

**BRCM College of Engineering & Technology**

**Bahal**

**Measurement and Instrumentation Laboratory**

**(PCC-EE – 212-G)**



**LAB MANUAL**

**III SEMESTER**

Prepared By.

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***Bahal***

## INDEX

S No.	List of Experiments	Page No.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

## Measurement and Instrumentation Laboratory

Class Work:	25
Exam :	25
Total :	50

<b>Course Code</b>	<b>PCC-EE-212G</b>	
Category	<b>Engineering Science Course</b>	
Course title	<b>Measurement and Instrumentation (Laboratory)</b>	
Scheme	<b>L</b>	<b>TP</b>
	-	-2

### Notes:

- (i) At least 10 experiments are to be performed by students in the semester.
- (ii) At least 7 experiments should be performed from the list, remaining three experiments may either be performed from the above list or designed and set by the concerned institution as per the scope of the syllabus

### LIST OF EXPERIMENTS

1. To Study construction of different types of meters & study how to connect them in a circuit..
2. To calibrate a voltmeter & an ammeter using a potentiometer.
3. To study the working of a electronic energy meter (LCD/Digital display type).
4. To measure power & p.f. by 3-ammeter & 3 Voltmeter methods.
5. To study star to delta & delta to star in a Three phase system for balanced & unbalanced load.
6. To measure power & p.f in 3-phase circuit by 2-wattmeter method.
7. To measure capacitance by De Sauty's bridge.
8. To measure inductance by Maxwell's bridge.
9. To measure frequency by Wien's bridge.
10. Determination of unknown inductance & Q factor by Hays Bridge.
11. To Measure resistance using Wheatstone bridge /Post office box.
12. To measure low resistance by Kelvin's double bridge.
13. 14. To measure high resistance by loss of charge/Leakage method.
14. Study blocks wise construction of an analog oscilloscope & Function generator.
15. Determine output characteristics of a LVDT and Measure displacement using LVDT
16. Study characteristics of temperature transducer like Thermocouple, Thermistor & RTD with implementation of a small project using signal conditioning circuits like instrumentation amplifier.
17. Measurement of Strain using Strain Guage.
18. To study differential pressure transducer & signal conditioning of output signal.
19. Measurement of liquid level using capacitive transducer.
20. Study of Distance measurement using ultrasonic transducer.

### Note:

1. Each laboratory group shall not be more than about 20 students.  
To allow fair opportunity of practical hands on experience to each student, each experiment may either done by

## Experiment:1

### Aim

To measure power and power factor in a single – phase a.c. circuit using three ammeters.

### Apparatus:

voltmeter 0 – 300 V,

M.I. single phase inductive variable load rheostat 100 ohm , 5 A.

M.I. ammeter 10 A,5A,

Variac 230V,10 A

### THEORY

The circuit to be used for measurement of power in an A.C circuit using three ammeter .in a D.C. circuit the power is given by the product of voltage and current, where in ac circuit it is given by the product of voltage current and

power factor . For this reason it is not possible to find power in an a.c circuit simply from reading of ac voltmeter and ammeter. In a circuit power is normally measured by wattmeter.

This method demonstrate that the power in a single phase ac circuit can be measured by using three ammeter

Power consumed by load  $P = VI_3 \text{ COS } \phi$  .....

Where  $I_3$  is the current through load and V is the voltage across load. The phasor diagram of this circuit can be drawn by taking the supply voltage V as the reference phasor. The complete phasor diagram is shown in figure

### PHASOR DIAGRAM:

From the phasor diagram we can write:

$$I_1^2 = I_2^2 + I_3^2 + 2I_2I_3\cos\phi \dots\dots\dots 2$$

$$\text{Power factor } \cos\phi = \frac{I_1^2 - I_2^2 - I_3^2}{2I_2I_3} \dots\dots\dots 3$$

$$I_2 = V/R \text{ (R is a known resistance)}$$

Now from equation 1

$$I_3 \cos\phi = P/V \dots\dots\dots 4$$

Put the value in equation 2

$$I_1^2 = I_2^2 + I_3^2 + 2I_2I_3\cos\phi$$

$$I_1^2 = I_2^2 + I_3^2 + 2I_2P/V$$

$$2I_2P/V = I_1^2 - I_2^2 - I_3^2$$

$$P = \frac{(I_1^2 - I_2^2 - I_3^2)V}{2I_2}$$

From equation 4 we put the value of  $I_2$

$$p = \frac{(I_1^2 - I_2^2 - I_3^2)R}{2} \dots\dots\dots 5$$

**PROCUDERE:**

- (1) Make the equation as per the figure 1
- (2) Keep the rheostat at its max value
- (3) Keep the variac at its minimum position.
- (4) Switch on supply.
- (5) Increase the voltage applied using variac slowly, so that the reading of voltmeter and ammeter  $A_1$  are appreciable.
- (6) Decrease the rheostat so that the ammeter  $A_2$  gives suitable reading.

(7) Take down the readings of voltmeter and three ammeters.

(8) Change the position of rheostat and repeat step 7 a number of times.

**OBSERVATION:**

S.N.	V(volt)	I <sub>1</sub> (amp)	I <sub>2</sub> (amp)	I <sub>3</sub> (amp)	P	COS $\phi$
1.						
2.						
3.						

**CALCULATION:**

For each set of observation calculation the power consumed equation 5 and the power factor equation 3. Next take the average of all the set of calculation for  $\cos\phi$ .

**RESULT:** the power factor of circuit and the power consumed in circuit should be recorded here.

**PRECAUTIONS:**

(1) All connection should be tight.

(2) The zero setting of all meter should be checked before connecting in the circuit.

(3) The current through ammeter should never be allowed to exceeds the current rating of rheostat and load used

## Experiment:2

### AIM:

To measure power and power factor in a balanced three phase circuit using two single phase wattmeter.

Apparatus: three phase variable load, Ammeter 0-10 A .M.I. 2 nos, Wattmeter 0-5 A, 300v, 2 nos., Voltmeter 0-300 v M.I., Three phases variac.

**Theory** :Only two single phase wattmeter are sufficient to measure the total power consumed by a three phase balance circuit. The two wattmeter are connected as shown in figure 1 . The current coil are connected in series with any two lines say R AND y

$$W_1 = \sqrt{3} V_{ph} I_{ph} \cos(30^\circ - \Phi) \dots \dots \dots (1)$$

$$W_2 = \sqrt{3} V_{ph} I_{ph} \cos(30^\circ + \Phi) \dots \dots \dots (2)$$

The addition of 1 & 2 eqn. power gives

$$\begin{aligned} W_1 + W_2 &= \sqrt{3} I_{ph} V_{ph} [ \cos(30^\circ - \Phi) + \cos(30^\circ + \Phi) ] \\ &= \sqrt{3} V_{ph} \cdot I_{ph} (2 \cos 30^\circ \cos \Phi) \\ &= \sqrt{3} V_{ph} \cdot I_{ph} [ \sqrt{3} V_{ph} \cdot I_{ph} \cos \Phi \end{aligned}$$

$$W_1 + W_2 = 3 V_{ph} I_{ph} \cos \Phi \dots \dots \dots (3)$$

Sum of the two wattmeter reading gives the total power consumed in the three – phase balanced system. Since  $I_L = I_{ph}$  and  $V_L = \sqrt{3} V_{ph}$  eqn. (3) can also be written in terms of the line voltage as

$$W_1 + W_2 = 3 V_L / \sqrt{3} I_L \cos \Phi$$

$$W_1 + W_2 = \sqrt{3} V_L I_L \cos\Phi \dots\dots\dots(4)$$

To measure the load power factor angle dividing eqn.(1) by eqn. (2), we get

$$W_1/W_2 = \cos(30^\circ - \Phi) / \cos(30^\circ + \Phi)$$

$$\text{Or } W_1 - W_2 / W_1 + W_2 = \cos(30^\circ - \Phi) - \cos(30^\circ + \Phi) / \cos(30^\circ - \Phi) + \cos(30^\circ + \Phi)$$

$$= 2 \sin 30^\circ \sin \Phi / 2 \cos 30^\circ \cos \Phi$$

$$W_1 - W_2 / W_1 + W_2 = \tan 30^\circ \tan \Phi$$

$$\text{Or } \tan \Phi = \sqrt{3} [W_1 - W_2 / W_1 + W_2] \dots\dots\dots(5)$$

In this experiment one wattmeters may get a negative deflection in one of the wattmeters. In that case, the connections of either the current coil or the pressure coil of that wattmeter are reversed. The wattmeter will start giving positive deflection. This regarding to be regarded as negative while putting in eqn. (4) or (5). The Eqn. (4) and (5) have been derived for balanced three phase load,. But, these hold good for unbalanced load too.

**PHASOR DIAGRAM:**

**PROCEDURE:**

- (1) Make the equation as per the figure 1.
- (2) Keep the three phases variac at its zero position.
- (3) Keep the three phase variable load so as to have maximum impedance.
- (4) Switch on the supply.
- (5) Increase the voltage supplied to the circuit by changing the position of a variac so that all the meters give readable deflection.
- (6) Note down the reading of all the meter.
- (7) change the supply voltage and repeat the step 5 and 6 for at least six times.
- (8) If changing the supply voltage does not give sufficient number of different readings the three phase load can also be changed to take different readings.
- (9) Decrease the voltage supplied to the circuit using variac.

(10) Switch off the supply

**OBSERVATION TABLE:**

S.NO.	V	I	$W_1$	$W_2$	$P=W_1+W_2$	$P=W_1-W_2$	$\text{COS}\Phi$
1.							
2.							
3.							

**CALCULATION:**

The value of read power consumed in the load and power factor of three phase load can be calculated using equation 3 and 5 .the result should be recorded in the last three column of table.

**PRECAUTIONS:**

- (1) All connection should be tight.
- (2) The reading in ammeter should not exceed the current rating of wattmeter.
- (3) During the experiment one of the wattmeter may give a – ve deflection .the deflection can be observed easily but cannot be read because there is no marking on –ve side of the wattmeter. The connection of either the current coil or the pressure coil of the wattmeter should be reversed, then the wattmeter will give + ve deflection, the reading of that wattmeter should now be recorded with – ve sign.

### Experiment:3

#### Aim:

To measure the low resistance using Kelvin's Double Bridge.

#### Apparatus:

Kelvin's Double Bridge, galvanometer, unknown resistance, DC.

#### Theory:

Kelvin's bridge is a modification of whetstone's bridge and always used in measurement of low resistance. It uses two sets of ratio arms and the four terminal resistances for the low resistance consider the ckt. As shown in fig. The first set of ratio P and Q. The second set of ratio arms are p and q is used to connected to galvanometer to a pt d at an Approx. potential between points m and n to eliminate the effects of connecting lead of resistance r between the known std. resistance 's' and unknown resistance R .The ratio P/Q is made equal to p/q. under balanced condition there is no current flowing through galvanometer which means voltage drop between a and b, Eab equal to the voltage drop between a and c, Eamd.

Now  $E_{ad} = P/P+Q$  ;

$$E_{ab} = I[R+S + \frac{(p+q)r}{p+q+r}] \text{ -----(1)}$$

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

For zero deflection  $\rightarrow E_{ac} = E_{ad}$

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

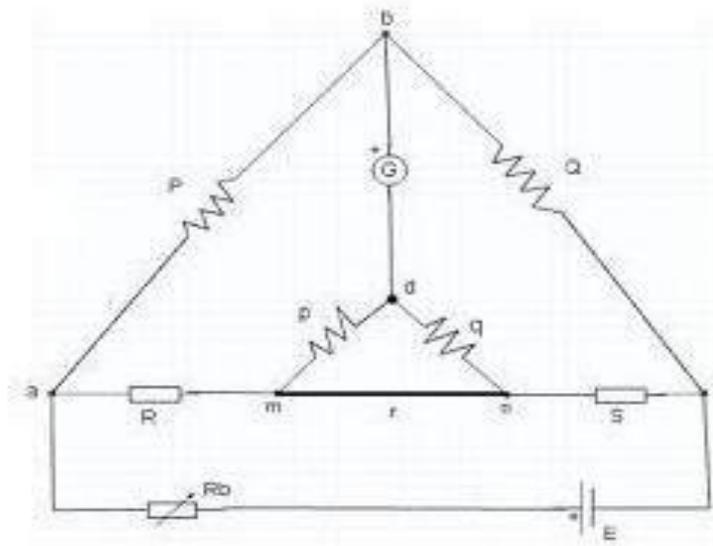
Now, if

$$P/Q = p/q$$

Then equation... (3) becomes

$$R = P/Q = S \text{ -----(4)}$$

**Circuit diagram:**



Equation 4 is the usual working equation. For the Kelvin's Double Bridge .It indicates the resistance of connecting lead r. It has no effect on measurement provided that the two sets of ratio arms have equal ratios. Equation (3) is useful however as it shows the error that is introduced in case the ratios are not exactly equal. It indicates that it is desirable to keep r as small as possible in order to minimize the error in case there is a diff. between the ratio P/Q and p/q.  $R=P/QS$

**Procedure:**

1. The unknown resistance is connected between the terminals p& p1.
2. Connect the DC supply and adjust the current to the required value.
3. The range factor is put in the power position as the standard arm (decide and slide wire) is adjusted so that the galvanometer should show null deflection.
4. The corresponding reading is multiplied by range factor.

**OBSERVATION TABLE**

S.NO.	UNKNOWN RESISTANCE	RANGE MULTIPLIER	MILIOHM DECADE	SLIDE WIRE	CALCULATE RESISTANCE

**CALCULATION:**

**RESULT:**

(1) The resistance of DC ammeter .....ohm

(2) The resistance of probe.....ohm.

## Experiment :4

**Aim:** Measurement of the unknown inductance by using Hay's bridge method.

**Apparatus:**

Multimeter, LCR meter, Hay's bridge kit, Patch cords.

**Theory:**

A Hay bridge is an AC bridge circuit used for measuring an unknown inductance by balancing the loads of its four arms, one of which contains the unknown inductance. One of the arms of a Hay Bridge has a capacitor of known characteristics, which is the principal component used for determining the unknown inductance value. Figure 1 below shows a diagram of the Hay Bridge.

As shown in Figure , one arm of the Hay bridge consists of a capacitor in series with a resistor (C1 and R2) and another arm consists of an inductor L1 in series with a resistor (L1 and R4). The other two arms simply contain a resistor each (R1 and R3). The values of R1 and R3 are known, and R2 and C1 are both adjustable. The unknown values are those of L1 and R4. Like other bridge circuits, the measuring ability of a Hay Bridge depends on 'balancing' the circuit. Balancing the circuit means adjusting R2 and C1 until the current through the ammeter between points A and B becomes zero. This happens when the voltages at points A and B are equal. When the Hay Bridge is balanced, it follows that  $Z1/R1 = R3/Z2$  wherein Z1 is the impedance of the arm containing C1 and R2 while Z2 is the impedance of the arm containing L1 and R4. Thus,  $Z1 = R2 + 1/(2\pi fC)$  while  $Z2 = R4 + 2\pi fL1$ . Mathematically, when the bridge is balanced,

$$[R2 + 1/(2\pi fC1)] / R1 = R3 / [R4 + 2\pi fL1]; \text{ or}$$

$$[R4 + 2\pi fL1] = R3R1 / [R2 + 1/(2\pi fC1)]; \text{ or}$$

$$R3R1 = R2R4 + 2\pi fL1R2 + R4/2\pi fC1 + L1/C1.$$

When the bridge is balanced, the reactive components are equal, so

$$2\pi f L_1 R_2 = R_4 / 2\pi f C_1, \text{ or } R_4 = (2\pi f)^2 L_1 R_2 C_1.$$

Substituting  $R_4$ , one comes up with the following equation:

$$R_3 R_1 = (R_2 + 1/2\pi f C_1)((2\pi f)^2 L_1 R_2 C_1) + 2\pi f L_1 R_2 + L_1 / C_1; \text{ or}$$

$$L_1 = R_3 R_1 C_1 / (2\pi f)^2 R_2^2 C_1^2 + 4\pi f C_1 R_2 + 1); \text{ or}$$

$L_1 = R_3 R_1 C_1 / [1 + (2\pi f R_2 C_1)^2]$  after dropping the reactive components of the equation since the bridge is balanced.

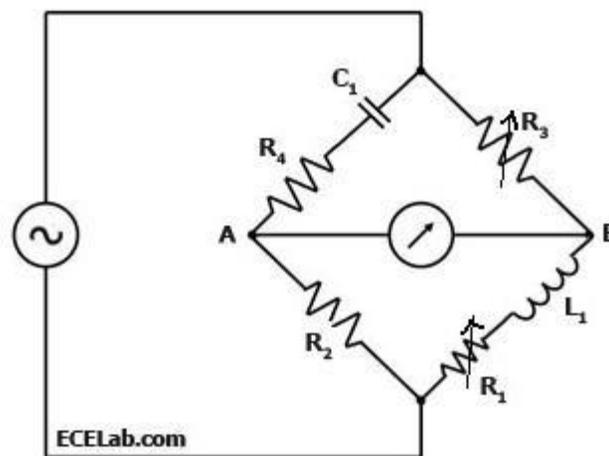
Thus, the equations for  $L_1$  and  $R_4$  for the Hay Bridge in Figure 1 when it is balanced are:

$$L_1 = R_3 R_1 C_1 / [1 + (2\pi f R_2 C_1)^2]; \text{ and}$$

$$R_4 = (2\pi f C_1)^2 R_2 R_3 R_1 / [1 + (2\pi f R_2 C_1)^2]$$

Note that the balancing of a Hay Bridge is frequency-dependent

### Circuit diagram



### Procedure:

1. Select the indicator value from 40,60 and 80 mh.
2. Select the capacitor value by selecting the knob.
3. Connect the milliammeter across the galvanometer probes
4. Apply 5v peak to peak, 1 KHz, sine wave.
5. By adjusting the pot R2, adjust the current to a minimum value.
6. Adjust the self resistance of the inductor by R1.

7. Adjust the current through detector to 0 by adjusting R3.
8. Measure the value of R3 across the terminals.
9. Now calculate the value of self-inductance L1 of resistance R1 by the formula.

**Conclusion:**

**Experiment:5**

**Aim :**

To determine the unknown frequency by wein's bridge.

**Apparatus**

- 1.R1=R2---Three Decade Resistance Dials having range 10 Ohms to 10000 Ohms.
- 2.R3--- Two Decades resistance dials having range 10 ohms to 10000 ohms.
3. R4--- Two more decade of same values are above.
4. C1=C2---Two standard capacitor having values 0.1mfd.
5. Inbuilt AC supply of different frequency and 3 ½ digit digital null detector.

**FORMULA USED:**

R1=R2=R and C1=C2=C

$$\omega = \frac{1}{RC} \rightarrow f = \frac{1}{2\pi RC}$$

Switches for R1 and R2 are mechanically linked so as to full-fill the condition R1=R2.

**PROCEDURE:**

- (1) Make the connections accordingly. Connect the unknown terminals to the AC supply terminals of unknown frequency and connect the detector terminals to the detector Input terminals of digital null detector.
- (2) Set the decade resistance dial R3 at 100 ohms and R4 at 200 ohms and set the null detector switch at initial position.

(3) Now adjust the decade dial  $R_1=R_2$  so that the digital display shows Zero-Zero-Zero (0.00) or (0.01).

(4) Now set the null detector switch at final position and re-adjust the resistance dials  $R_1=R_2$ , if there is any reading in the display. Note the values of  $R_1=R_2$  and  $C_1=C_2$ .

(5) Calculate the unknown frequency using formula.

**Circuit diagram**

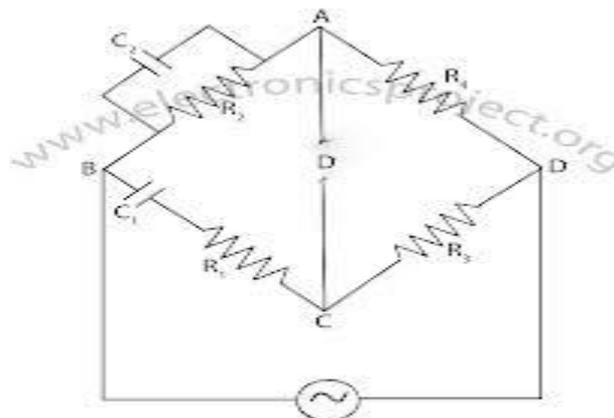


Figure 1: Wien Parallel Bridge

Perform the same experiments at another values of unknown frequencies.

**Calculation:**

**RESULT:**

The value of frequency is .....HZ.

## EXPERIMENT 6

### AIM:

To measure power and power factor in a single – phase A.C. Circuit using three voltmeter method.

### APPARATUS USED:

Voltmeter 0 – 300 V, M.I. single phase inductive variable load rheostat 100 ohm , 5 A., M.I. ammeter 10 A, 5A, Variac 230V, 10 A

### Theory :

The circuit to be used for performing the experiment .the silent features of this diagram includes an inductive load in a series with a known resistor R. The voltage  $V_1$  and  $V_2$  and  $V_3$  are noted with the help of a single voltmeter and a pair of probes. Now we can draw the phasor diagram for this circuit. I should be taken as reference phasor.

### CIRCUIT DIAGRAM:

### PHASOR DAIGRAM:

From the phasor diagram:

$$V_3^2 = V_1^2 + V_2^2 + 2V_1V_2\cos\Phi \dots\dots\dots(1)$$

The phasor factor of the coil is  $\cos\Phi$

$$\cos\Phi = \frac{V_3^2 - V_1^2 - V_2^2}{2V_1V_2} \dots\dots\dots(2)$$

Power consumed by the coil

$$P = V_2 I \cos\Phi = \frac{V_2 V_1 \cos\Phi}{R} \dots\dots\dots(3)$$

$$V_1 V_2 \cos\Phi = PR \dots\dots\dots(4)$$

Put equation 4 in 2

$$V_3^2 = V_1^2 + V_2^2 + 2PR$$

$$P = \frac{V_3^2 - V_1^2 - V_2^2}{2R} \dots\dots\dots(5)$$

Therefore, the power in the circuit, P and power factor of circuit  $\cos\Phi$  can be determined using equation 5 and 2 respectively

**PROCEDURE:**

- (1) Connect the circuit as shown in figure.
- (2) Keep the rheostat at its max value
- (3) Keep the variac at its minimum position.
- (4) Switch on supply.
- (5) Increase the voltage applied using variac slowly, so that the reading of voltmeter and ammeter are appreciable.
- (6) Decrease the rheostat so that the ammeter gives suitable reading.
- (7) Take down the readings of 3 voltmeter and ammeters.
- (8) Change the position of rheostat and repeat step 7 a number of times.

**OBSERVATION TABLE:**

S.NO.	I (amp)	V <sub>1</sub> (VOLT)	V <sub>2</sub> (VOLT)	V <sub>3</sub> (VOLT)	P(WATT)	COSΦ
1.						
2.						
3.						

## **CALCULATION:**

Calculate the value of power consumed P using equation 5 and value of power factor using equation 2 for each set of observation

Since the power consumed is different so average power factor can be calculated.

**RESULT:** The power factor of circuit and the power consumed in circuit should be recorded here.

## **PRECAUTION:**

- (1) All connection should be tight.
- (2) The zero setting of all meter should be checked before connecting in the circuit.
- (3) The current through ammeter should never be allowed to exceed the current rating of rheostat and load used

## **EXPERIMENT 7**

### **Aim:**

Measurement of the medium resistance by using Wheatstone bridge

### **Apparatus:** -

Power supply (0-32V D.C)

Resistor: -  $R_1=1K\Omega$ ,  $R_X=1K\Omega$ ,  $R_3=1K\Omega$ ,  $R_4=10K\Omega$ .

Unknown resistor= $100\Omega$ ,

Wheatstone bridge kit.

Digital multimeter-1no,

Patch chords.

### **Theory-**

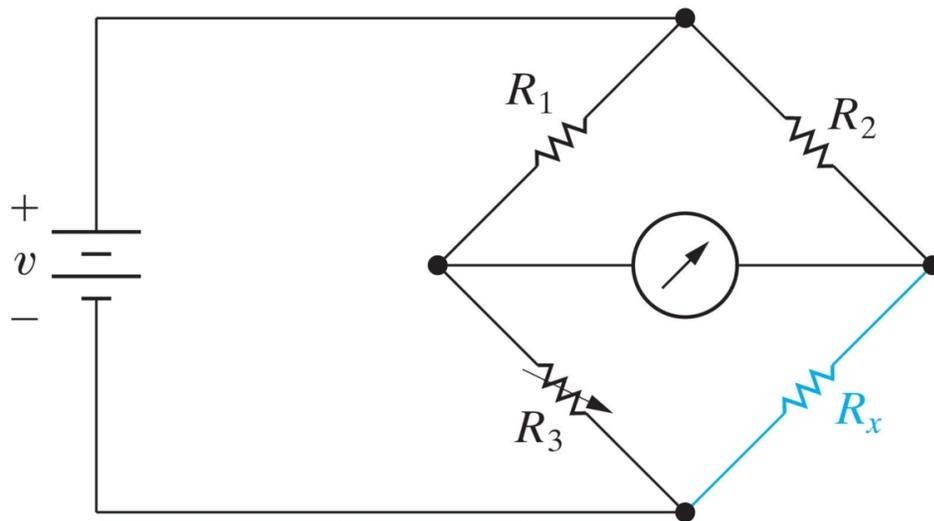
Wheatstone Bridge is a very important device used in the measurement of medium resistances. It is an accurate and reliable instrument. The wheatstone bridge is an instrument based on the principle of null indication and comparison measurements.

The basic circuit of a wheatstone bridge is shown in fig. It has four resistive arms, consisting of resistances  $R_1, R_X, R_3$  and  $R_4$  together with a source of emf and a null

detector , usually a galvanometer G or other sensitive current meter is used. The bridge is said to be balanced when there is no current through

**Circuit diagram:**

## Wheatstone Bridge



The galvanometer or when the potential difference across the galvanometer is zero. This occurs when the voltage from point 'a' to point 'd' equals the voltage from point 'd' to point 'b' or by referring to other battery terminal, when the voltage from point 'a' to point 'c' equals the voltage from point 'c' to point 'b'.

For bridge balance;

$$I_1 = I_3 = E / (R_1 + R_3) \tag{1}$$

$$I_2 = I_4 = E / (R_x + R_4) \tag{2}$$

E = emf of battery.

Combining equation (1) and (2) we get  

$$R_x * R_3 = R_1 * R_4$$

OR

$$R_X = (R_1 * R_4) / R_3$$

Where  $R_X$  is the unknown resistance,  $R_1$ ,  $R_3$  and  $R_4$  are called the ratio arms.

**Observation table**

Ratio arm resistor	Std. arm resistor	Measured resistor $R_X$	calculated $R_X$
$R_1$ $R_3$	$R_4$		

**Procedure: -**

- (1) Connect the patch chords as per the circuit diagram.
- (2) Note the resistance of  $R_1$ ,  $R_4$  and  $R_3$  using multimeter.
- 3) Switch on the power supply and adjust the resistance  $R_4$  such that galvanometer shows the zero deflection.
- 4) Disconnect the supply & measure the value of  $R_X$ .
- (5) Now calculate the value of unknown Resistor  $R$ , Using formula

$$R_X = (R_1 * R_4) / R_3.$$

**Result:-** Unknown Resistance found to be \_\_\_\_\_  $\Omega$

## **EXPERIMENT 8**

**Aim:-** Measurement of the unknown inductance by using OWEN'S bridge method

### **Apparatus:-**

Digital multimeter, Patch chords.

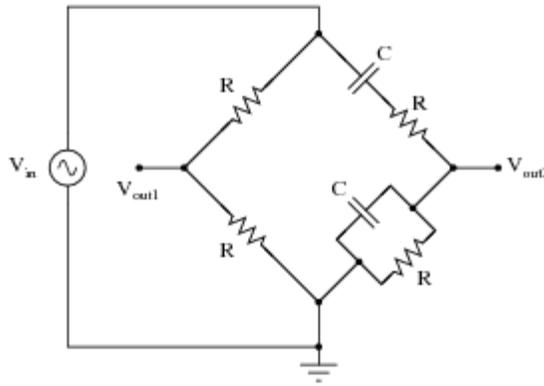
### **Components used:**

$R_3=1K\Omega$  (pot),  $C_4=1\mu F$ ,  $R_2=1K\Omega$ (pot),

$L_1= L_2= \text{-----}$

Galvanometer, 12VAC source.

### **Circuit Diagram:-**



## OWEN'S BRIDGE

### THEORY:

Bridges are used for the accurate measurement of electrical quantities viz; resistance, Capacitance, Inductance, Storage Factor, Loss factor etc. Depending upon the excitations used, the bridge is classified as AC bridges & DC bridges.

Owens's – Inductance Capacitance Bridge comes under category of AC bridges and it is used for measurement of an Inductance in terms of capacitance. General form of AC bridges consists of four arms of impedances & AC excitation.

Let

$L_1$ = unknown self inductance of resistance  $R_2$ =variable non- inductive resistance

$R_3$ = fixed non- inductive resistance  $C_2$ =variable standard capacitor  $C_4$ =fixed standard capacitor

And

At balance condition,

$$(R_1 + j\omega L_1) (1/j\omega C_4) = (R_2 + 1/j\omega C_2) * R_3$$

Separating the real & imaginary terms, we

$$\text{obtain: } L_1 = R_2 R_3 C_4$$

&

$$R_1 = R_3 * C_4 / C_2$$

### PROCEDURE:-

1. Study the circuit provided on the front panel of the kit.

2. Connect unknown inductance  $L_{X1}$  OR  $L_{X2}$  by patch chords
3. Switch ON power supply
4. By varying the pot  $R_2$  &  $R_9$  make bridge balance
5. Switch off the power supply, disconnect the patch chords & measure the value of  $R_3$  &  $R_2$
6. Find the value of unknown inductance by using formula

$$L_1 = R_2 R_3 C_4$$

**OBSERVATIONS:**

MEASURED VALUE OF L	CALCULATED VALUE OF L

**RESULT:-**

Using Owens's Bridge we can calculate the value of unknown inductance & we found there is short difference between theoretical and practical value of L.

**EXPERIMENT 9**

**Aim:-** Measurement of the unknown inductance by using Maxwell's bridge.

**APPARATUS:-**

Digital multimeter,

Patch chords.

$R_2 = 100\Omega$ ,  $R_4 = 1K\Omega$ ,  $R_3 = 4.7K\Omega$ ,

$C_4 = 1\mu f$ ,  $L_{X2} = 318Mh$ ,  $L_{X1} = 73 Mh$

**CIRCUIT DAIGRAM:**

## **THEORY:**

The Maxwell's bridge is used to measure inductance by comparison with a standard variable capacitance. One of the ratio arms has a resistance and the capacitance in parallel.

In this bridge at the balance condition there is no current flow in the galvanometer.

At balanced condition,

$$(R_1 + j\omega L_1) (R_4 / (1 + j\omega C_4 R_4)) = R_2 R_3$$

By separating the real and imaginary terms, the unknown value of the resistor ( $R_1$ ) and the unknown value of the capacitor ( $C_1$ ) has given below.

$$R_1 = R_2 R_3 / R_4$$

$$L_1 = (R_2 R_3 C_4)$$

## **OBSERVATION:-**

$$R_2 = \underline{\hspace{2cm}}.$$

$$C_4 = \underline{\hspace{2cm}}.$$

### **For Unknown Inductance $L_{x1}$ :-**

$$\text{Calculated } L_{x1} = (R_2 R_3 C_4)$$

$$L_x = \underline{\hspace{2cm}} \text{ M}$$

$$\text{Measured } L_{x1} = \underline{\hspace{2cm}} \text{ Mh.}$$

$$\text{Quality factor (Q)} = \omega R_4 C_4$$

### **For Unknown Inductance**

**Lx2:**

Calculated -

$$L_{x2} = (R_2 R_3 C_4)$$

Measured -  $L = \dots$ mh

**PROCEDURE:-**

- 1) Study circuit on kit from panel.
- 2) Connect unknown inductance  $L_{X1}$  in circuit. Make all possible connections to complete the network. Switch the supply on.
- 3) Set null point of galvanometer by adjusting variable resistance  $R_3$
- 4) Note values of  $R_2$ ,  $R_3$ ,  $C_4$  by removing their connections. Calculate theoretical values of  $L_X$  using  $L_1 = R_2 R_3 C_4$ .
- 5) Measure actual value of  $L_{X1}$  using LCR meter. Compare this value with calculated. Also calculate Q factor by using above equation.

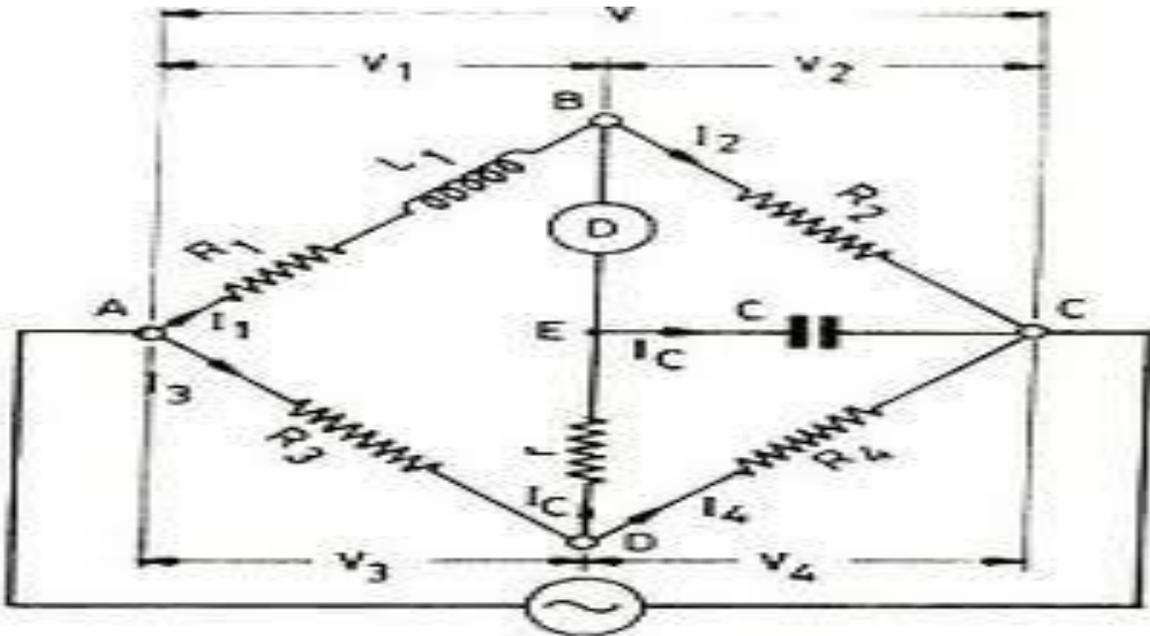
**RESULT:** - Unknown inductance measured using Maxwell's bridge is found to be  $L_{X1} = \underline{\hspace{2cm}}$ , &  $L_{X2} = \underline{\hspace{2cm}}$ -----.

**EXPERIMENT 10**

**Aim:-** Measurement of the unknown capacitance using Schering bridge.

**Apparatus:** - Shearing bridge kit digital  
multimeter, patch chords,

**CIRCUIT DAIGRAM:**



## SCHERING BRIDGE

### THEORY:

The Schering Bridge is one of the most important ac bridge used extensively for the measurement of capacitance.

In Schering Bridge the arm 1 contains a series combination of the resistor and the capacitor and standard arm contain only one capacitor. The standard capacitor is usually a standard high quality mica capacitor.

In the balance condition of the bridge the sum of the phase angles of the arms 1 and 4 is equal the sum of the phase angle of arms 2 and 3. At the balance condition there is no current flow in the galvanometer.

At balance condition,

$$[R_1 + (1/j\omega C_1)] * [R_4 / (1 + j\omega C_4 R_4)] = R_3 / (j\omega C_2)$$

After solving & equating real & imaginary parts, we get

$$R_1 = C_4 * R_3 / C_2.$$

$$C_1 = R_4 * C_2 / R_3$$

### Observation:-

$R_4 = \underline{\hspace{2cm}}$ .

$C_2 = \underline{\hspace{2cm}}$ .

**For Unknown Capacitor C1:-**

Calculated -  $C_1 = (R_4 * C_2 / R_3)$

$C_1 = \underline{\hspace{2cm}}$ .

Measured -  $C_1 = \underline{\hspace{2cm}}$ .

Dissipation factor (D.f)  $= \omega R_4 C_4$

**Procedure: -**

- 5) Study the circuit provided on the front panel on the kit.
- 6) Connect the unknown capacitance of the position given.
- 7) Set the null point of galvanometer by adjusting the variable resistor  $R_4$
- 8) Calculate the value of unknown capacitance by formula given

**Result:** -The values of unknown capacitance is found to be  $C_1 = \underline{\hspace{2cm}}$  uF.

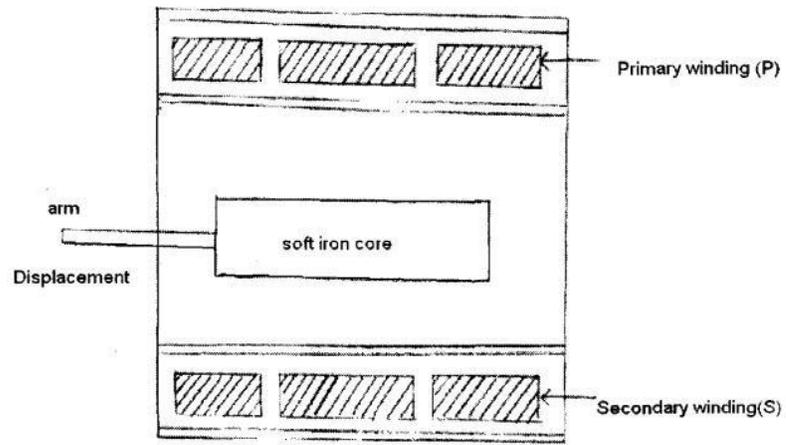
### **EXPERIMENT No. :-11**

**AIM:-**To measure output voltage w.r.t the displacement of the core on the LVDT kit and find the graphical relationship between the two.

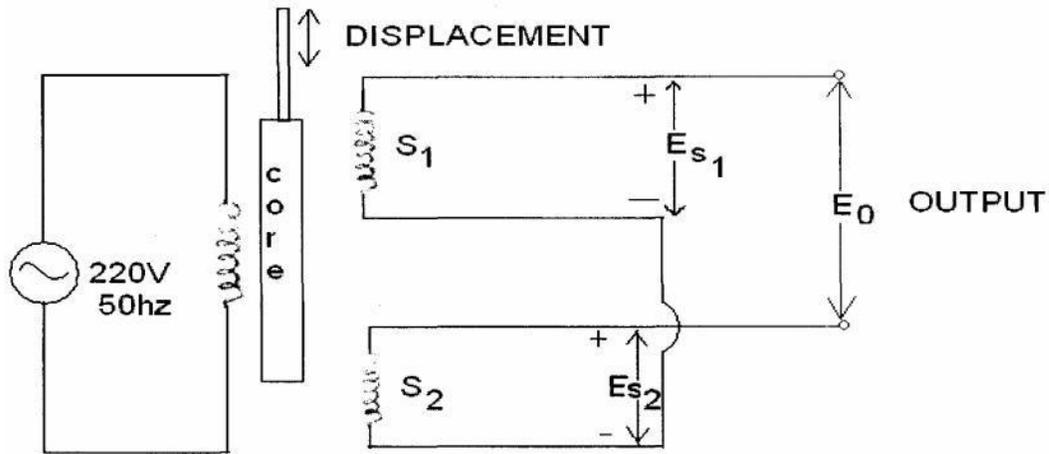
**APPARATUS:** - LVDT kit, Multimeter

**THEORY:** - LVDT is basically a mutual inductance type transformer with variable coupling between the primary and two secondary coils. It is equivalent to E.Pick off in its operation except the reluctance of magnetic path is mostly due to air path. Uniformly wound over a certain length of transducer and two identical secondary coil systematically wound on either side of the primary coils and away from center. The iron rod is free to move inside the coil in either direction from the null point when primary coil is excited by AC supply the induced emf of secondary are equal to each other with the core lying in null position. The secondary are connected in series with but in phase opposition so that resultant output voltage is zero. Displacement of core in either direction from the null position results in output voltage as read by an AC rms voltmeter and it is observed that there is a residual voltage at the null position. Due to capacitance coupling between primary and secondary and the characteristics of a linear over a limited displacement.

**DIAGRAM:**



### CIRCUIT DIAGRAM



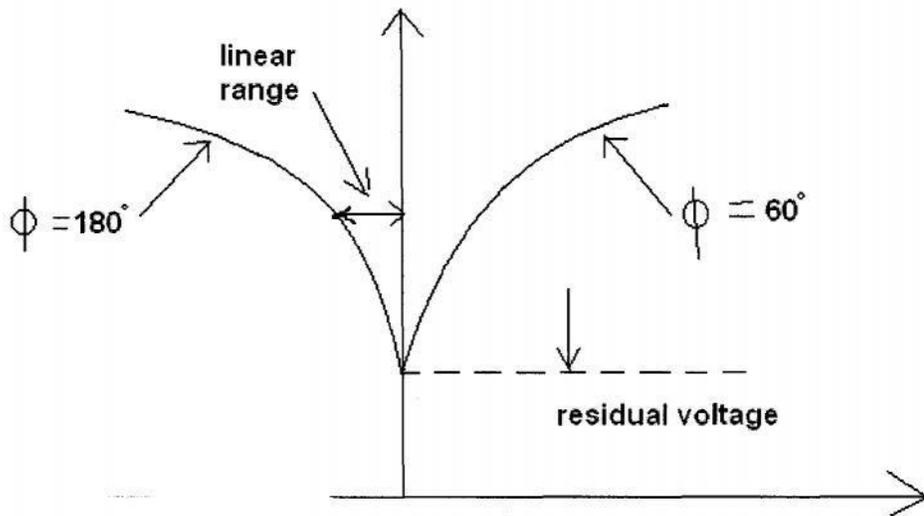
### PROCEDURE: -

1. Connect the multimeter at the output of kit..
2. Set the range to a maximum value of 10 mm.
3. Move the gauge from zero to maximum of 20mm.
4. Value and note the corresponding values of voltages in the multimeter.
5. Plot the graph between displacement and voltages on the graph paper.

### OBSERVATION TABLE

s.no	Displacement	Electrical displacement	Voltage(V)

### GRAPH :-



#### PRECAUTION: -

1. The values on the multimeter should be carefully noted.
2. The core should be set to a maximum value of 20mm.
3. To get the good performance from the kit, main room temperature.
4. To check the power supply, it should be  $220 \pm 10\%$  50Hz to avoid voltage hazard.

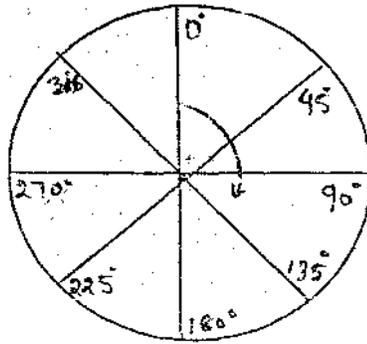
**RESULT:** - LVDT was studied well and graph of displacement was linear for a particular range.

## EXPERIMENT 12

**OBJECTIVES :** To study capacitive transducer

**REQUIREMENT:** Capacitive transducer kit, multimeter

### DIAGRAM



**THEORY :** The principal of operation of capacitive transducer is based upon familiar education for capacitance of a parallel plate capacitor.

$$C = \epsilon A / D$$

$$C = \epsilon_0 \epsilon_r A / D$$

Where A = overlapping area of plates

d = distance between plates

$\epsilon_r$  = relative permittivity

$\epsilon_0$  = permittivity of free space

The capacitive transducer works on the principle of change of capacitance which may be caused by

- 1 Change of area.
- 2 change in distance between plates
- 3 change in dielectric constant

The capacitance may be measured with bridge circuit. The output impedance of capacitive transducer is

$$X_c = 2\pi f C$$

Where

C = capacitance

F = frequency

Capacitance is maximum when two plates completely overlap each other i.e. when

$\theta = 180$  degree

**PROCEDURE:**

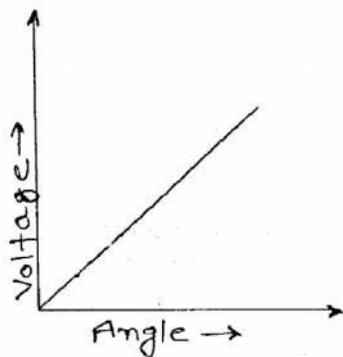
- 1 Turn on the power supply.
- 2 Change the angle step by step.
- 3 Using multimeter take corresponding voltage values.
- 4 Note down the readings for voltage and angles.
- 5 Plot the graph between Angle Vs Voltage.

Observation :-

Table:

S.NO.	Voltage (v)	Angle	Electrical d/s
1.			
2.			
3.			
4.			
5.			

Graph :-



**Result:-**

Capacitive transducer is studied .The plot of graph of angle V/s voltage is a straight line.

## EXPERIMENT: 4

### AIM:

To measure pressure using strain gauge.

### APPARATUS REQUIRED:

- Strain measurement kit
- Scale
- Connecting wires

### THEORY:-

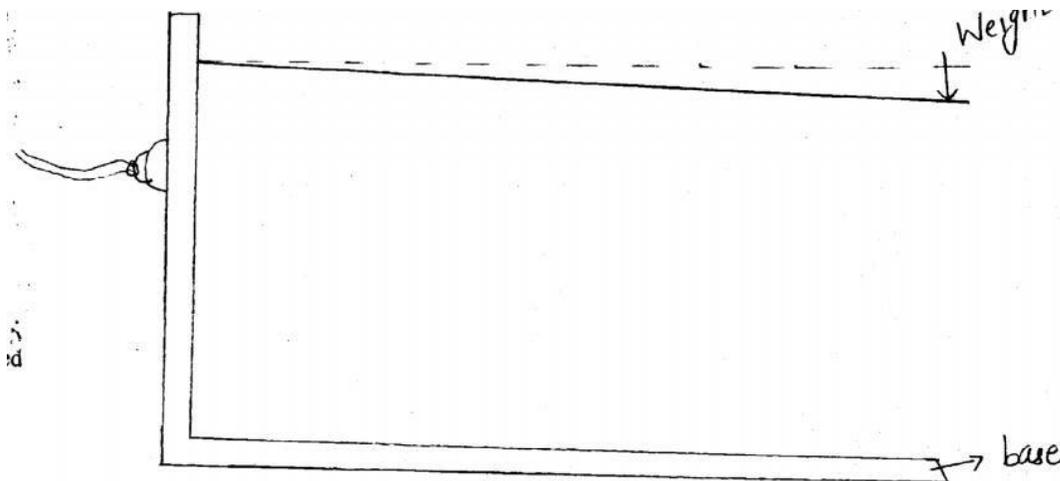
When regular bodies are subjected to stress then strain developed can be measured electrically and relationship between the forces responsible for the stress of resulting electrical output signal can be obtained. The resistance strain gauge element is one such device that plays the role of secondary transducer is sending the tensile or compressive strain is a particular at a point on the surface of a body. If the body is known as modulus of electricity  $E$  of the material of body, the strain can be measured. the strain gauge transducer depend upon the fact that when the wire is stretched elastically its length and diameter are altered. This result in overall change of resistance to both the dimensionally change of resistivity.

### PROCEDURE:-

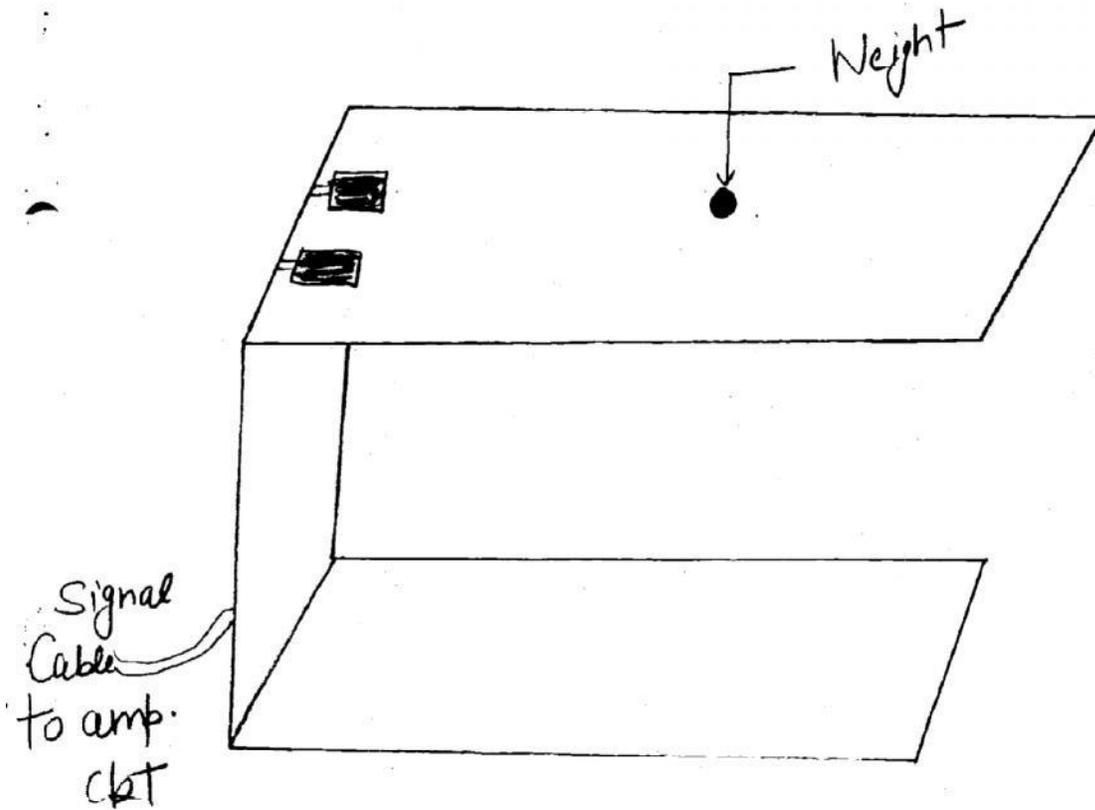
- Connect the strain cantilever of a pin connector through wire.
- Power ON the switch, the Red LED indicates the power available
- On instrument.
- Give sometimes to stabilize the instrument.
- Balance the strain cantilever bridge by SPAN the twintrimpot.
- Now apply the weight on the strain cantilever and measure it on the
- Display output.
- Repeat this to measure different weight on cantilever.

Now find out the strain in the cantilever by applying stress from Calculation

### DIAGRAM.



## STRAIN GUAGE



### **PRECAUTIONS:**

To get good performance from the exp., we have to maintain room temp.

To check the power source, it should be 230V, 50hz to avoid overall Voltage hazards.

### **RESULTS:**

Experiment is performed successfully and observations are noted.

## EXPERIMENT 13

### AIM:

Measurement of temperature using thermocouple .

### APPARTUS:

Thermometer, thermocouple, sensor, tutor, vessel and water, multimeter and conducting rod.

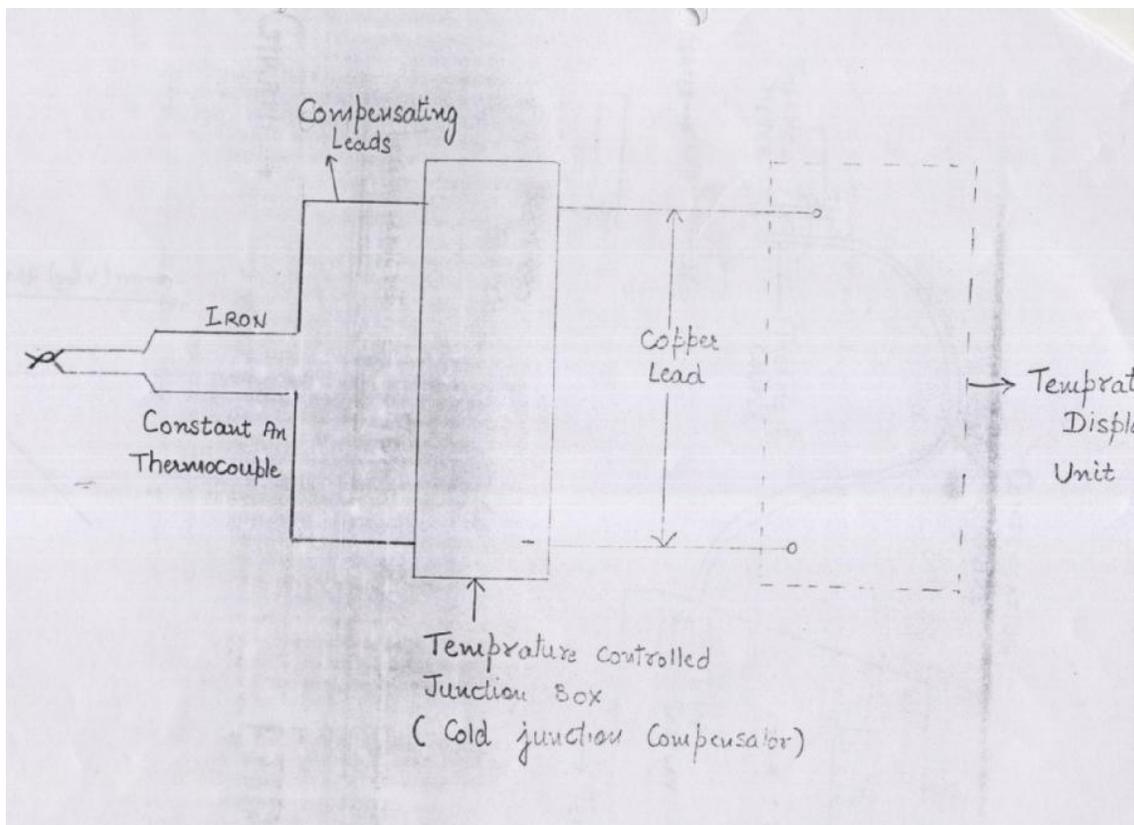
### THEORY:

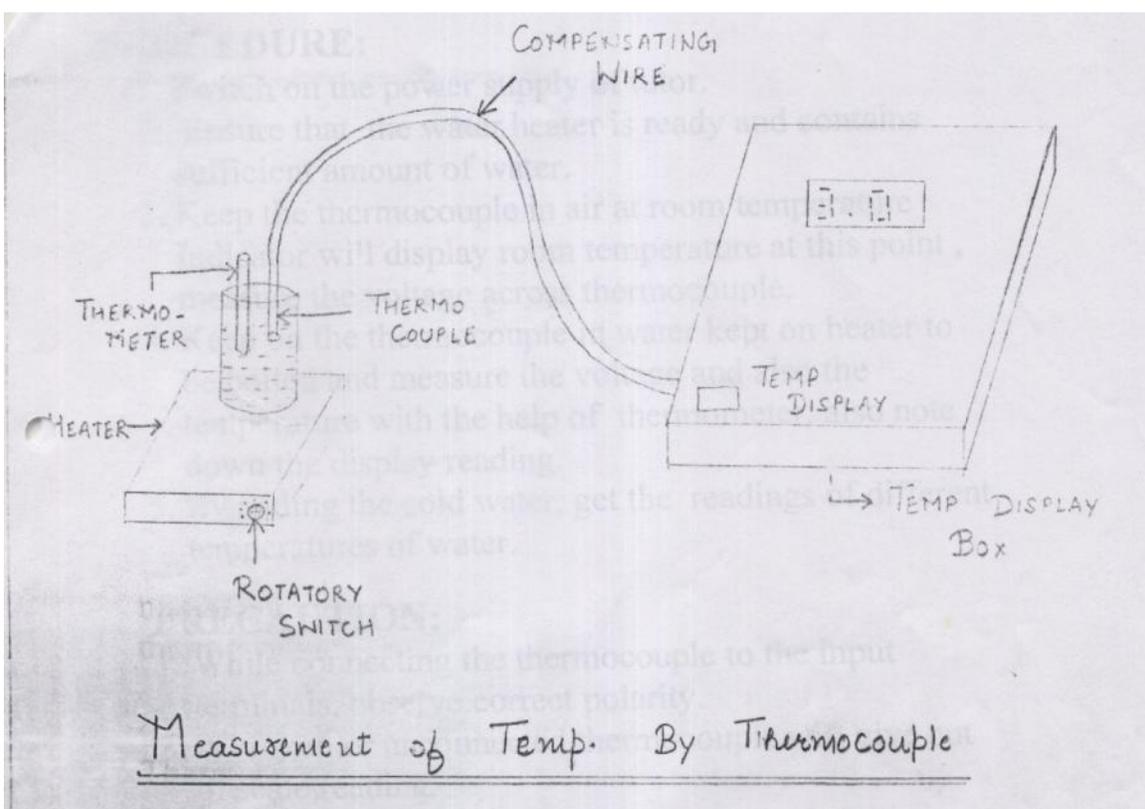
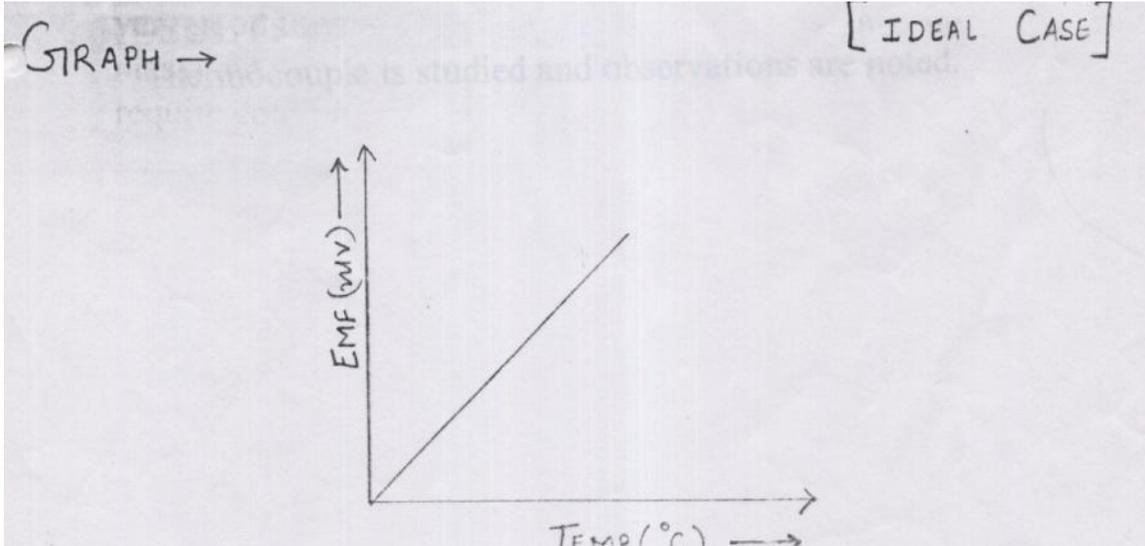
Thermocouple is a transducer based on the seeback effect. It is most widely used and common signal *device* for temperature measurement in industrial application. For the range of 0-400 F. Thermocouple is a self generating transducer and is basically a pair of dissimilar metal conductors joined so as to produce an emf when the junction are kept at different temperatures and material of conductors. Combination used for base metal thermocouples are

Copper-Constantan (-300F to 600F)

Iron-Constantan (-300F to -1500F) etc.

Thermocouples are cheap, reliable in service, are easily used, wide. range of temperature measurement and have a very good time of response characteristics(low thermal mass) but they are not perfectly linear over centre range, require cold junction compensation.





## OBSERVATION TABLE

S.NO.	Thermometer reading	Display reading	EMF.(mv)

### PROCEDURE:

1. Switch on the power supply of tutor.
2. Ensure that the water heater is ready and contains sufficient amount of water.
3. Keep the thermocouple in air at room temperature indicator will display room temperature at this point, measure the voltage across thermocouple.
4. Keep on the thermocouple in water kept on be boiled and measure the voltage and also temperature with the help of thermometer, down the display reading.
5. By adding the cold water, get the reading of different temperatures of water.

### PRECAUTION:

1. While connecting the thermocouple to the input terminals, observe correct polarity.
2. A broken or unconnected thermocouple will give out of scale reading.

### RESULT:.

Thermocouple is studied and observations are noted.