List of Experiments

B.Sc. IV Semester (Electronic hon's) Cor-10
Electronic Instrumentation Laboratory

1. Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
2. Measurement of Capacitance by de' Sautys bridge.
3. Measurement of an unknown self-inductance using Anderson bridge.
4. Measurement of an unknown self-inductance using Maxwell Inductance bridge.
5. Measurement of an unknown self-inductance using Maxwell Inductance capacitance bridge.
6. Measurement of an unknown capacitance using Schering bridge.
7. Measurement of an unknown capacitance using Wiens bridge.
8. To study the characteristics of LDR, Photodiode and Phototransistor:
   1) Variable Illumination 2) Linear Displacement
9. To determine the characteristic of LVDT.
10. To determine the Characteristic of Thermistors and RTD.
11. To determine the Characteristics of resistance transducer-Strain Gauge (Measurement of Strain using half and full bridge).

Experiment No.-1

Objective: - Measurement of resistance by using whetstone bridge and measurement of bridge sensitivity.

Range of measurement – 0.001 ohms to 11.1M ohms

Accuracy – 0.5 to 1%

Series Arms -consist of four-decade resistance dial having equal step of 1,10,100 and 1000.

Theory:

A very important device used in the measurement of medium resistances is the Wheat stones bridge .it is an accurate and reliable instrument. The wheat stone bridge is an instrument based on the principle of null indication and comparison measurements. The basic circuit of a wheat stone bridge is shown in fig. it has four resistive arms, consisting of resistances P, Q, R and S together with a source of emf and a null detector, usually a galvanometer G or other sensitive current meter is used. The current through the galvanometer depends on the potential difference between point's b and d. The bridge is said to be balanced when there is on current through the galvanometer or when the potential difference across the galvanometer is zero. this occurs when the voltage from point 'b' to point 'a' equals the voltage from point 'd' to point 'a' or by referring to other battery terminal, when the voltage from point 'd' to point 'c' equals the voltage from point 'b' to point 'c'.

For bridge balance;

$I1P=I2\ R$ ……………. .1)

$I1=I3=E/P+Q$ ………...(2)

$I2=I4=E/R+S$………… (3)

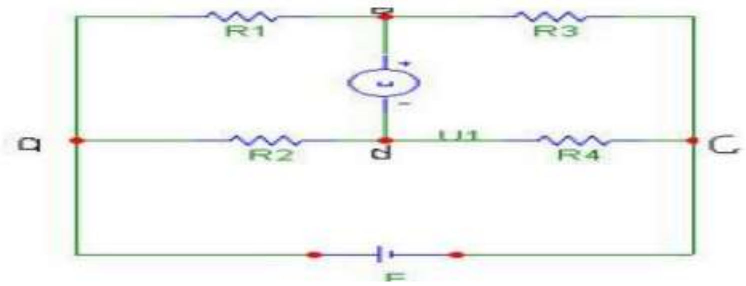
E=emf of battery.

Combining equ (1) and (2) we get $P/P+Q=R/R+S$……………………… (4)

$QR=PS$………………………………… (5)

Shows the balance condition of wheat stone bridge. If three of the resistances are known then fourth may be determined by formula… $R = S * P/Q$ Where R is the unknown resistance, S is called the standard arm resistor and P and Q are called the ratio arms.

Circuit Diagram:-



Procedure -

1. Connect the unknown resistance to be measured across the terminals marked unknown resistance

2. Select a proper multiplication factor from multiply by dial, depending upon the range of resistance measurement**.**

Here is range of resistance measurement.

Ratio (multiply by)	**Total Resistance in ohms**	**Least step (ohm)**
0.001	0 to 11.110	0.001
0.01	0 to 111.1	0.01
0.1	0 to 1111.0	0.1
1	0 to 11110	1
10	O to 111100	10
100	0 to 1111000	100
1000	O to 11.11 M ohm	1000

3. Set the initial/ final switch to initial position and press the press key and adjust the four-decade resistance dials until the galvanometer pointer reads zero and then set the initial/final switch to final position & adjust the dials for final balance point.

4. Note the readings of the four-decade dials and the multiplier dial.

Then the unknown resistance can be calculated as follows.

Unknown Resistance = (Decade resistance reading X multiply by dial readings)

Result: - Hence, we have studied the low resistance by using whetstone bridge.

Precautions:

1. Connections should be tight.

2. Instrument should be handled carefully

Experiment No- 2

Objective: Measurement of capacitance by de-Sautys bridge

Theory: – De Sauty Bridge is an AC bridge used to find the unknown capacitance in a circuit. French engineer Paul de Sauty invented it. De Sauty Bridge compares the unknown capacitance with another standard or known capacitor. It can also be used to compare the capacitors used in a circuit. De Sauty Bridge has a high degree of accuracy in measuring unknown capacitance over a wide range of capacitances. It works on the principle of null deflection. It is the simplest way to compare two pure(non-inductive) capacitors. The circuit design of the De Sauty Bridge is very simple and straightforward and the calculations are also simple. However, it can only measure capacitors that are free from dielectric loss.This bridge is used to determine unknown capacitance by comparing it with known standard capacitor.

Arm of the bridge are as follows: –

1. The first arm ab contains a loss free unknown capacitor C_1μF.
2. The second arm ad contains a known capacitance in the form of single decade of 10* 0.01μF.
3. The third arm bc contains a non-inductive variable resistance R_3 in the form of three decades of 10*10Ω, 100*100Ω, and 10*1000Ω.
4. The fourth arm cd also contains a non-inductive variable resistance R_4 in the form of three decades of 10*10Ω, 100*100Ω, and 10*1000Ω.
5. An oscillator of 1kHz is used as supply.
6. 4mm sockets are provided to connect head phone.

The four arm Impedance of the bridge are,

$$Z_1=(-j/wC_1)$$

$$Z_2=(-j/wC2)$$

$$Z_3=R_3$$

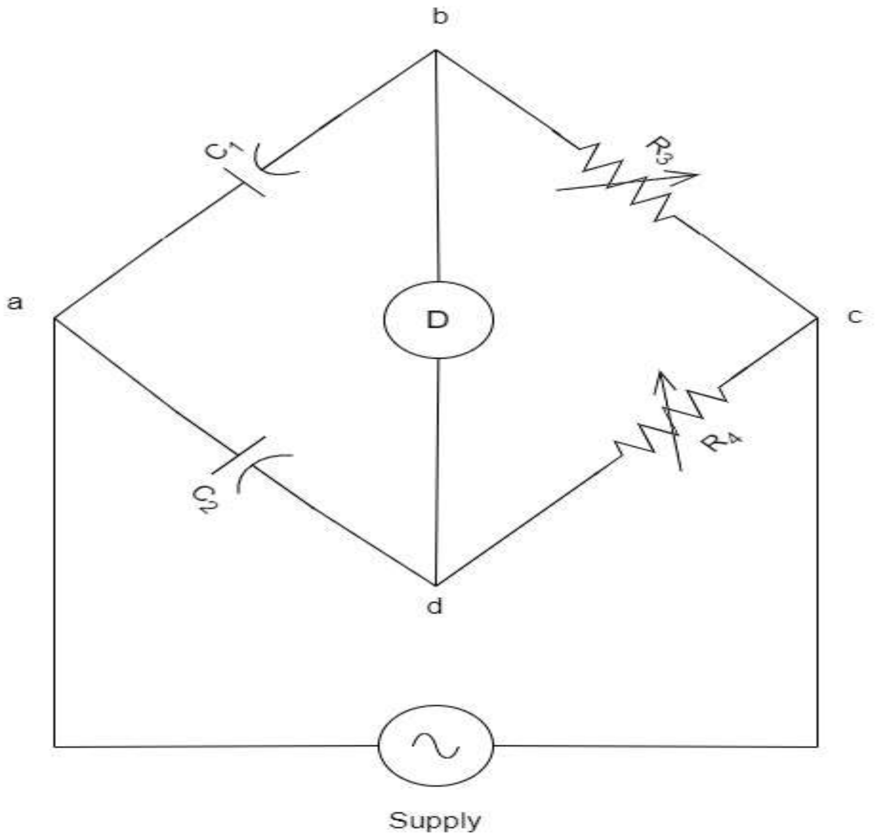
$$Z_4=R_4$$

Under balanced condition of the bridge,

$$Z_1Z_4=Z_2Z_3$$

$$C_1=(R_4/R_3)C2$$

Circuit Diagram:



De-Sauty's Bridge

Procedures: –

1. Keep C_2 at a certain value.
2. Now adjust the decade resistance dial R_3 and R_4 so as to minimize the second in the headphone.
3. Note the value of resistance dial R_3, R_4 and C_2 and calculate the value of unknown capacitor C_1 using above formula.
4. Repeat the above procedures for all other values of the capacitor C_1.

Observation Table: –

Sl. No	C_2 in farad	R_3 in Ohms.	R_4 in Ohms.	C_1 in farad
1				
2				
3				
4				
5				
6				
7				
8				

Calculation: $C_1=(R_4/R_3)C_2$

Experiment No. 3

Objective: Measurement of an unknown self-inductance using Anderson bridge.

Main Features of the bridge:

R- Single decade resistance dials having value 100x10Ω and continuously

variable resistance from 0-100 ohms connected in series with the dial R

r--- Three-decade resistance dials having value 10x1000Ω, 10x100Ω and 10x10Ω

P=Q----Fixed standard resistances having value 1000 ohms.

C-----Two Fixed standard capacitors having value 0.1µf and 0:2µf. (loss free)

Unknown inductance.

Terminals are provided for external connections to connect unknown inductance,

supply and head phone

Formula used:

$$L = C\,R\,(Q+2r)$$

Where Q is a known standard resistance 1000 ohms and C is a standard known capacitor 0.1µf. R and rare known resistances from resistance dials.

Procedure:

DC Balance: -

1. Connect DC supply 3 volts with the terminals marked supply, unknown inductance with the terminals marked unknown and galvanometer in series with a press key with the terminals marked D.
2. Set the resistance dial r to zero position.
3. Now adjust the decade resistance dial R to find out the balance point in the galvanometer.
4. Note the value R and Q.

Or

Note: you can measure the resistance of inductance with any digital multimeter available in the lab and then the value of R can be adjusted at the same value

AC Balance: -

1. Without disturbing the position of the bridge, connect oscillator 1 KHz instead of DC supply and head phone instead of galvanometer.
2. Set the capacitor C at 0.1uf.
3. Now adjust the resistance dial r to minimize the sound in the headphone.
4. Note the value resistance dial rand C and calculate the value unknown inductance using above formula.
5. Repeat the experiment at another value of C.

Note: the value of unknown inductance is --- 100 mh app, res. - 80 ohms If minimum sound at balance point is not achieving properly, then interchange the terminals of oscillator and perform the experiment again.

Experiment No.4

Objective: - Measurement of the unknown self -inductance by using Maxwell inductance bridge method.

Theory:

Maxwell Inductance Bridge is an AC bridge used to measure the inductance. 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.

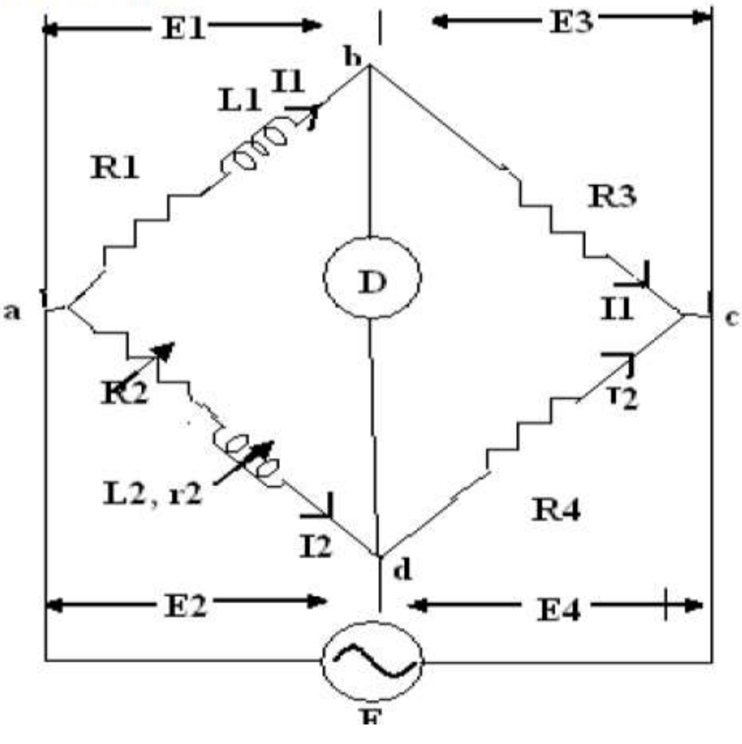
Let, L1 = unknown inductance of resistance R1,

L2 = variable inductance of fixed resistance r2,

R2 = variable reance 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.

Note: value of unknown inductance is 10 Mh

Experiment No.5

MAXWELL INDUCTANCE CAPACITANCE BRIDGE

Objective: Measurement of an unknown self-inductance using Maxwell Inductance - Capacitance Bridge.

Theory: Maxwell Inductance Bridge is an AC bridge used to measure the inductance. This Bridge circuit measures an Inductance by comparison with the variable self-inductance. The connection & Phaser diagram of the bridge under balance conditions. Maxwell's Bridge, named after the renowned physicist James Clerk Maxwell, is a type of bridge circuit used for measuring unknown electrical parameters. It is specifically designed for measuring self-inductance and mutual inductance. The bridge is constructed using resistors, capacitors, and inductors, and it operates based on the principle of balanced bridge circuits, where the ratio of two impedances is compared.The main idea behind Maxwell's Bridge is to balance the bridge circuit by adjusting known components until there is no current flowing through the galvanometer. This balanced condition indicates that the ratio of the impedances in the arms of the bridge is equal, allowing for the calculation of the unknown parameter – in this case, self-inductance.

Main Feature of the bridge:

C -Three-decade capacitance dials having value *1uf, *0.1uf and *0.01µf.

R-Single decade resistance dial having value 10 * 100 ohm and a continuously variable resistance 0-100 ohms connected in series with dial R.

L- Unknown inductance.

Q-Two fixed standard resistances having value 1000 ohms & 100 ohms.

P-- Fixed standard resistance having value 1000 ohms.

Terminals are provided for external connections to connect unknown inductance, AC supply and head phone.

Formula Used **L = QRC**

Where Q and R are known standard resistances and C is a standard known capacitance.

Procedure:

DC BALANCE

1. Connect DC supply 5 Volts with the terminals marked supply, unknown inductance with the terminals marked **unknown** and a galvanometer in series with a tapping with the terminals marked D.

2. Set the resistance Q at 1000-ohm position.

3. Now adjust the decade resistance dial R and continuously variable R to find out balance point in galvanometer.

OR

Note: -- you can measure the resistance of inductance with any digital multimeter available in the lab and then the value of R can be adjusted at the same value.

AC BALANCE

1. After DC balance without disturbing the position of the bridge (or set the resistance dial R at the value measured by the digital mustimeter). Connect the AC supply 1 khz instead of DC supply and head phone instead of galvanometer.

2. Now adjust the capacitance dial C to minimize the sound in the head phone.

3. Note the value of C and calculate the value of unknown inductance by using above given formula.

4 .Repeat the above procedure at 100 ohms.

Note: -- the value of unknown inductance is --- 100 mh and, resistance is. – 80 ohms If minimum sound at balance point is not achieving properly, then interchange the terminals of oscillator and perform the experiment again.

Experiment No. 6

Objective: Measurement of unknown capacitance using Schering bridge.

Main Features of the bridge:

R_1--Three-decade resistance dials having value 10x1000Ω, 10x1000Ω and 10x100Ω

R_2-- Two fixed standard resistances having value 1000 ohm & 100 ohms.

R_3-- Single decade resistance dial having value 10x1000Ω

C_1--Unknown capacitor.

C_2-- Fixed standard capacitor having value 0.01 µf (loss free)

C_3--Single decade capacitance dial having value 10x0.001 µf.

Terminals are provided for external connections to connect unknown capacitor, AC supply and head phone

Formula Used:

$$C_1=R_1/R_2xC_2$$

Where R_1 & R_2 are known standard resistance and C_2 is a known standard Capacitor.

Procedure:

1. Connect the AC supply 1khz with the terminals marked supply, unknown capacitor with the terminals marked unknown and head phone/digital null detector with the terminals marked D.
2. Set the resistance dial R_3 to zero position and also set capacitance dial C_3 to zero position. And also set R_2 at 1000 ohms.
3. Now adjust the decade resistance dial R_1 to minimize the sound in the head phone or minimum readings in the digital null detector.
4. Note the value R_1, R_2 and C_2 and calculate the value of unknown capacitor using above formula.
5. Repeat the same experiment on another value of R_2 say 100 ohms.

Additional Experiment:

To determine the dissipation factor of a capacitor.

Formula used,

$$D=\omega C_1R_3$$

Where $\omega=2\Pi f$

C_1= capacitance of a capacitor

R_3= Series resistance of a capacitor representing the loss in the capacitor.

F = frequency of oscillator which is 1KHz.

Procedure:

Without disturbing the setting of the bridge introduce some resistance say 500 ohms from resistance dial Rs. There will again be some sound in the in the head phone or the digital null detector will show some readings. Now adjust the capacitor dial C_3 to minimize the sound in the head phone or minimum, readings in the digital null detector. Calculate the value of dissipation factor or power factor using above formula. (with only R_2 at 1000 ohms)

Experiment No.7

Objective: Measurement of unknown capacitance using Wein's Bridge.

Theory: –The wien's bridge is generally used to determine unknown frequency of supply. The bridge has a series R-C combination in one arm and a parallel combination in the adjoining arm

MAIN FEATURES OF THE BRIDGE: ---

P - Three-decade resistance dials having value 10 * 100ohms and 10 * 10 ohms and 10 * 1 ohms

Q-Two fixed standard resistance having value 100 ohm & 10 ohms.

R -- Two-decade resistance dials having value 10 * 10K ohm, 10 * 1K C{x} - Unknown capacitor.

R{x} Unknown resistance.

C Fixed standard capacitor having value 0.01 µf. (loss free)

Terminals are provided for external connections to connect unknown capacitor, AC supply and head phone.

FORMULA USED

$C_x = P / Q * C$

Where P & Q are known standard resistances and C is a known standard Capacitor.

$R_x = Q / P * R$

Procedure –

1. Connect the AC supply 1khz with the terminals marked supply, unknown capacitor with the terminals marked unknown and head phone marked D.

2. Set the resistance dial R to zero position and also short circuit R_x terminals with a connecting lead. And set resistance Q at 100 ohms.

3. Now adjust the decade resistance dial P to minimize the sound in the heaphone.

4. Note the value P, Q and C and calculate the value of unknown capacitor using above formula.

5. Repeat the experiment at another value of resistance Q.

ADITIONAL EXPERIMENT

MEASUREMENT OF UNKNOWN RESISTANCE

1. Without disturbing the position the bridge, disconnect the connecting lead From R_X terminals. There will again be some sound in the head phone.

2. Now adjust the decade resistance R to minimize the sound in the head phone

3. Note the value of P, Q and R and calculate the value of unknown resistance Rx using above given formula.

PRECAUTIONS:

1. Connections must be tight.

2. Impedances in four arms of the bridge should be of same order so that the bridge is most sensitive.

3. The surrounding should be peaceful and noise less. Initially the intensity of source should be kept low and at balance point it should be increased

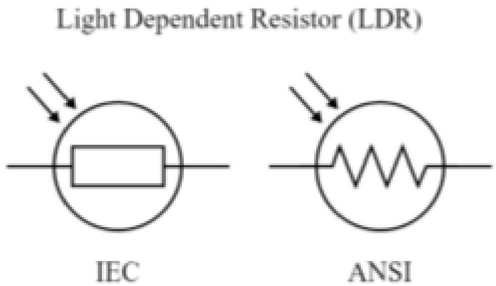
Experiment No. 8

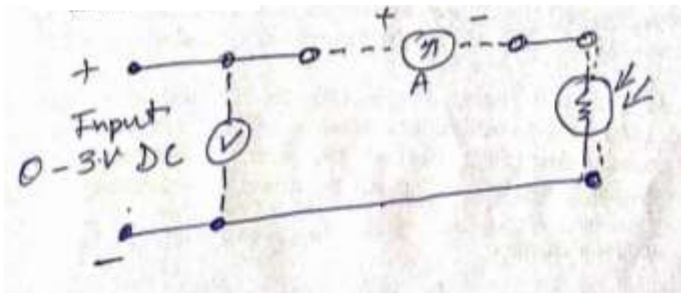
Objective: To study the characteristics of LDR, Photodiode and Phototransistor:
1) Variable Illumination 2) Linear Displacement

Equipment: One DC regulated power supply of 0-3 volts, phototransistor (red terminal for collector and black terminal for emitter), LDR, photodiode, voltameter 0-3-volt DC, DC milliammeter, and one lamp with stand.

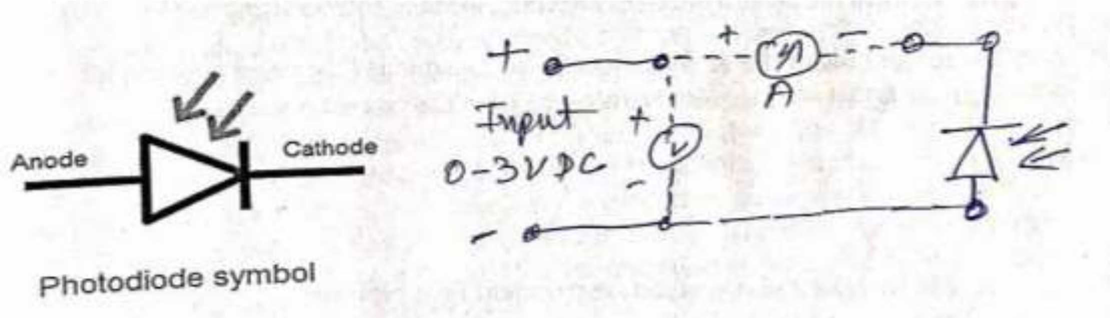
Theory: figure 1. Shows the standard symbol of n phototransistor which can be regarded as a conventional transistor housed in a case that enable its semiconductor functions to be exposed to external light. The device is normally used with it, base open circuit. The collector junction of the transistor is effectively reverse biased and thus acts as a photodiode the photo generated current of the base-collector jwlction feed directly in to the base of the diode and normal current amplifying transistor action causes the output current to appear(greatly amplified form)as collector current.in practice the collector and emitter current of the transistor are virtually identical and since base is open circuit, the device is not subjected to significant negative feedback. The sensitivity of a phototransistor is typically one hundred times greater than that of a photodiode, but its useful maximum operating frequency (a few hundred kilo hertz) is proportionally lower than that of a photodiode (ten of megahertz). A phototransistor can be converted in to a photo diode by using only its base and collector terminal and ignore the emitter.

LDR: A light dependent resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it. A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on thedevice, the electrons in the valence band of the semiconductor material are excited to the, conduction band These photos in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR.

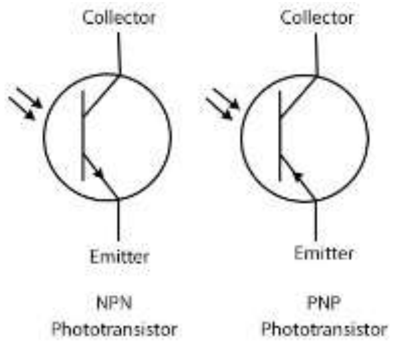


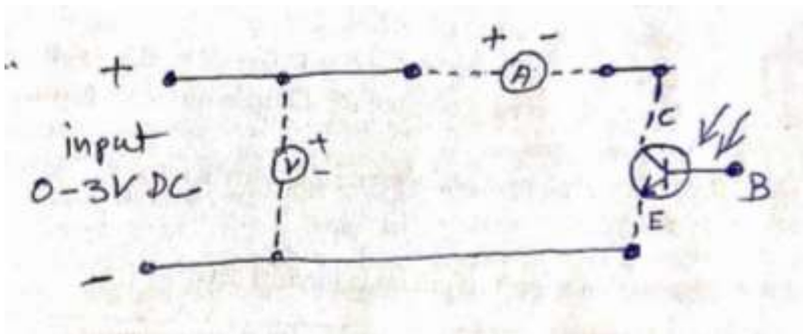


Photodiode: The semiconductor photodiode is a light detector device which detects presence of light. It is used to convert optical power into electrical current.PN junction Photo diode have P type and N type semiconductor forms junction. Thin P type layer is deposited on N type substrate. P-N junction has a space charge region at the interface of the P and N type material. Light enters through P-layer as shown in the following figure. This diode has relatively thin depletion region around the junction. It is reverse biased to increase width of the depletion region. Photons of light entering in P-layer ionize electron-hole pair. Photon generates electron-hole pair in the depletion region that moves rapidly with the drift velocity by the electric field. Responsivity is important technical term related to the photodiode. It is ratio of photocurrent to incident optical power. Responsivity of the photodiode is proportional to width of the junction. Photo diode is used in fiber optic comminution at receiver side. It detects incoming light from the fiber end and converts it into electrical signal. It can be also used in remote control receiver.



Phototransistor: a transistor, usually bipolar, in which minority carriers are injected on the basis of an internal photoelectric effect. Phototransistors are used to convert light signals into amplified electric signals. A phototransistor consists of a single crystal Ge or Si semiconductor wafer in which three regions arc produced by means of special technological processes. As in n conventional transistor, the regions are called the emitter, collector, and base; as a rule, the base has no lead. The crystal is placed in a housing with a transparent window. A phototransistor is connected to an external circuit in the same way as a bipolar transistor with a common-emitter connection and a zero-base current. When light is incident on the base or collector, charge carrier pairs (electrons and holes) are generated in that region; the carrier pairs arc separated by the electric field in the collector junction. As a result, the curriers accumulate in the base region, causing a reduction of the potential barrier in the emitter junction and an increase, or amplification, of the current across the phototransistor in comparison with the current that is due only lo the migration of carriers generated directly by the action of the light.





As with other photoelectric devices, such as photocells and photodiodes, the main parameters and characteristics of phototransistors are the luminous sensitivity, spectral response, and time constant. The luminous sensitivity is the ratio of the photoelectric current to the incident luminous flux. For the best specimens of phototransistors-for example, diffused planar devices the luminous sensitivity may be as high as 10 amperes per lumen. The spectral response, which is the sensitivity to monochromatic radiation as a function of wavelength, defines the long-wavelength limit for the use of a particular phototransistor, this limit, which depends primarily on the width of the forbidden band of the semiconductor material, is 1.7 micrometres for germanium and 1.1micro meters for silicon. The time constant characterizes the inertia of a phototransistor and does not exceed several hundred microseconds. In addition, a phototransistor is characterized by the photoelectric gain, which may be as high as 10^2-10^3.

Procedure:

LDR

1. Connect the output of DC power supply (0-3 VDC) to the input of the LDR circuit. Also connect voltmeter, current meter and LDR in the circuit through patch cords shown by doted lines.

2. Place the lamp holder and LDR on a graduated wooden stand opposite to each other. Connect the lamp to AC mains and focus the light on LDR. Select the range of current meter to 5mA.
3. Switch on the instrument (power supply unit) using ON/OFF toggle switch provided on the from panel.
4. Now increase the power supply voltage in small step and every time note down the voltage & current in observation table. Calculate the resistance value of LDR by using formula R = V/I
5. Vary the distance (d) between LDR & light source and repeat the experiment again.
6. Plot a graph between resistance (R) vs Distance (d^2, SQURE).
7. also note down the current (mA) for different distances between LDR & light source for fixed voltage.

Photodiode

1. Connect circuit as shown in figure.
2. Maintain a known distance between the bulb and photodiode say 5cm
3. Set the bulb voltage, vary the voltage of the diode in steps of 1V and note the diode current Ic.
4. Repeat above procedure for V=4V, 6V, etc.
5. Plot the graph: V Vs Ic for constant V

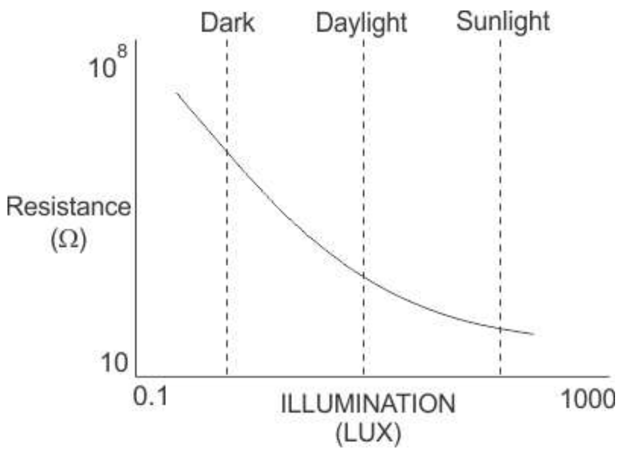
Phototransistor

1. Connect the output of DC power supply (0-3 V DC) to the input of the photo transistor circuit. Also connect volt meter, current meter and photo transistor in the circuit through patch cords shown by circuit diagram.
2. Place the lamp holder and photo transistor on a graduated wooden stand opposite to each other. Connect the lamp to AC mains and focus the light on photo transistor.
3. Switch ON the instrument (power supply Unit) using ON/OFF toggle switch provide on the front panel.
4. Now increase the power supply voltage in small step and every time note down the voltage and current in table no. 1.
5. Plot a graph between voltage and current by taking voltage along X axis & current along Y axis. 6. Repeat the same procedure for different distances between photo transistor and lamp wen circuit is reverse bias.
6. Plat a graph between distance and current by taking distance along X axis & current along Y axis.

Observation table:

LDR

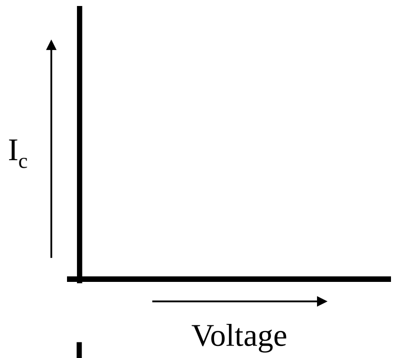
SI. No.	Distance of lamp from LDR (d) cm	Voltameter reading (V) in volt	Milliammeter reading (I) mA	Resistance of LDR (R=V/I)	d^2



Photodiode

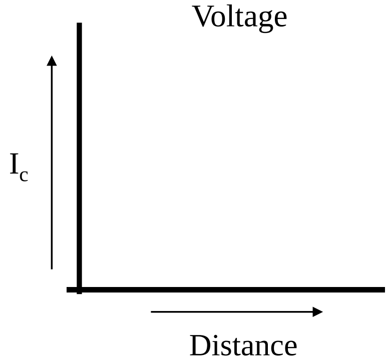
If circuit is forward bias

SI. No.	Voltage(V)	Collector current (I_c)



If circuit is reverse bias (Voltage constant)

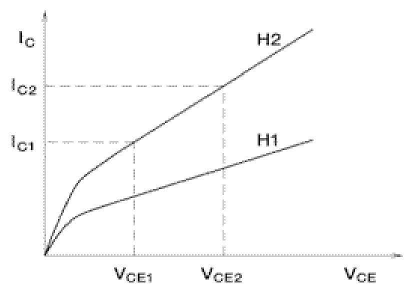
SI. No.	Distance (d) or intensity of light	Current (I_c)



Phototransistor

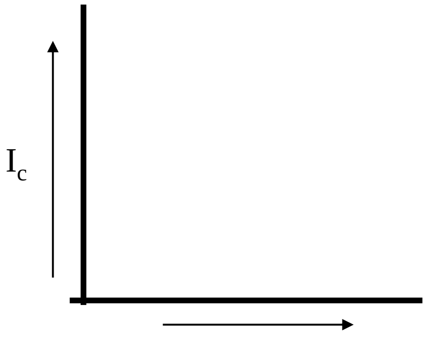
If circuit is forward bias

SI. No.	Collector Voltage(V)	Collector current (I_c)



If circuit is reverse bias (Voltage constant)

SI. No.	Distance (d) or intensity of light	Collector current (I_c)



Results:

1. Forward resistance of LDR is …………..
2. The forward resistance of photodiode is ……………and found the reverse current (I_c) (decreases when the intensity of light decreases, distance between lamp and transistor increases)
3. The forward resistance of phototransistor is ……………and found the reverse current (I_c) (decreases when the intensity of light decreases, distance between lamp and transistor increases)

Precautions:

1. Firstly, read about complete experiment then perform
2. Connect circuit properly according to diagram.
3. Check connecting wires before use.
4. Connect current meter in series only.

Experiment No. 9

Objective: To determine the characteristic of Linear Variable Differential Transformer (LVDT).

Equipment: LVDT, Resistor, signal generator, DMM, CRO, Digital multimeter, connecting wires etc.

Theory: Position transducers are used widely in industrial and applications, among them the linear variable differential transformer (LVDT) is excellent in performance compared to potentiometric transducer to measure position and displacement. Displacement is the vector representing a change in position of a point with respect to a reference point. It can be either rotary or linear. The linear variable differential transformer type of displacement transducer particularly suitable as a short stroke, position measuring device. In given set up the open cage construction is provided to observe the basic construction of device.

1. Construction:

The LVDT consists of two identical secondaries (symmetrically placed on both sides of primary). one primary coil and a movable core called actuator. The displacement to being measured is transferred to the magnetic core in flux linkage. When the primary coil is connected to a sinusoidal excitation source, the amount of voltage on the secondary S, and S, depends on the position of the core m(x) or m_2(x) corresponding to null position x. There are three positions can be accounted, (1a) core is placed centrally (within the primary coil area) hence x 0, (1b) towards coil S, side where x Ax, and (1) towards coil S, side whore x-AX. In situation (1a) the minor flux linkage obtained called residual flux but as the S, and S, are connected in anti-series way the output is negliable due to phase cancellation between these minor voltages. In position, b the S, and primary position, b the S, and primary have maximum linkage the output voltage e, will be more than (a) in polarity similar to (or closer to the excitation signal. In position (c) the output voltage e, will be again more than (a), but in opposite polarity than e. The magnitude of output voltage e, depends upon the displacement of the core to either side, while the polarity depends upon the core position. Thus, LVDT is a transformer which can produce an output voltage in according to displacement and position,

2a. The L.V.D.T.:

As per construction it is fitted upon the top of the panel, has two identical secondaries one primary. The actuator is moved far and fro with respect to center through a micrometer attachment length of the coils are made slight larger to observe the effect of linearities of the transformer and demodulating circuitry. The complete construction is fitted in acrylic cage to secure from dust. The connections are made internally and brought out upon panel for observation of electrical signa's. The LVDT has range up to 10mm, which is extended up to + 15mm

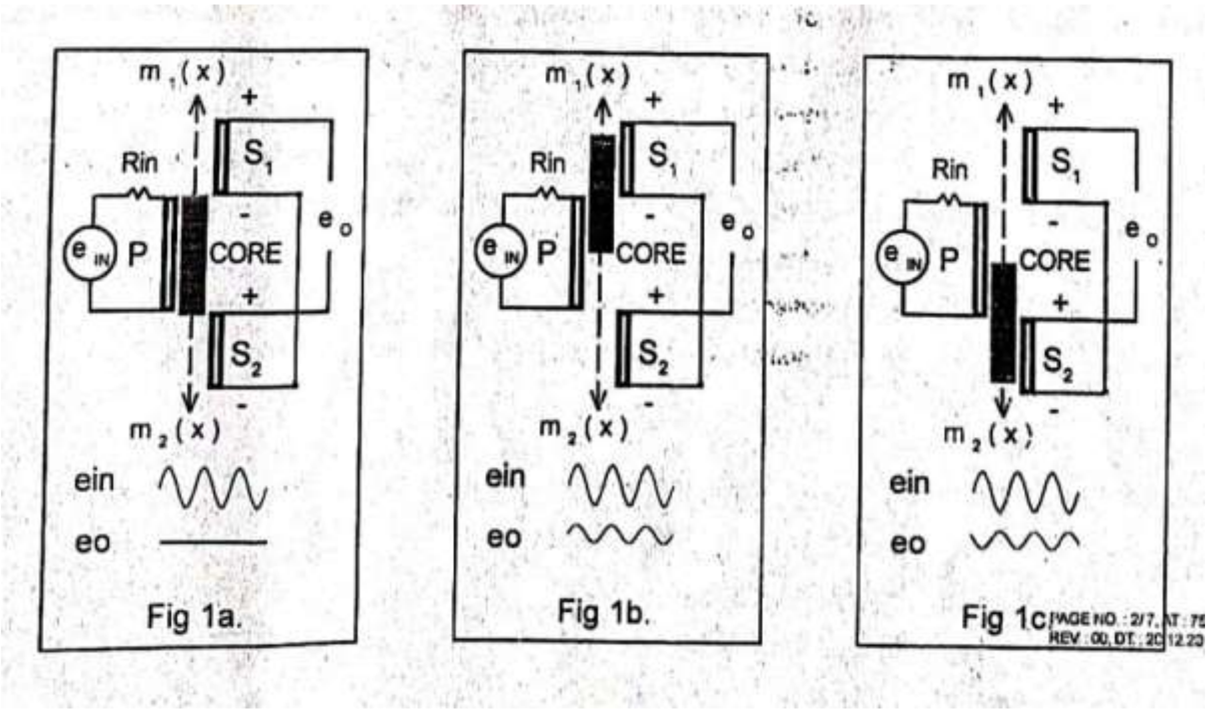


Fig 1a. Fig 1b. Fig 1c

2b. The Balanced Demodulator:

Shown as basic block it receives output signals from the secondary of the transformer compare it with excitation signal to produce phase sensitive dc output: A two quadrant multiplier IC MC 1596L, is used as balanced demodulator. The offset correction is involved with the IC circuitry to null cut the residual voltage when the actuator is placed centrally

2c. The Scaler:

The dc voltages obtained from balanced demodulator are not sufficient for measuring or scaling purpose. It also contains some ripples voltage which are superimposed upon do voltages. A scaler circuit is used to scale t the incoming de voltage to required output voltage. An op-amp is used for scaling purpose which has gain factor of k = V req/vin. The gain control is fitted upon panel to me quired scaling.

2d. Display Unit:

It is a $3^1/2$ digit digital voltmeter has + 1.999 volk f. s. d reading. The decimal point is shifted to 2nd digit position thus a resolution of 0.01 mm 001 volt achieved. it is connected with the output of scaling op-amp output.

2e. A.F. Osc:

A built-in audio frequency oscillator provided as internal excitation source. It has 8Vpp output at 2.25 Khz app. A miniature toggle switch fitted upon panel by mean of it internal oscillator can be disabled thus external excitation signal may feed to LVDT.

2f. Power Supplies:

The board consists internal regulated do supplies necessary for the circuitry and display.

3. Circuit Theory:

The output signal of LVDT may be written as eo, as a function of the core position and input signal ein. The relation between eo and ein is given by

$$\text{eo} = \text{ein}\,\frac{j\omega(M1(x)-M2(x)}{\tau+j\omega\, Lp}$$

Where M1 (x) and M2 (x) are the mutual inductances between the primary and the two secondaries as a function of position of the actuator, and is the wavelength of signal. The above equation shows that the output voltage is also a function of frequency also. The sensitivity is proportional to frequency fand the primary Current Ip and for best linearity Ax << w, where w is width of primary coil. The large Ip result in core saturation, hence larger harmonics at null position making adjustment difficult. A resistance in saries with primary limit this current Ip to reasonable value.

Procedure:

NOTE: Before conducting experiment, a warm up period of at least 3 minutes should be given to thermally stabilize the internal circuitry.

1. Connect the instrument into mains and Switch "ON" the power using ON/OFF Switch.
2. Connect CRO one channel (ground lead with ground) across the primary of LVDT sockets. Connect other channel with secondary output.
3. Select internal oscillator mode by mean of switch provided upon panel. Measure input voltage ein, across primary by CRO
4. Adjust micrometer (actuator) to read zero (0) on its scale. Adjust zero adjust control provided near scaler gain control to read DPM 0.00. Observe that trace upon CRO

connected across secondary has lowest amplitude. To observe it rotate micrometer slightly to both side in respect of 0 mark see that amplitude is minimum at balance condition.

5. Observe residue ac signal (with its noise level) as residual ac signal. To measure ac output voltage at secondary better to use ac millivoltmeter.
6. Increase/decrease (rotate) micrometer to either side upto 2 mm. Adjust scaler gain control for the displaced reading i.e. 2.00 or -2.00 mm.
7. Readjust micrometer to again '0' position and note that for any shift, if occurred recorrect it with zero adjust control
8. Repeat step 7 again to ensure the scaler adjustment.
9. Rotate micrometer (μ meter) towards same position (step 6) and note the readings of ac output voltage at secondary as eo.w.r.t. μ meter reading & at DPM as displacement reading, w.r.t μ meter in mm upto 10 mm.
10. Rotate micrometer in other direction towards outside and adjust 2.00 mm calibration as before to null out the μmeter lag and residue effect. Note the readings from 0 to 10 mm as above step.
11. Prepare a Table (1) from the results.
12. Plot DPM reading or S1 output voltage (measured either peak to peak from CRO or rms by meter) versus displacement from Table (1). Find out the useful range from the linear part of the curve. From the slope of curve in linear region (may be taken upto 5mm).

Sensitivity of LVDT = $\frac{Output\ voltage}{Displacement\ in\ mm}$ in V/mm

& percentage of accuracy in useful area

$$\%\ \text{Accuracy of LVDT} = \frac{\delta\ displayed\ reading}{Displacement\ (\mu\ meter)} \times 100$$

Observation table: Table 1 (Displacement v/s Display reading in pp/rms)

SI. No.	↑ S1 AC* (volt)	↓ S1 AC V (volt)	μ meter (mm)	↑ Display (mm)	↓ Display (mm)
			0		
			1		
			2		
			3		
			4		
			5		
			6		
			7		

Standard Accessories

1. Instructional Manual : 1No

Optional Accessories

1. Dual Trace CRO. 20 MHz :1No
2. Faction Generator :1No
3. Digital Multimeter :1No

Results:

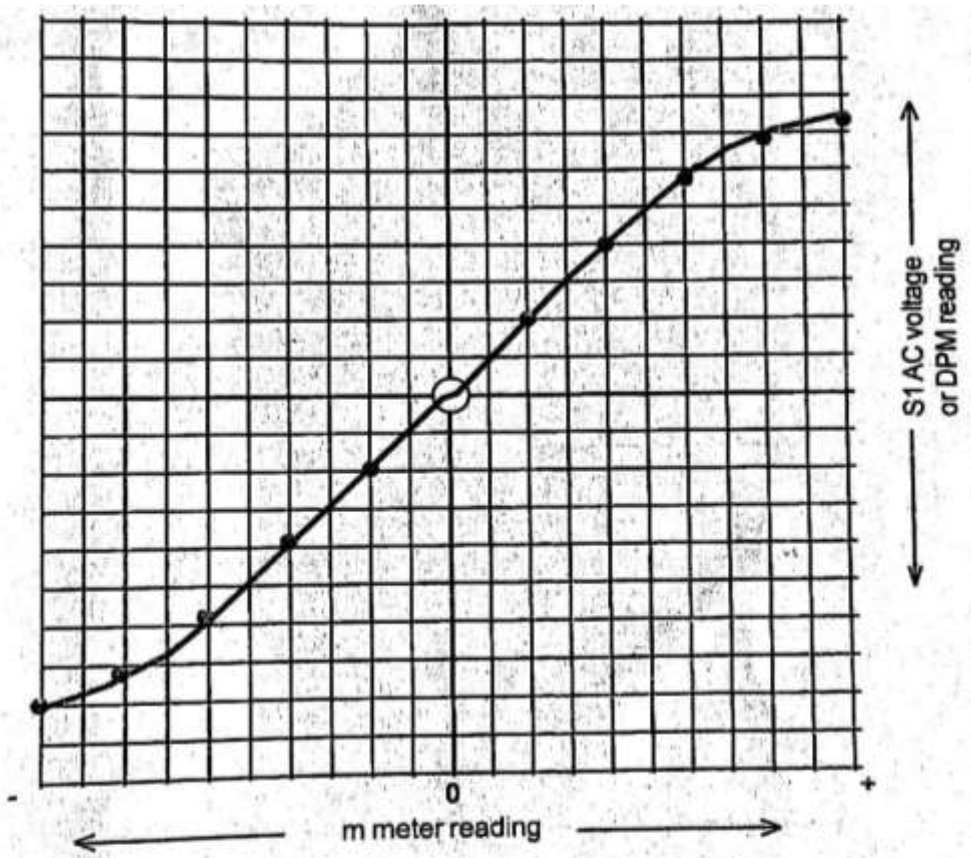


FIG. (2) LVDT S response curve : Plot of micrometer reading v/s display reading.

Encircle area show residue voltage with lag.

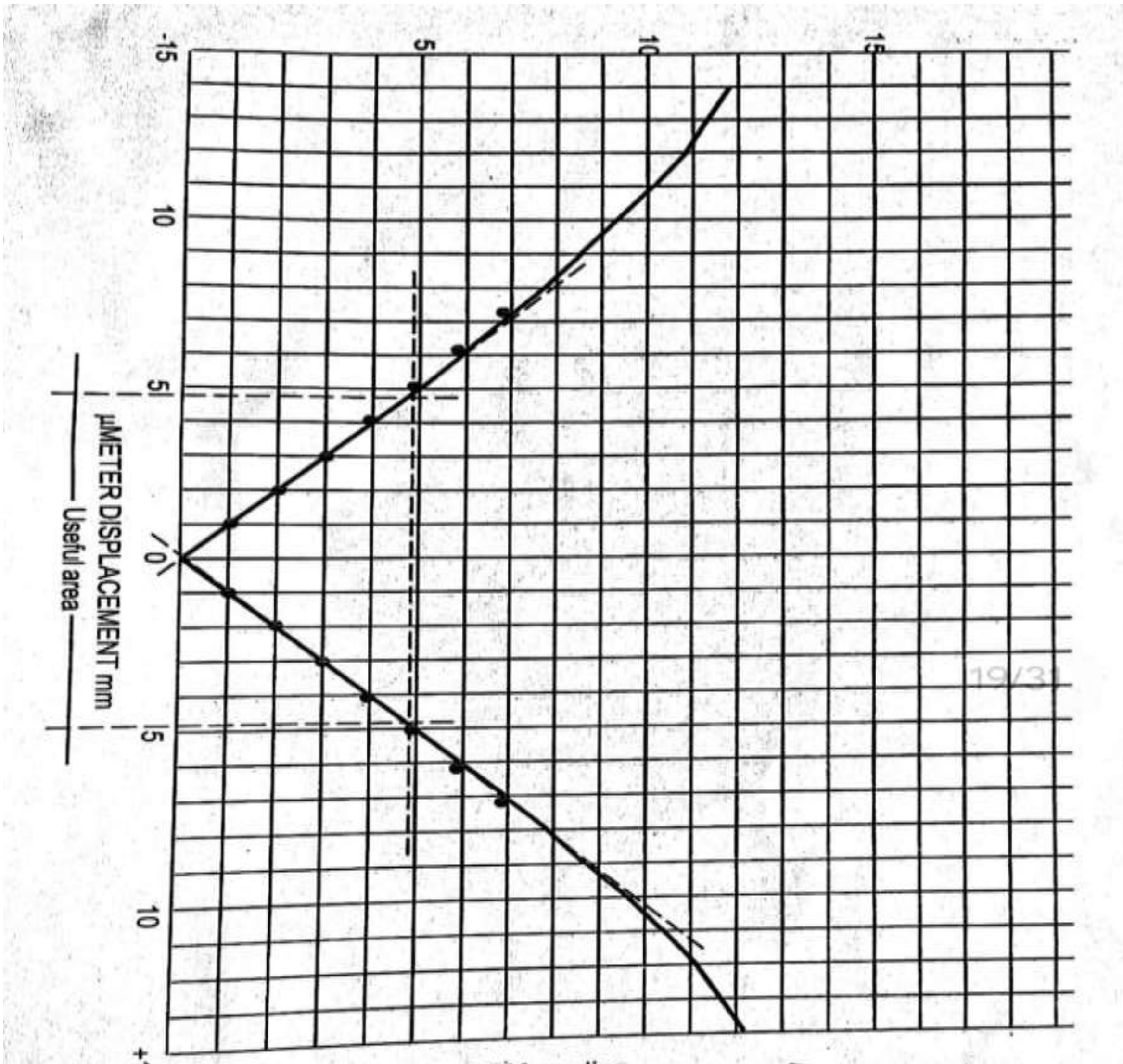


FIG. (3) L.V.D.T Characteristic Wing Curve

Precautions:

1. To get the good performance from the tutor you take to maintain the room temperature.
2. To check the power source, it should be 230 volts + 10%, 50 Hz to avoid over voltage hazardous.
3. To get best performance you take to put the instrument at dust proof and humidity free environment.

Experiment No. 10

Objective: To determine the characteristic of Thermistor and RTD.

Equipment: Thermistor, rheostat, voltmeter, multimeter, oil bath/ Heating Lamp arrangement.

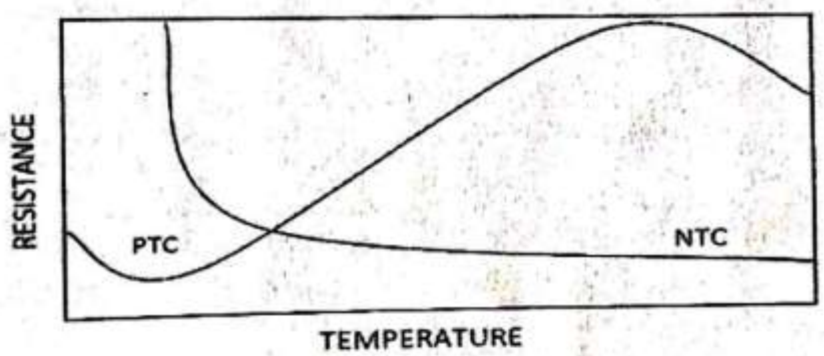
Theory:

A thermistor type of resistor whose resistance strongly depends on temperature. The word thermistor combination of words "thermal" and "resistor". A thermistor temperature- sensing element composed sintered semiconductor material sometimes mixture of metallic oxides Mn, Ni, Co, Fe, which exhibits a large change resistance proportional small change in temperature. Pure metals have positive temperature coefficient of resistance, alloys have nearly equal zero temperature coefficient of resistance and semiconductors have negative temperature coefficient of resistance.

Thermistors can be classified two types:

1. Positive temperature coefficient (PTC) thermistor: -resistance increase with increase in temperature.
2. Negative temperature coefficient (NTC) thermistor: -resistance decrease temperature.

   The thermistor exhibits a highly non-linear characteristic of resistance vs. temperature.



PTC thermistors can be used as heating elements in small temperature-controlled ovens. NTC thermistor can be used as inrush current limiting devices in power supply circuits. Inrush current refers to maximum, instantaneous input current drawn by an electrical device when first turned on. Thermistors are available in variety of sizes and shapes; smallest in size are beads with a diameter of 0.15mm to 1.25mm.

There are two fundamental ways to change the temperature of thermistor internally or externally. The temperature of thermistor can be changed externally by changing the temperature of surrounding media and internally by self-heating resulting from a current flowing through the device.

The dependance of the resistance on temperature can be approximated by following equation,

$$R= R_0 \exp [\beta\{(1/T) - (1/T_0)\}] \text{ ....(1)}$$

R is the resistance of thermistor at the temperature T (in K)

R_0 is the resistance at given temperature T_0 (in K)

B is material specific constant.

The material specific-constant of a NTC thermistor is a measure of its resistance at one temperature compared to its resistance at a different temperature. Its value may be calculated by the formula shown below and is expressed in degrees Kelvin (°K)

Differentiating (1) w. r. t. T, we get

$$\frac{dR}{dT} = -\frac{R\beta}{T^2}$$

And $\alpha = -\frac{dR}{R\, dT}$ is the temperature coefficient of the resistance

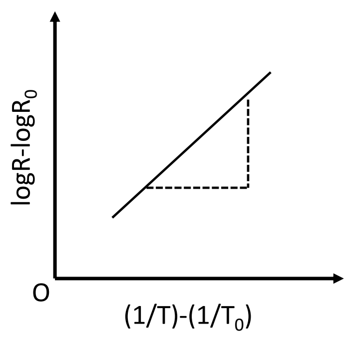
Taking log of (1) and simplifying we get,

$$\beta = \frac{logR - logR_0}{\frac{1}{T} - \frac{1}{T_0}} \text{ ....(2)}$$

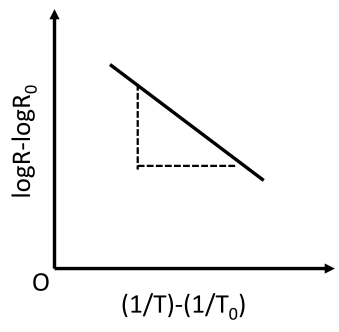
$$\alpha = -\frac{\beta}{T^2} \text{ ....(3)}$$

A graph plot with $logR-logR_0$ in y axis and $(\frac{1}{T} - \frac{1}{T_0})$ in x axis for NTC and PTC is shown below.

The slope of the graph gives the value of β.



NTC



PTC

Procedure:

1. Connections are made as shown in the figure.
2. Place the thermistor in an oil bath using the heating arrangement.
3. Note the room temperature T_0.
4. Turn on the power supply and fix to a constant voltage.
5. Note the current readings using a digital multimeter or a milliammeter.
6. Corresponding resistance is found, using equation R=V/I and is noted as R_0.

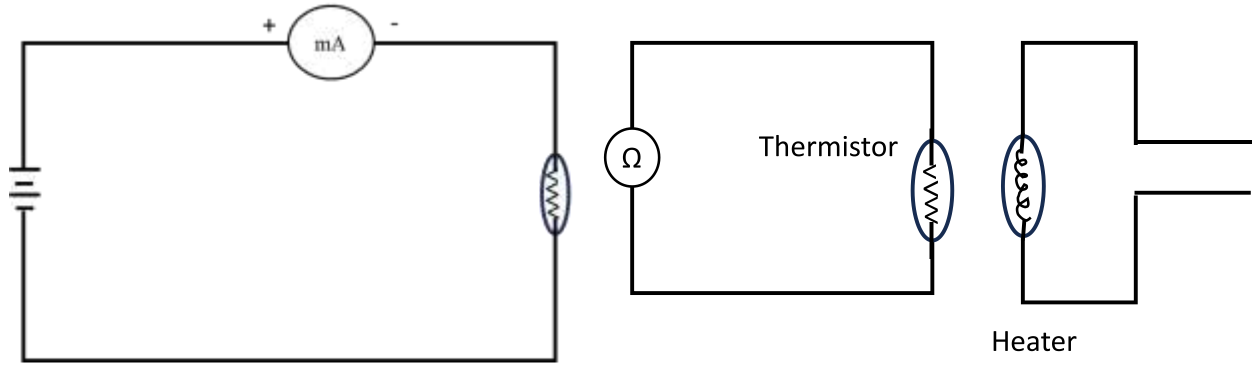
7. Vary the temperature of oil bath using the heating arrangement.
8. Note the current readings at regular intervals of temperatures.
9. Corresponding resistance R is found using the same equation.
10. From the reading, $logR-logR_0$, $1/T-1/T_0$ is calculated.

$$\beta = \frac{logR-logR_0}{\frac{1}{T}-\frac{1}{T_0}}$$

11. The value of β is calculated from equation.

$$\alpha = -\frac{\beta}{T^2}$$

12. Temperature coefficient of resistance is found from the equation,
13. Repeat the experiment for another voltage.



Observation table:

Voltage V	Temperature (°C)	Temperature (K)	Current I (mA)	Resistance R_0	$(1/T) - (1/T_0)$	$logR-logR_0$	β	$\alpha = -\beta/T^2$

SI. No.	Temperature in increasing order (°C)	Resistance	Temperature in decreasing order (°C)	Resistance
1.	…….		……	
2.	26		75	
3.	27		74	
4.	28		73	
5.	29		72	
6.	30		71	
7.	31		70	
8.	32		69	
9.	33		68	
10.	34		67	

Result:

The material constant of thermistor, β=

The temperature coefficient of thermistor, α=………..(K^{-1})

Precautions:

1. Use thermometer very carefully.
2. Don’t ON heating lamp un-necessary.
3. Draw observation table in your observation book before start reading.
4. Note reading of ohm meter with respect corresponding changes of every degree of thermometer increasing and decreasing order carefully.
5. Don't play with thermometer and ohm meter.
6. Ohm meter ON only if start reading otherwise do Off.

Experiment No. 11

Objective: To determine the Characteristics of resistance transducer-Strain Gauge (Measurement of Strain using half and full bridge).

Equipment: Strain gauge kit, cantilever beam weights, multimeter etc.

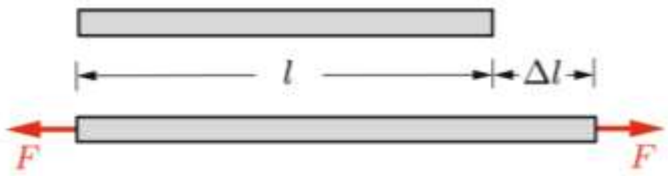
Theory:

A Strain gage is a sensor whose resistance varies with applied force and is commonly used for load, weight, and force detection. It is basically a foil resistor, whose line resistance is proportional to the length and inversely to the area of the cross section. It consists of a small diameter wire, that is attached to a backing material (usually made of plastic). The wire is looped back and forth several times to create an effectively longer wire. The longer the wire, the larger the resistance, and the larger the change in resistance. However, the change of the resistance is very small, so we need a good amplifier and measurement principle to detect such small differences. It is one of the most important tools of the electrical measurement technique applied to the measurement of mechanical quantities. Strain gages, that are glued to a larger structure under stress, are named Bonded gages. Typical strain gages have resistances range from 120 Î© to 350 kÎ© (unstressed) and are smaller than a postage stamp. This resistance may change only a fraction of a percent for the full force range of the gage, given the limitations imposed by the elastic limits of the gage material and of the test specimen. Forces great enough to induce greater resistance changes would permanently deform the test specimen and/or the gage conductors themselves, thus ruining the gage as a measurement device. That's why, in order to use the strain gage as a practical instrument, we must measure extremely small changes in resistance with high accuracy. The ideal strain gage would undergo the change in resistance only because of the deformations of the surface to which the sensor is coupled. However, in real applications, there are many factors that influence detected resistance such as temperature, material properties, the adhesive that bonds the gage to the surface, and the stability of the metal.

Strain:

As with stresses, two types of strains exist: normal and shear strains, which are denoted by ε and γ, respectively. Normal strain is the rate of change of the length of the stressed element in a particular direction. Let us first consider a bar with a constant cross-sectional area which has the undeformed length l. Under the action of tensile forces, it gets slightly longer. The elongation is denoted by Δl and is assumed to be much smaller than the original length l. As a measure of the amount of deformation, it is useful to introduce, in addition to the elongation, the ratio between the elongation and the original (undeformed) length:

$$\varepsilon = \frac{\Delta l}{l}$$



The undeformed length l and the deformed length l

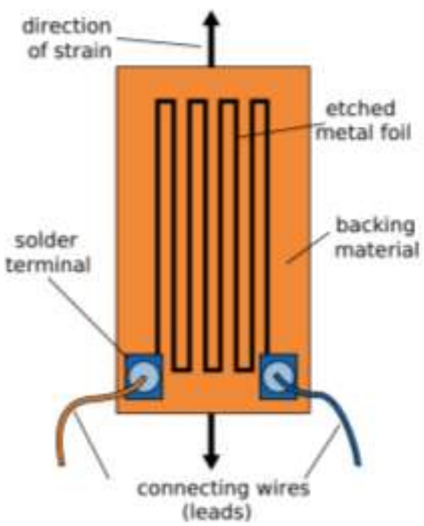
The dimensionless quantity ε is called strain.

Gage factor (GF or k)

If a wire is held under tension, it gets slightly longer and its cross-sectional area is reduced. This changes its resistance (R) in proportion to the strain sensitivity (S) of the wire's resistance. When a strain is introduced, the strain sensitivity, which is also called the gage factor (GF), is given by:

$$\text{GF} = \frac{\frac{\Delta R}{R}}{\frac{\Delta l}{l}} = \frac{\frac{\Delta R}{R}}{\varepsilon}$$

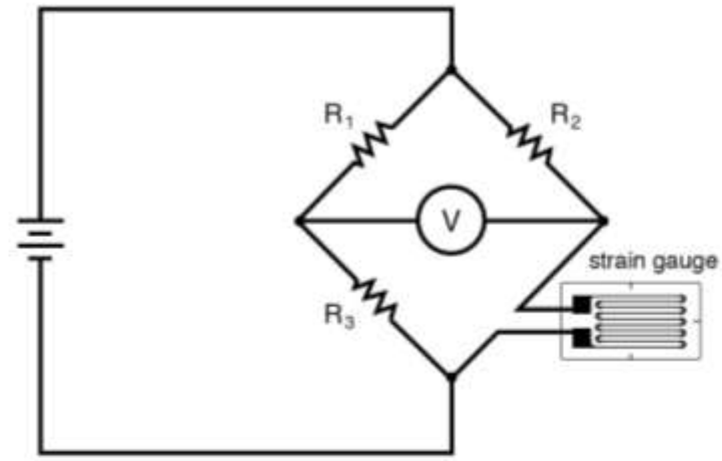
ε = strain



Strain gauge

Working of strain gauge:

The strain gauge is connected into a Wheatstone Bridge circuit. The change in resistance is proportional to applied strain and is measured with Wheatstone bridge.



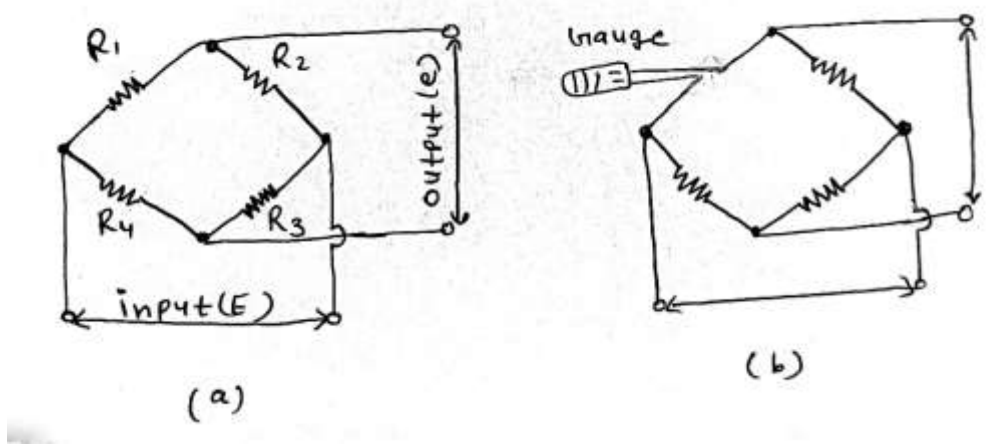
Wheatstone Bridge:

- Wheatstone bridge is an electric circuit suitable for detection of minute resistance changes, therefore used to measure resistance changes of a strain gauge.
- The bridge is configured by combining four resistors as shown in Figure.
- Initially $R_1=R_2=R_3=R_4$, in this condition no output voltage is there, e=0.
- When one of the Resistances is replaced by strain Gauge attached to the object whose strain is to be measured and load is applied, then there is small change in the resistance of gauge, hence some output voltage is there which can be related to strain as

$$e = \frac{1}{4}.\frac{\Delta R}{R}.E$$

- From this, strain can be easily determined using the relation,

$$e = \frac{1}{4}.K.\varepsilon.E$$

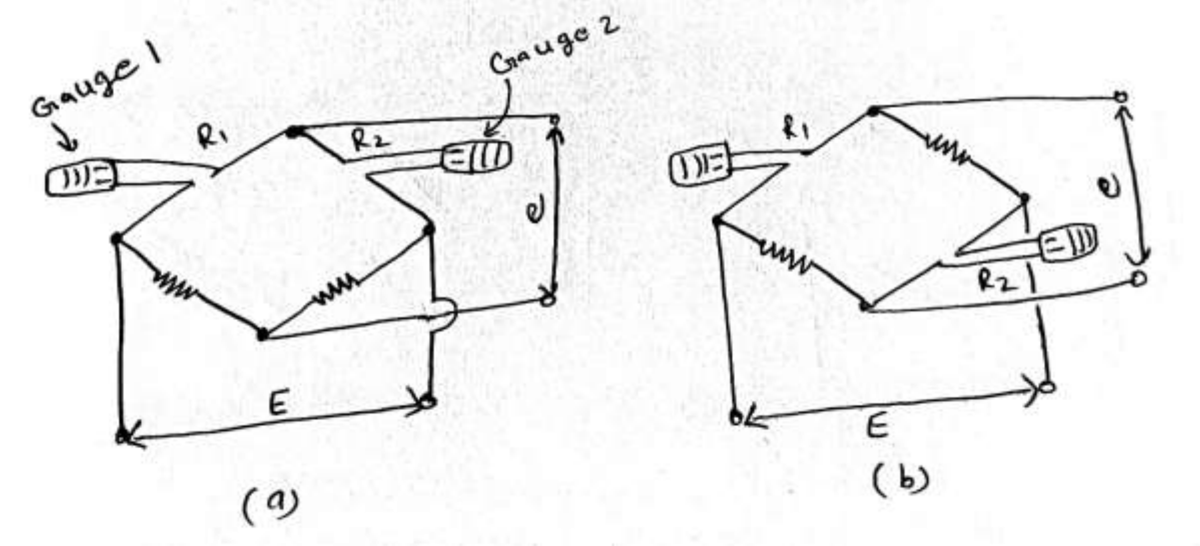


Half Bridge Configuration:

To increase the sensitivity of measurement, two strain gauges are connected in the bridge, this type of configuration is called as Half bridge as shown in figure and the output voltage and strain can be related as,

$e = \frac{1}{4} K (\varepsilon_1 - \varepsilon_2) E$, when gauge are connected to adjacent arms and

$e = \frac{1}{4} K (\varepsilon_1 + \varepsilon_2) E$, when gauge are connected to opposite arms



Full bridge configuration:

To further enhance the sensitivity, all 4 resistances are replaced by strain gauges. While this system is rarely used for strain measurement, it is frequently applied to strain gauge transducers. When the gauges at the four sides have their resistance changed to $R_1+\Delta R_1$, $R_2+\Delta R_2$, $R_3+\Delta R_3$ and $R_4+\Delta R_4$, respectively, the bridge output voltage, e is

$$e = \frac{1}{4} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4}\right) E$$

or $e = \frac{1}{4}.K\,(\varepsilon_1 - \varepsilon_2 + \varepsilon_3 - \varepsilon_4)$

Where K is the gauge factor