + R_2) + R_2 R_4] \quad R_1 = \frac{R_2 R_3}{R_4} - r_1$$

Procedure:

1. Switch on the trainer & connect the unknown inductance in the arm marked R₁.
2. Connect the CRO between the ground & the output point and check for the balance condition.
3. Observe the sine wave at the secondary of the isolation transformer by using CRO.
4. Vary the resistance R from minimum position in a clockwise direction.
5. For further fine balance vary the resistance r₁ which will compensate for the resistive Component of the inductor.
6. Remove the wiring and measure the values of R and r₁ using DMM.
7. The above steps (3, 4, 5&6) are repeated for different values of unknown inductance.

Tabular Column:

S. No	R(Ω)	r ₁ (Ω)	R ₂ (Ω)	R ₃ (Ω)	R ₄ (Ω)	R ₁ (Ω)	$Q = \frac{\omega L_1}{R_1}$	L ₁ (mH)		%Error
								True	Measured	

Model Calculation:

Post-Lab Exercise:

1. What do you mean by Q-factor? What is its significance?
2. What are the other bridges used to measure inductance?
3. State the merits and demerits of Anderson's bridge?
4. What will happen to the measured inductance value if frequency of the input is not maintained constant?
5. What are the limitations of Anderson Bridge?

Result:

Thus the unknown inductance of the coil is measured using Anderson's Bridge.

Exp No.:7
Date:

CHARACTERISTICS OF STRAIN GAUGE

Aim:

To study the characteristics of strain gauge.

Apparatus required:

S. No.	Components / Equipment	Specification	Quantity
1.	Strain Gauge Kit	---	1
2.	Digital Multimeter	---	1
3.	Standard weights	100g, 200g & 500g	1,2 & 1

Pre-Lab Exercise:

1. What is the principle employed in measurement using strain gauge?
2. Strain gauge _____ type of sensor.
3. What is meant by gauge factor.
4. What is the difference between active and passive transducer?
5. What are the types of strain gauges?
6. What is Rosettes?

Theory:

If a metal conductor is stretched or compressed, its resistance changes on account of the fact that both length and diameter of conductor change. Also there is a change in the value of resistivity of the conductor when it is strained and this property is called piezo resistive effect. Therefore resistance strain gauge is also known as piezo resistive gauges. The strain gauges are used for measurement of strain and associated stress in experimental stress analysis.

The change in the value of resistance by straining the gauge may be partly explained by the normal dimensional behavior of elastic material. If a strip of elastic material is subjected to tension or in other words positively strained, its longitudinal dimension will increase while there will be reduction in the lateral dimension. So, when a gauge is stretched to a positive strain, its length increases while its area of cross section decreases. Since the resistance of the conductor is proportional to its length and inversely proportional to its area of cross section the resistance of the gauge increases with positive strain. The extra change in the value of resistance is attributed to a change in the value of resistivity of a conductor when strained.

Let us consider in the case the value of resistance is attributed to a change in the value of resistivity. Length = L, area = A, diameter = D before strained. The material of the wire has a resistivity ρ Therefore resistance of a strained gauge $R = \rho L/A$. Let a tensile stress S be applied to the wire. This produces a positive strain. The length is to increase and area to decrease. Let ΔL =change in length, ΔA =change in area, ΔD =change in diameter and ΔR

= change in resistance

$$\frac{dR}{ds} = \rho \frac{\partial L}{A \partial s} - \frac{\rho L}{A^2} \frac{\partial A}{\partial s} + \frac{L \partial \rho}{A \partial s} \dots \dots \dots (1)$$

Divide by resistance $R = \frac{\rho L}{A}$, we have

$$\frac{1}{R} \frac{dR}{ds} = \frac{1}{L} \frac{\partial L}{\partial s} - \frac{1}{A} \frac{\partial A}{\partial s} + \frac{1}{\rho} \frac{\partial \rho}{\partial s} \dots \dots \dots (2)$$

It is evident from the equation 2, that the per unit change resistance is due to

- (i) per unit change length in length = $\Delta L/L$
- (ii) per unit change in area = $\Delta A/A$
- (iii) per unit change in resistivity = $\Delta\rho/\rho$

$$\text{Area } A = \frac{\pi}{4} D^2 \quad \therefore \frac{\partial A}{\partial s} = 2 \cdot \frac{\pi}{4} D \cdot \frac{\partial D}{\partial s} \dots\dots\dots(3)$$

$$\frac{1}{A} \frac{dA}{ds} = \frac{(2\pi/4)D}{(\pi/4)D^2} \frac{\partial D}{\partial s} = \frac{2}{D} \frac{\partial D}{\partial s} \dots\dots\dots(4)$$

Equation 2 can be written as

$$\frac{1}{R} \frac{dR}{ds} = \frac{1}{L} \frac{\partial L}{\partial s} - \frac{2}{D} \frac{\partial D}{\partial s} + \frac{1}{\rho} \frac{\partial \rho}{\partial s} \dots\dots\dots(5)$$

$$\text{Now poisson's ratio} = \frac{\text{lateral strain}}{\text{longitudinal strain}} = -\frac{\partial D/D}{\partial L/L} \dots\dots\dots(6)$$

$$\frac{\partial D}{D} = -\nu \times \frac{\partial L}{L}$$

$$\frac{1}{R} \frac{dR}{ds} = \frac{1}{L} \frac{\partial L}{\partial s} + \nu \frac{2}{L} \frac{\partial L}{\partial s} + \frac{1}{\rho} \frac{\partial \rho}{\partial s} \dots\dots\dots(7)$$

For a small variation, the above relationship can be written as

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + 2\nu \frac{\Delta L}{L} + \frac{\Delta\rho}{\rho} \dots\dots\dots(8)$$

The gauge factor is defined as the ratio of per unit change in resistance to per unit change in length. Gauge factor $G_f = \frac{\Delta R/R}{\Delta L/L} \dots\dots\dots(9)$

$$\frac{\Delta R}{R} = G_f \frac{\Delta L}{L} = G_f \times \epsilon \dots\dots\dots(10)$$

$\epsilon = \text{Strain} = \frac{\Delta L}{L}$. The gauge factor can be written as

$$G_f = \frac{\Delta R/R}{\Delta L/L} = 1 + 2\nu + \frac{\Delta\rho/\rho}{\Delta L/L} \dots\dots\dots(11)$$

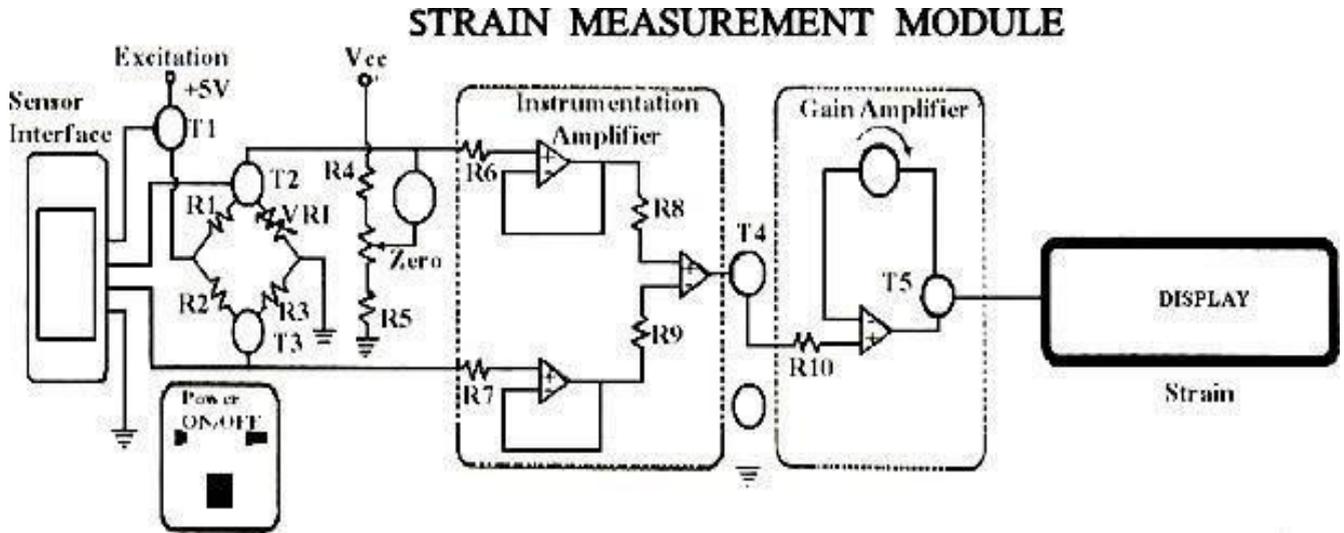
If the change in the value of resistivity of a material when strained is neglected, the gauge factor is

$$G_f \approx 1 + 2\nu \dots\dots\dots(12)$$

The equation 12 is valid only for piezo electric effect. The Poisson's ratio for all metals is found to be between 0 and 0.5. This gives a gauge factor of approximately 2. The common values of gauge factor for wire wound strain gauges are:

Material	Gauge factor	Material	Gauge factor
Nickel	-12.1	Platinum	+4.8
Manganin	+0.47	Carbon	+20
Nichrome	+2.0	Doped crystals	100 to 5000
Constantan	+2.1	Soft iron	+ 4.2

Module Diagram:



Procedure:

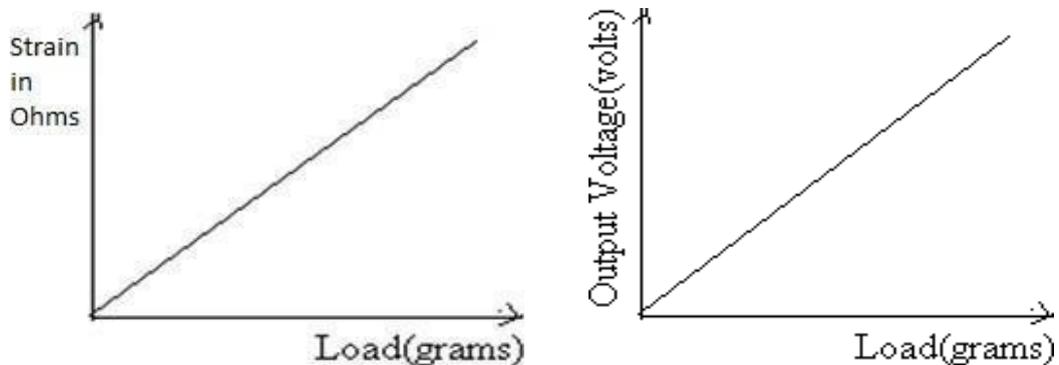
1. Connect the trainer with the load applying column.
2. Connect the multimeter at the output terminal.
3. Switch ON the kit.
4. Initially at no load, zero adjustment has to be done.
5. Gradually increase the load and note down the corresponding output voltage.

Graph: Plot the graph: Strain Vs Load and Output Voltage Vs Load.

Tabular column:

S.No.	Load (g)	Strain (Ω)		% error	Output Voltage (V)
		Theoretical	Practical		

Model graph:



Post-Lab Exercise:

1. State piezo resistive effect.
2. What is the importance of gauge factor of a strain gauge?
3. What are the applications of strain gauges?
4. Define Poisson's ratio.
5. What are the advantages of semiconductor strain gauge?
6. What are the disadvantages of semiconductor strain gauges?

Result:

Thus, the characteristics of strain gauge were studied and the graphs were plotted for different weights.

Exp No.: 8

DEMONSTRATION OF CRO

Date:

Aim:

To measure the AC input signal using CRO and determining the time period and amplitude.

Apparatus required:

S. No.	Components / Equipment	Specification	Quantity
1.	CRO	-	1
2.	Function Generator	-	1

Pre lab Questions

1. What is a Cathode Ray Oscilloscope (CRO)?
2. What are the main components of a CRO?
3. How does the time base generator function in a CRO?
4. What is the purpose of the vertical deflection system in a CRO?
5. How do you measure the frequency of a signal using a CRO?

Theory

The Cathode Ray Oscilloscope (CRO) is an instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies.

Like a television screen, the screen of an oscilloscope consists of a cathode ray tube. Although the size and the shape are different, the operating principle is the same. Inside of the tube is vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the phosphorescent screen.

The electron beam is bent, or deflected, by voltages applied to two sets of plates fixed in the tube. The horizontal deflection plates or X-plates produce side to side movement. As you can see, they are linked to a system block called the time base. This produces a saw tooth waveform. During the rising phase of the saw tooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right to left, but the spot is blanked out so that nothing appears on the screen. In this way, the time base generates the X-axis of the V/t graph.

The slope of the rising phase varies with the frequency of the saw tooth and can be adjusted, using the TIME/DIV control, to change the scale of the X-axis. Dividing the oscilloscope screen into squares allows the horizontal scale to be expressed in seconds,

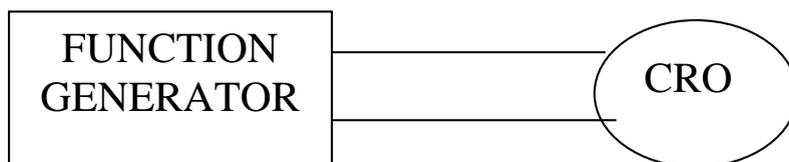
milliseconds or microseconds per division (s/DIV, ms/DIV, and μ s/DIV). Alternatively, if the squares are 1 cm apart, the scale may be given as s/cm, ms/cm or μ /cm.

The signal to be displayed is connected to the input. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the Y-amplitude. In the AC position (switch open) a capacitor is placed in the signal path. The capacitor blocks DC signals but allows AC signals to pass. The Y-amplifier is linked in turn to a pair of Y-plates so that it provides the Y-axis of the V/t graph. The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control, so that the resulting display is neither too small nor too large, but fits the screen and can be seen clearly. The vertical scale is usually given in V/DIV or mV/DIV.

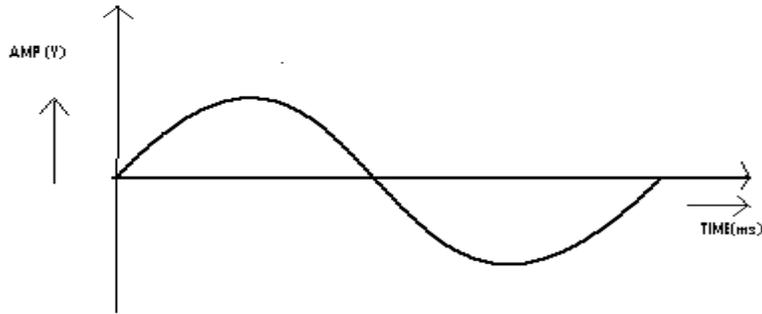
The trigger circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal.

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the positions of the axes. This is possible using the X-POS and Y-POS controls. For example, with no signal applied, the normal trace is a straight line across the centre of the screen. Adjusting Y-POS allows the zero level in the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signals like pulse waveforms which do not alternative between positive and negative values. The screen usually displays a V/t graph, with voltage V on the vertical axis and time t on the horizontal axis. The scales of both axes can be changed to display a huge variety of signals.

BLOCK DIAGRAM:



MODEL GRAPH:



TABULATION:

SL.NO.	Amplitude (Volts)	Time Period (ms)

Post Lab Questions

1. What type of waveform did you observe during the CRO demonstration, and how did you identify it?
2. How did changing the time base setting affect the waveform display?
3. Describe how you calibrated the CRO before taking measurements.
4. What challenges did you encounter while using the CRO, and how did you overcome them?

Result:

Thus the measurement of amplitude and time period using CRO.

Exp No.:9 (a)

CHARACTERISTICS OF A/D CONVERTER

Date:

Aim:

To test the characteristics of analog to digital converter using ADC.

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Op-amp	IC 741	1
2.	Binary counter	IC 7493	1
3.	AND Gate	IC 7408	1
4.	Resistors	3.3 k Ω , 6.8 k Ω ,	Each one
5.	Resistor	1.5 k Ω	2
6.	Digital trainer kit	-	1
7.	Regulated Power Supply	(0-15) V	1
8.	Connecting wires	---	Few

Pre-Lab Exercise:

1. What is ADC?
2. What are the types of ADC?
3. What is the need for ADC?
4. State Shannon's sampling theorem?

Theory:

An analog-to-digital converter, or ADC as it is more commonly called, is a device that converts analog signals into digital signals. A/D converters are electronic circuits that have the following characteristics;

□ The input to the A/D converter is a voltage.

□ The output of the A/D converter is an n-bit binary signal corresponding to the voltage at the input at a specific instance. Therefore Analog to Digital conversion is a mapping from continuous ranges to binary numbers.

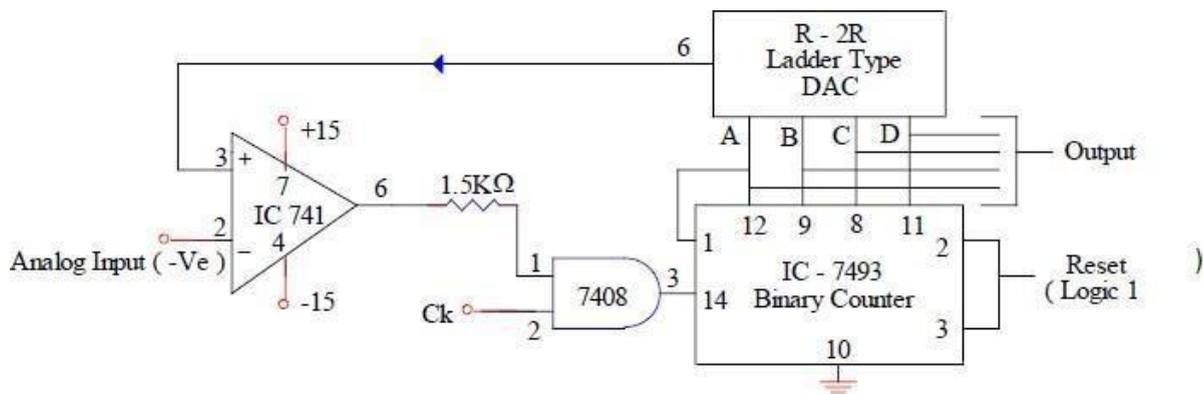
The conversion involves quantization of the input, so it necessarily introduces a known amount of error, called quantization error or quantization noise. The resolution of the converter is the number of discrete values it can produce over the range of analog values. The values are usually stored electronically in binary form, so the resolution is usually expressed in bits. For example, an ADC with a resolution of 8 bits can encode an analog input to one in 256 different levels. Resolution can also be expressed in volts. In that case the resolution is $Q = V_{\text{range}} / (2^n - 1)$. where Q is the resolution of ADC, 'n', is the resolution of ADC in bits, V_{range} is the whole voltage range at the input.

Analog to Digital converters can be designed with or without the use of DAC as part of their circuitry. The commonly used types of ADC's incorporating DAC are:

a. Successive Approximation type. b. Counting or Ramp type.

The block diagram of a counting type ADC using a DAC is shown in the figure. When the clock pulses are applied, the contents of the register/counter are modified by the control circuit. The binary output of the counter/register is converted into an analog voltage V_p by the DAC. V_p is then compared with the analog input voltage V_{in} . This process continues until $V_p \geq V_{in}$. After which the contents of the register /counter are not changed. Thus the output of the register /counter is the required digital output.

Circuit Diagram:



For DAC $R = 1.5K\Omega$ $2R = 3.3K\Omega$ $R_f = 6.8K\Omega$

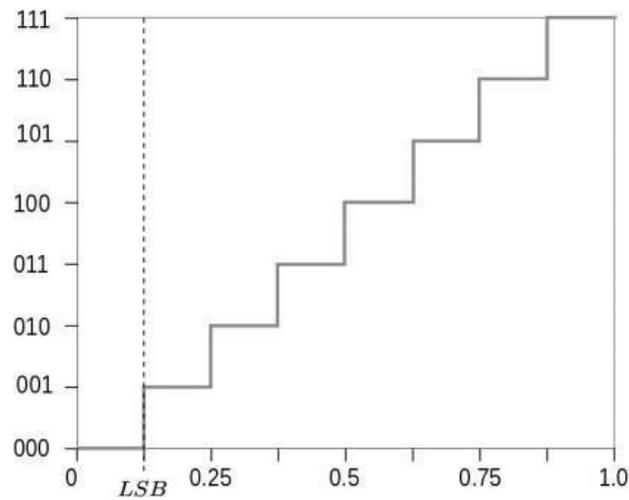
Procedure:

1. By making use of the R-2R ladder DAC circuit set up the circuit as shown in the figure.
2. Apply various input voltages in the range of 0 to 10V at the analog input terminal.
3. Apply clock pulses and observe the stable digital output at QD, QC, QB and QA for each analog input voltage.

Tabular Column:

S.No.	Analog Input Voltage (V)	Digital Output Voltage (binary form)

Model graph: For 3-bit ADC



Post-Lab Exercise:

1. How SA type converts analog signal to digital signal?
2. What is the resolution of n-bit ADC?
3. What is meant by quantization level?
4. What are the methods of quantization?
5. What are the advantages of Successive Approximation type over ramp type?
6. State the advantages of ramp type over successive approximation type?

Result:

Thus the characteristics of analog to digital converter is tested and it is plotted.

Exp No.:9 (b)

CHARACTERISTICS OF D/A CONVERTER

Date:

Aim:

To design and test a 4 bit D/A Converter by R - 2R ladder network.

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Op-amp	IC 741	1
2.	Resistors	11 kΩ	4
3.	Resistors	22 kΩ	6
4.	Digital trainer kit	-	1
5.	DMM	-	1
6.	Regulated Power Supply	(0-15) V	1
7.	Connecting wires	---	Few

Pre-Lab Exercise:

1. Draw the block diagram of DAC
2. What are the different types of DAC?
3. Define Resolution and Quantization
5. Define aperture time.

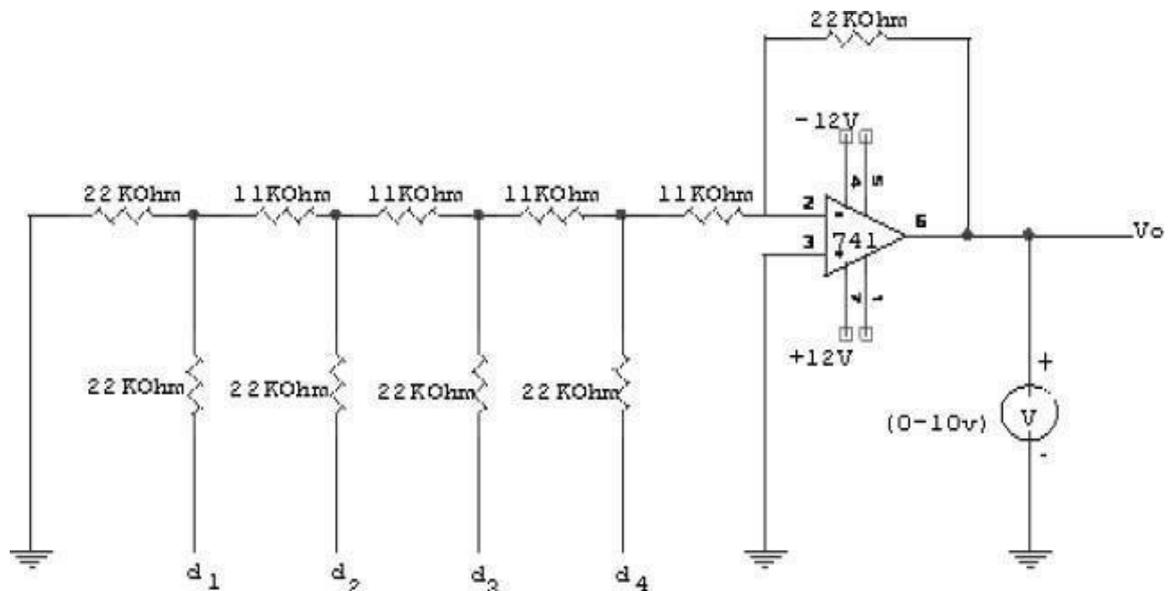
Theory:

The input is an n-bit binary word 'D' and is combined with a reference voltage 'VR' to give an analog output signal. The output of D/A converter can either be a voltage or current. For a voltage output D/A converter is described as

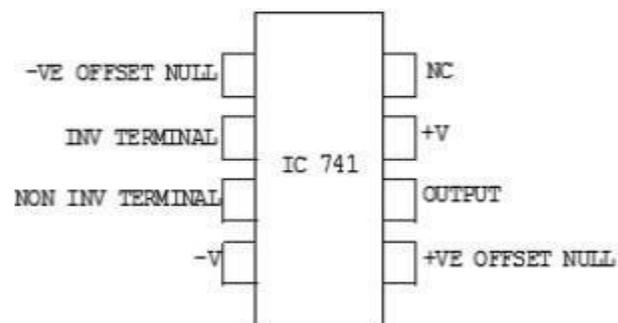
$$V_0 = \left(\frac{-V_{ref} \cdot R_f}{n \cdot R} \right) \left(\frac{d_1}{2^1} + \frac{d_2}{2^2} + \frac{d_3}{2^3} + \frac{d_4}{2^4} + \dots + \frac{d_n}{2^n} \right)$$

Where, **V0** is the output voltage, **d1, d2, d3 and dn** are n bit binary word with the decimal point located at the left. , **d1** is the MSB with a weight of $V_{fs} / 2$, **dn** is the LSB with a weight of $V_{fs} / 2^n$

Circuit Diagram:



Pin diagram



Formulae used:

$$V_0 = \left(\frac{-V_{ref} \cdot R_f}{n \cdot R} \right) \left(\frac{d_1}{2^1} + \frac{d_2}{2^2} + \frac{d_3}{2^3} + \frac{d_4}{2^4} \right)$$

Where V_{ref} is the full scale voltage

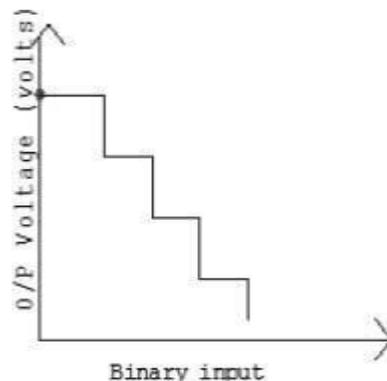
Procedure:

- 1) Set up the circuit as shown in the circuit diagram
- 2) Measure the output voltage for all binary inputs (0000 to 1111).
- 3) Plot the graph for binary input versus output voltage.

Tabular Column:

S.No.	Digital Input				Analog Output	
	D ₁	D ₂	D ₃	D ₄	Theoretical Output(V)	Practical Output (V)
1	0	0	0	0		
2	0	0	0	1		
3	0	0	1	0		
4	0	0	1	1		
5	0	1	0	0		
6	0	1	0	1		
7	0	1	1	0		
8	0	1	1	1		
9	1	0	0	0		
10	1	0	0	1		
11	1	0	1	0		
12	1	0	1	1		
13	1	1	0	0		
14	1	1	0	1		
15	1	1	1	0		
16	1	1	1	1		

Model graph:



Model Calculation:

Post-Lab Exercise:

1. What are the resistor values used in R-2R ladder type DAC?
2. Resistor values used in Weighted resistor type DAC-----
3. What are the advantages of R-2R ladder type DAC over Weighted resistor type DAC?
4. Explain how digital input is converted into analog using R-2R ladder type DAC.
5. Explain how digital input is converted into analog using Weighted resistor type DAC.

Result:

Thus the characteristics of digital to analog converter is tested and is plotted.

ExpNo.10(a)

CALIBRATION OF AMMETER

Date:

Aim:

To calibrate the given ammeter using standard ammeter.

Apparatus Required:

S. No.	Components / Equipments	Specification	Quantity
1.	RPS	0-30V	1
2.	Standard Ammeter (MC)	0-500 μ A	1
3.	Ammeter to be calibrated (MC)	0-500 μ A	1
4.	Single phase auto transformer	-	1
5.	Lamp load unit	-	1
6.	Resistor	10K Ω	1
7.	Bread Board	---	1
8.	Connecting wires	---	Few

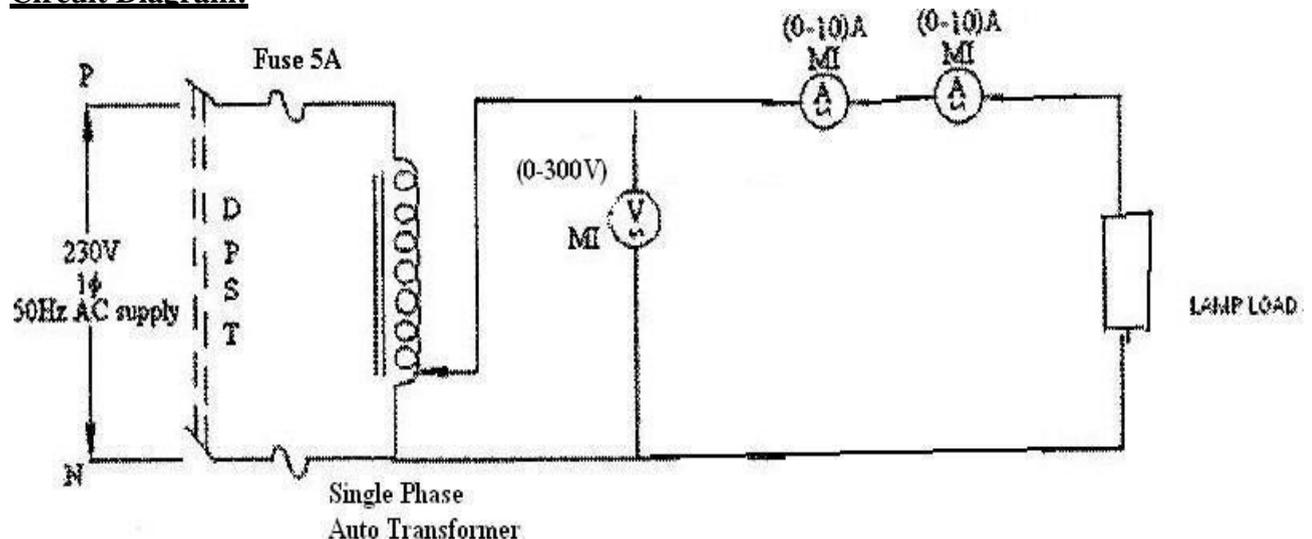
Pre-Lab Exercise:

1. What is meant by calibration?
2. Why periodic calibration is needed?
3. What are the types of instruments used as ammeters?
4. What are the types of errors which occur in most of the ammeters?

Theory:

D.C ammeters are used to measure current from one micro ampere to several hundred amperes. The D'Arsonval movement is used in most DC ammeter as a current detector. Typical lab meters of this type can withstand 1 mA of their full scale reading. Since the coil winding is small and light, it can carry very small current only. When heavy currents are to be measured the major part of the current is bypassed through a low resistance called a SHUNT.

Circuit Diagram:



Procedure:

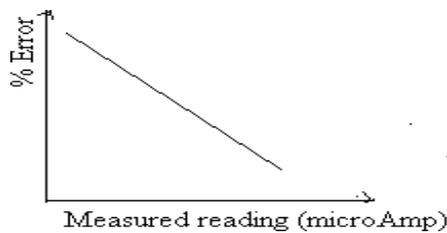
1. Connect the circuits as shown in the circuit diagram.
2. Switch ON the supply.
3. Adjust the voltage using RPS & compare both the values that are shown by the standard ammeter & the meter to be calibrated.
4. Find out the % error by using the formula.

Graph: Plot the error graph by taking % error along y axis & current along x axis.

Tabular Column:

S.No	Load (Watt)	Voltmeter Reading (V)	Std. ammeter reading (A) (True reading)	Meter to be calibrated(A) (Measured reading)	%Error

ModelGraph:



Formulaused:

$$\% \text{ Error} = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

Model Calculation:

Post-Lab Exercise:

1. What is the use shunt in ammeter?
2. What are the requirements of shunts?
3. What are the materials used for constructing shunt resistance?
4. Define multiplying power of shunt.

Result:

Thus the given ammeter is calibrated against the given standard ammeter and the percentage error graph is plotted.

ExpNo.10 (b)

CALIBRATION OF VOLTMETER

Date:

Aim:

To calibrate the given voltmeter using standard voltmeter.

Apparatus required:

S. No.	Components / Equipments	Specification	Quantity
1.	Power Supply	0-30V	1
2.	Standard Voltmeter	(0-30V), MC	1
3.	Voltmeter to be calibrated	(0-30V), MC	1
4.	Single phase auto transformer	-	1
5.	Lamp load unit	-	1
6.	DRB	---	1
7.	Bread Board	---	1
8.	Connecting wires	---	Few

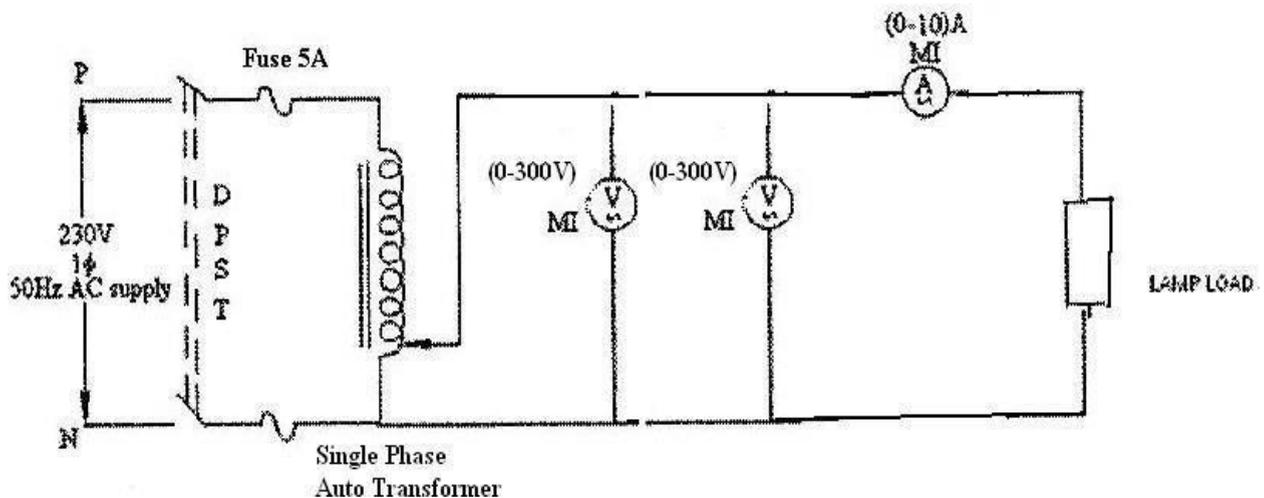
Pre-Lab Exercise:

1. How standards are classified?
2. How calibration is performed?
3. Which standard has the highest accuracy?
4. What are the types of instruments used as voltmeters?

Theory:

Most DC voltmeters use D' Arsonval movements. The D' Arsonval movement itself can be considered to be a voltmeter. D' Arsonval movement causes a certain voltage drop which equals the current flowing in it multiplied by its internal resistance. The calibration can be done by comparing it with the standard meter. The error will give us an idea how much the zero & span adjustment has to be done. To increase the voltage range of the meter a series resistance has to be connected with the meter to be extended. The extra resistance is called a 'MULTIPLIER' which limits the current flowing through the meter.

Circuit Diagram:



Procedure:

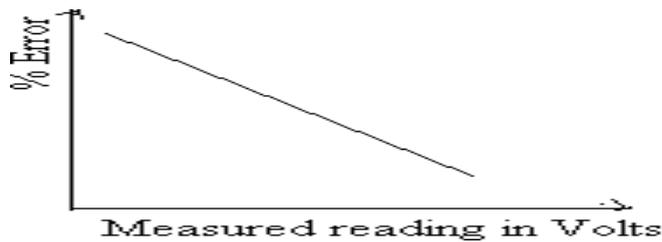
1. Connect the circuits as shown in the circuit diagram (a) and switch on the supply.
2. Adjust the voltage using RPS & compare both the values that are shown by the std. voltmeter & the meter to be calibrated.
3. Find out the % error by using the formula.

Graph: Plot the error graph by taking % error along Y axis & voltage along X axis.

Tabular Column:

S. No	Std. voltmeter reading (V) (True reading)	Meter to be calibrated (V) (Measured reading)	%Error

Model Graph:



Formulae used:

% Error =

$$\frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

Model Calculation:

Post-Lab Exercise:

1. What are the types of errors which occur in most of the voltmeters?
2. What is multiplier?
3. What are the essential requirements of multiplier?
4. What are the materials used for constructing multiplier?
5. Explain the effect of temperature changes in voltmeters.

Result:

Thus for the given voltmeter percentage error was calculated and the same was plotted.