

## 1. CALIBRATION OF LVDT TRANSDUCER FOR DISPLACEMENT MEASUREMENT

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

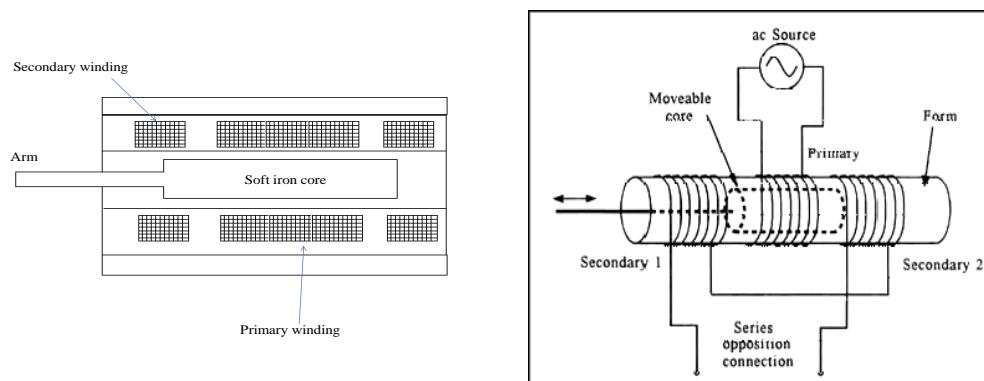
**Apparatus required:** LVDT, Digital displacement indicator, Calibration jig (with micrometer).

### Procedure:

1. Plug power chord to AC mains 230 V, 50 Hz and switch on the instrument.
2. Place the READ/CAL switch at READ position.
3. Balance the amplifier with the help of zero knob so that display should read zero (00.00) without connecting the LVDT to instrument.
4. Replace the READ/CAL switch at CAL position.
5. Adjust the calibration point by rotating CAL knob so display should read 10.00 ie., maximum calibration range.
6. Again keep the READ/CAL switch at READ position and connect the LVDT cable to instrument.
7. Make mechanical zero by rotating the micrometer. Display will read (00.00) this is null balancing.
8. Give displacement with micrometer and observe the digital readings.
9. Plot the graph of micrometer reading v/s digital reading.

### THEORY : LVDT (LINEAR VARIABLE DIFFERENTIAL TRANSFORMER)

The most widely used inductive transducer to translate the linear motion into electrical signals is the linear variable differential transformer (LVDT). The basic construction of LVDT is shown in fig:



The transformer consists of a single primary P and two secondary windings S1 and S2 wound on a cylindrical former. The secondary windings have equal number of turns and are identically placed on either side. A moveable soft iron core is placed inside the transformer. The displacement to be measured is applied to the arm attached to the soft iron core. In practice the arm is made of highly permeability, nickel iron which is hydrogen annealed.

This gives low harmonics low null voltage and high sensitivity. This is slotted longitudinally to reduce eddy current losses. The assembly is placed in stainless steel

housing and the end leads provides electrostatic and electromagnetic shielding. The frequency of AC applied to primary windings may be between 50 Hz to 20 kHz.

Since the primary winding is excited by an alternating source, it produces an alternating magnetic field which in turn induces alternating current voltage in the two secondary windings.

Figure 3 depicts a cross-sectional view of an LVDT. The core causes the magnetic field generated by the primary winding to be coupled to the secondaries. When the core is centered perfectly between both secondaries and the primary, as shown, the voltage induced in each secondary is equal in amplitude and 180 deg out of phase. Thus the LVDT output (for the series-opposed connection shown in this case) is zero because the voltage cancel each other.  $E_0 = E_{s1} - E_{s2} = 0$

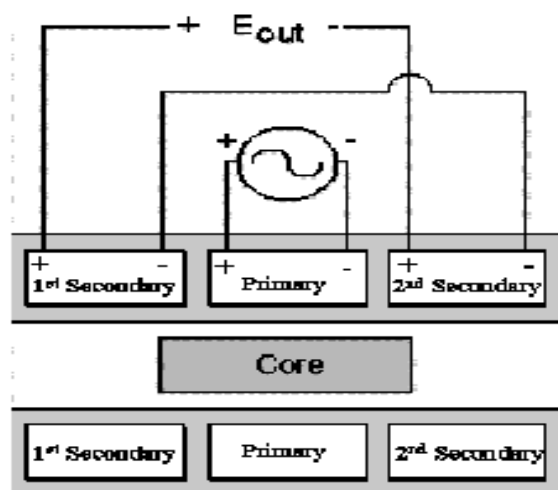


Figure 3. Cross-Sectional View of LVDT Core and Windings

Displacing the core to the left (Figure 4) causes the first secondary to be more strongly coupled to the primary than the second secondary. The resulting higher voltage of the first secondary in relation to the second secondary causes an output voltage that is in phase with the primary voltage.

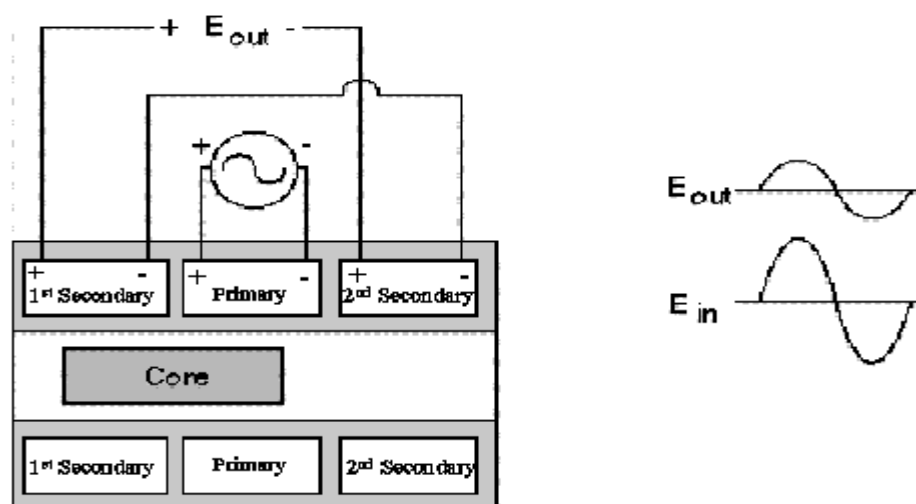


Figure 4. Coupling to First Secondary Caused by Associated Core Displacement

Likewise, displacing the core to the right causes the second secondary to be more strongly coupled to the primary than the first secondary. The greater voltage of the

second secondary causes an output voltage to be out of phase with the primary voltage.

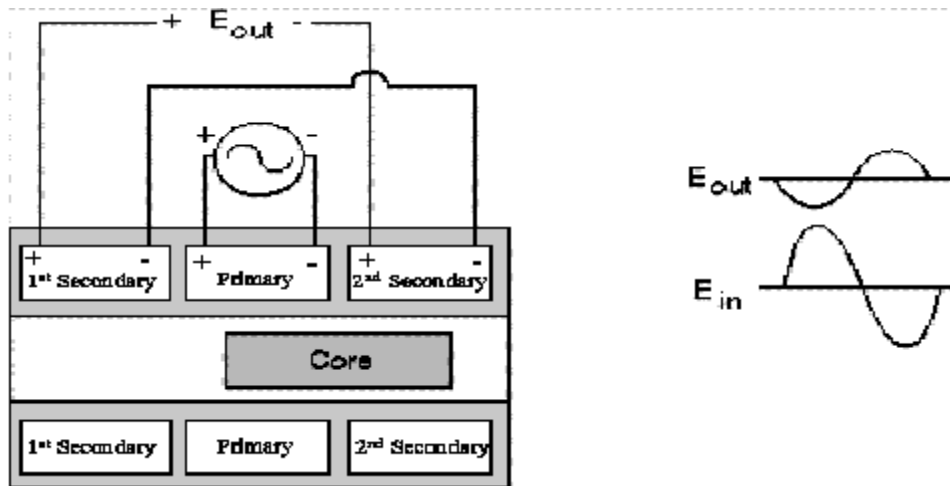
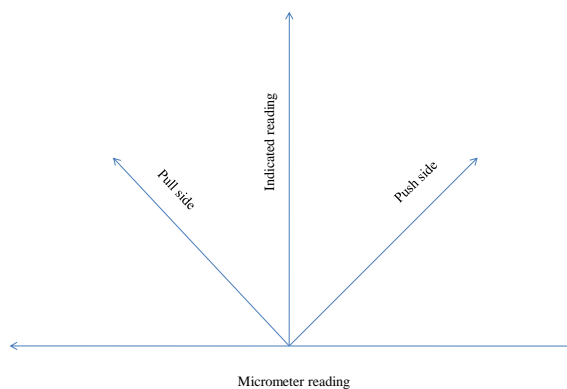


Figure 5. Coupling to Second Secondary Caused by Associated Core Displacement

**Tabulation :**

S.No.	Push side readings		Pull side readings	
	Micrometer Reading(mm)	Indicated reading(mm)	Micrometer Reading(mm)	Indicated reading(mm)
1				
2				
3				
4				
5				
6				

Model graph : Micrometer reading Vs Indicated reading



**Result :** Thus the displacement is calibrated by using LVDT

## 2. STUDY AND CALIBRATION OF FORCE CELL WITH FORCE INDICATOR

**Aim:** Calibration of the Force cell.

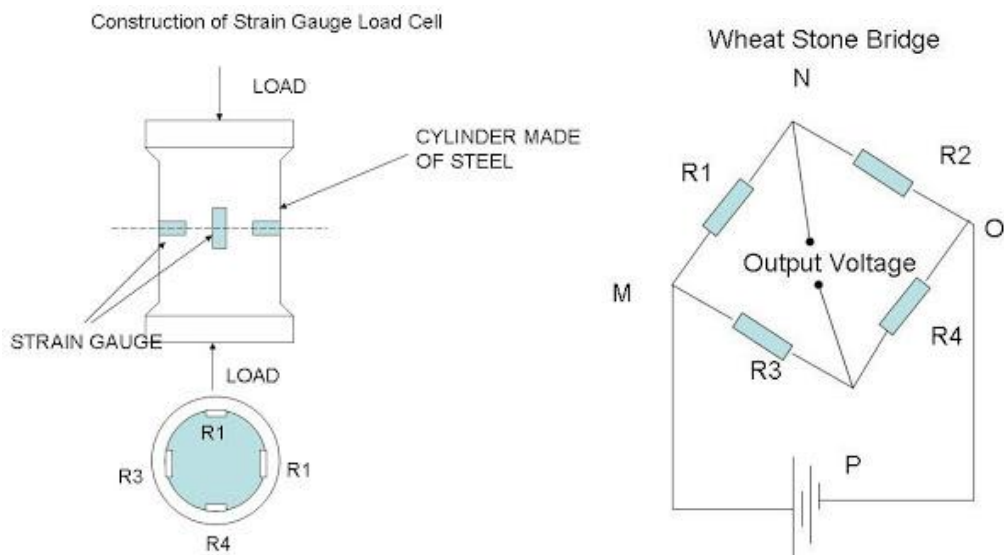
**Apparatus required:** Force cell, digital force indicators and necessary dead weights.

**Procedure:**

1. Connect the mains chord to the 230 V 50 Hz AC supply.
2. Connect the sensor to the sensor socket provided at the front panel.
3. Switch on the instrument.
4. Put the READ/CAL switch in READ position and set the zero pot to 0.00(i.e. balance the bridge).
5. Put the READ/CAL switch in CAL position and check calibration point that is 10.00 if not adjust that to 10.00 with the help of CAL pot.
6. Again put the READ/CAL switch in READ position and apply the load on the sensor.
7. Now the indicator shows the reading 3 digit seven segment display.
8. Plot the graph for applied voltage vs Indicator Reading.

**Theory :**

**Construction of strain gauge Load cell**



The main parts of the strain gauge load cell are as follows. They are a cylinder made up of steel on which four identical strain gauge are mounted and out of four strain gauges, two of them (R1 and R4) are mounted along the direction of the applied load (vertical gauges). The other two strain gauges (R2 and R3 Horizontal gauges) are mounted circumferentially at right angles to gauges R1 and R4

## Operation of strain gauge Load cell

Let study the operation in two cases

### **Case 1**

When there is no load (force) on the steel cylinder, all the four gauges will have the same resistance. As the terminals N and P are at the same potential, the wheat stone bridge is balanced and hence the output voltage will be zero.

### **Case 2**

Now the load (force) to be measured (say compression force) is applied on the steel cylinder. Due to this, the vertical gauges R1 and R4 will undergo compression and hence there will be a decrease in resistance. At the same time, the horizontal gauges R2 and R3 will undergo tension and there will be an increase in resistance. Thus when strained, the resistance of the various gauges change.

Now the terminal N and P will be at different potential and the change in output voltage due to the applied load (force) becomes a measure of the applied load force when calibrated.

Force cell is designed for tensile-compressive (universal type).it has bonded four equal resistance ( $350\Omega$ ) stain gauges and are connected in four arm of voltage sensitive bridge. Excitation to the bridge is supplied from load indicator i.e., regulated DC 12V, output of the load cell I is feeding to the highly sophisticated amplifier to the cable corresponding to the force applied on the cell. Amplified output is then converting in analog to digital. This digital output is calibrated to read directly in terms of Kgs with respect to amplified force.

### Uses of Strain Gauge Load Cell.

Strain gauge load cells are used when the load is not steady. Strain gauge load cells are used in vehicle weigh bridges, and tool force dynamometers.

### **SPECIFICATION OF FORCE CELL**

Type	: Tensile
Bridge resistance	: $350\ \Omega$
Bridge excitation	: 12 V DC max
Material	: Stainless steel

### **Indicator**

Type	: Digital
Display	: Green, seven segment LED
Calibration range	: 10 Kg
Operating voltage	: 230 V/50 Hz AC

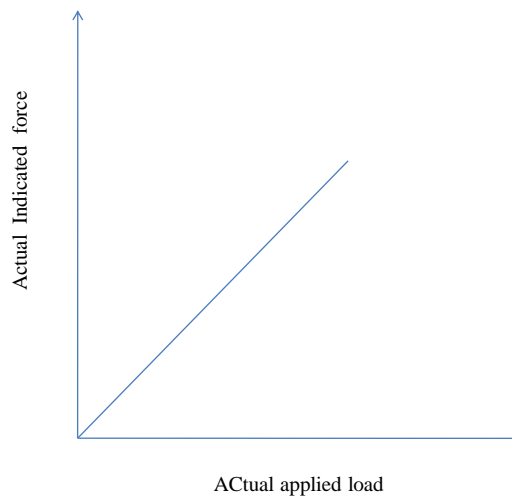
### CONTROLS

- POWER ON : SPDT switch supplies the AC mains into the indicator.
- ZERO : 10K 10 turn potentiometer to balance the strain gauge bridge.
- CALL : 10K single turn potentiometer is to adjust the Calibration point.
- READ/CAL : 2 position toggle switch to select READ/CAL position.
- RECORDER : Red and green screw type connecting terminal to measure the analog READ out and recording purpose.
- SENSOR : 5 pin sockets is provided to connect the sensor cable.
- POWER CHORD: 3 pin 3 cores interconnect the 230 V -50 Hz.
- FUSE : 500 mA fuse is used to protect the instrument from the short circuit.

### Tabulation

S.No.	Applied load (Kgs)	Indicated readings (KgF)
1		
2		
3		
4		
5		
6		

### Model graph:



Result : Thus the force cell is calibrated by using digital force cell indicator

### 3. DIGITAL SPEED MEASUREMENT SYSTEM BY USING PHOTO/MAGNETIC PICKUP

**Aim:** To measure the speed of the motor by using optical/photo/magnetic proximity sensors

**Apparatus required:** Digital speed indicator, Optical or photo sensor, Proximity or Magnetic sensor

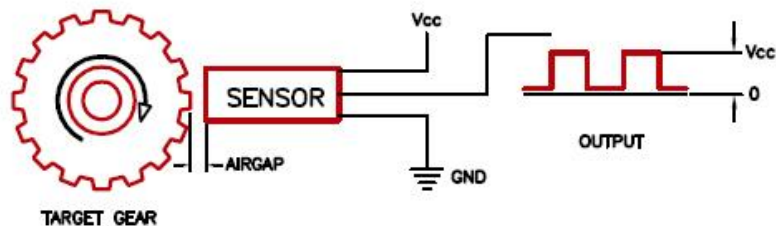
**Procedure:**

1. Connect the main chord to 230V 50Hz AC supply.
2. Connect the sensor socket provided at the back panel optical/proximity sensor.
3. Switch on the instrument and the motor. Then vary the speed of the motor in different steps.
4. Note the readings given in the tabular column.

Digital speed indicator is microprocessor circuit design, accuracy, digital read out. If it is ideal inspecting and measuring the speed of moving gear spans centrifuges, pumps, motors and other equipments. It is non contact sensing devices photo optical and magnetic/ proximity type sensors. It will take signals from this sensor and these signals will be input to the indicator and that signal will convert into actual RPM of the motor and indicator will indicate the reading in RPM directly.

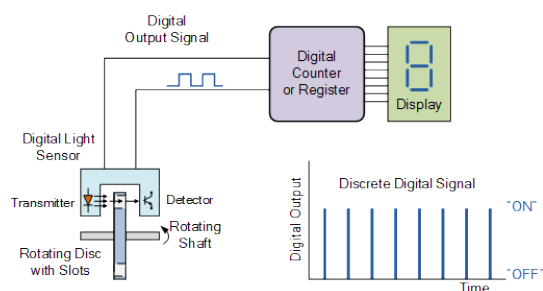
**Magnetic pickup ( Proximity) sensor**

It is not contacting sensing device, it sensor to the signal from the rotating body and is very accurate and very reliable and this sensing device is non contact type and is equal to magnetic pick up.



**Optical/ photo pickup**

It is not contacting sensing device, the lever which is fixed to a rotating shaft from a motor. As the lever rotates with the speed of the shaft, The light passes by the sensor and reflected back by lever is received by sensor in turn producing an output pulse representing a logic “1”. These pulses are sent to a register of counter and finally to an output display to show the speed or revolutions of the shaft.



**CONTROLS:** (1) FRONT PANEL

POWER ON : 2 SPDT switch supplies the AC mains into the indicator.

OPTICAL/PROXIMITY: This switch we can select the sensing device of optical/proximity.

(2) BACK PANEL

OPTICAL SENSOR : 3 pin sockets are provided to connect the sensor to indicator.

PROXIMITY : 3 pin sockets are provided to connect the sensor to indicator.

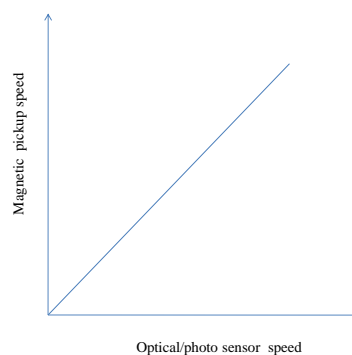
POWER CABLE: 2 pin 2 core cable interconnects the 230 V -50Hz AC main into the AC main into the instrument.

FUSE : 500 mA fuse is used to protect the instrument from the short circuit.

**Tabulation**

S.No.	Optical/photo sensing device Reading	Proximity/magnetic sensing device Reading
1		
2		
3		
4		
5		
6		

Model graph



**Result :** Thus the speed is calibrated by using photo/optical and magnetic pick up sensor



#### **4. TEMPERATURE MEASUREMENT BY THERMOCOUPLE, RTD, AND THERMISTOR**

**Aim:** To study temperature transducers, Thermocouple, RTD, Thermistor by using digital temperature indicator.

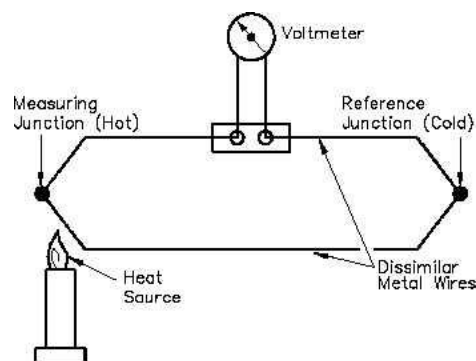
**Apparatus required:** Temperature transducers, Digital temperature indicator, Thermometer, Electric sterilizer.

**Procedure:**

1. Select the Thermocouple/RTD/Thermistor by selector switch.
2. Connect the Thermocouple/RTD/Thermistor to sensor socket provided at front panel.
3. Set the min pot to read the ambient temperature in display.
4. Insert Thermocouple/RTD/Thermistor in the hot bath.
5. 3 digit LED display shows the temperature obtaining at the hot bath directly in degrees Celsius.
6. If necessary adjust the max pot for the maximum level of temperature calibration.
7. Recorder red and green terminals for the anal output.
8. Fuse holder provider to protect the circuit from the over load (500 mA).

**Thermocouple:**

It is the simplest and commonly used methods of measuring process temperature. The operation of Thermocouple is based on seebeck effect. See back discovered that when heat is supplied to the junction of two dissimilar metals, an emf is generated which can be measured at the other junction. The two dissimilar metals form an electric circuit and current flows as a result of the generated emf.



**Construction of Thermocouple**

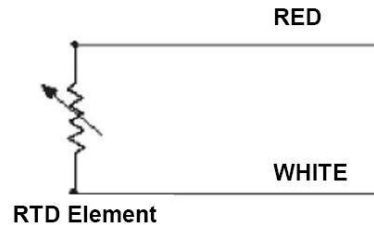
A pair of two dissimilar metals that are in physical contact with each other form a Thermocouple. These metals may be twisted, screwed, pinned, clamped or welded together. The most commonly used method for fabricating is to weld metals together. Thermocouple do not use bare conductors except in applications where atmosphere conditions permits their use. These conditions obtained when temperature to be measured are low and atmosphere is non corrosive. Industrial Thermocouples employ protective sheathing surrounding the junction and a portion of the extension leads. The lead and junction are internally insulated from the sheath using various potting

compound, ceramics beads or oxides. The type of insulations is used depends upon the process being monitored.

Type of the sensor : "J" type

Material use : chromium Alumel

### RTD :



The resistance of a conductor changes when its temperature is changed. This property is utilized for measurement of temperature. The resistivity of metals showed a marked dependence on temperature as platinum is used to this day as to primary element all high accuracy resistance thermometers. In fact, a platinum resistance temperature detector (PRTD) is used today as an interpolation standard from oxygen point ( $-188.96^{\circ}\text{C}$ ) platinum is especially to antimony point ( $630.74^{\circ}\text{C}$ ) platinum is especially suited for this purpose, as it can withstand high temperature while maintain excellence stability as a Nobel metal it shows limited susceptibility to contamination. All metals produce a positive change in resistance with temperature this of course is the main function of RTD the system error is minimized when the nominal value of RTD is large. This implies a metal with value of resistivity of metal, role material we will have to use.

The requirements of a conductor to be used in RTD are:

1. The change in resistance of a material per unit change in temperature should be as large as possible.
2. The material should have a high value of resistivity so that the minimum volume of material is used for the construction of RTD.
3. The resistance of material should have a continuous and stable relationship with temperature. Copper is used occasionally as an RTD element. It is to resistivity forces the element to be larger than the platinum element but it is low linearly and low costs making it is an economical alternative. Its upper limit of temperature  $120^{\circ}\text{C}$ . The most common RTD are made of either platinum, nickel or nickel alloys. The economical nickel wires are used over a limited temperature range, they are quiet long linear and tend to draft with time for measurement integrity platinum is the obvious choice the single most common value is  $100\ \Omega$  at  $0^{\circ}\text{C}$  with resistance temperature co-efficient  $0.00385/^{\circ}\text{C}$  the more chemically pure platinum wire has resistance temperature co-efficient  $0.00392/^{\circ}\text{C}$

Specification – RTD

Type: PT 100

Resistance value:  $100\ \Omega$  at  $0^{\circ}\text{C}$

**Thermister :**

Thermister is a contraction of term “thermal resistors”. Thermister are generally composed of semi conductor materials. Although positive temp co efficient of units which exhibits an increase in the value of resistance can be as large as several percent per degree Celsius. This allows the Thermister circuits to detect very small changes. This temperature which could not be observed with an RTD or a thermocouple, in some cases the resistance of Thermister at room temperature may decrease as much as 5% for each that is raise in temperature. This high sensitivity to temperature change makes Thermisters extremely useful for precision temperature measurements control and compensation.

Thermister are widely used in applications which involved measurements in the range of  $-16^{\circ}\text{C}$  to  $15^{\circ}\text{C}$  .The resistances of Thermister ranges from  $0.5\ \Omega$  to  $0.75\ \Omega$ . Thermister is highly resistive device. The price to be paid off for the high sensitivity is in terms of linearity. The Thermister exhibits highly non linear characteristics of resistance verse temperature.

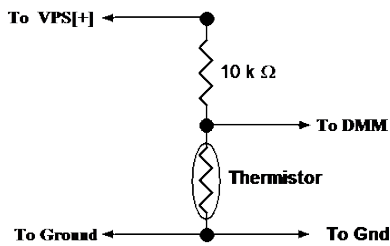


Fig : Temperature measuring circuit using thermister

**CONTROLS**

MIN: 10K single turn potentiometer to set the min level of temperature (i.e., ambient temperature)

MAX: 10K single turn potentiometer to adjust the max level of temperature.

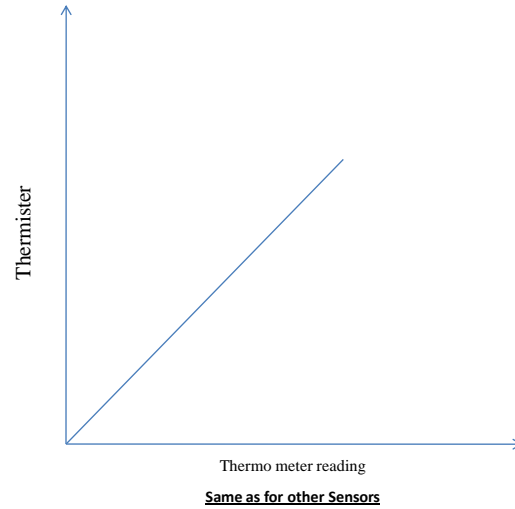
RTD/ Thermocouple: screw type connecting socket to connect the RTD/ Thermocouple/Thermister sensor.

**Tabulation:**

S.No.	Thermocouple Reading in °C			RTD Reading In °C	Thermister Reading In °C	Thermometer Reading In °C
	J	K	T			
1						
2						
3						
4						
5						
6						

- Graphs :
1. Thermometer Reading Vs Thermister Reading
  2. Thermometer Reading Vs RTD Reading
  3. Thermometer Reading Vs J-type Thermocouple Reading
  4. Thermometer Reading Vs K-type Thermocouple Reading
  5. Thermometer Reading Vs T-type Thermocouple Reading

**Model graph:**



**Result :** Thus the Temperature of transducer, Thermo couples, Thermister and RTD were calibrated using digital thermometer

## **5. STUDY OF MCLEOD GAUGE**

**Aim:** Low pressure measurement by McLeod gauge.

**Apparatus required:** McLeod gauge, vacuum chamber, vacuum pump.

**Procedure:**

1. Connect the tubes (pipes) from vacuum pump to vacuum chamber and vacuum pump to McLeod gauge.
2. Open the outlet wall before starting the vacuum pump.
3. Close the outlet wall after starting the vacuum pump.
4. Keep the McLeod gauge in horizontal position before starting the vacuum pump.
5. Switch ON the vacuum pump.
6. See the reading in McLeod pump by varying perpendicular axis and note down the readings.

### **INTRODUCTION**

**Low pressure gauge:**

Pressure less than 1mm of mercury are considered to be low pressure and are expressed in either of two units, namely the torr and micron. 1 torr is a pressure equivalent to 1mm Hg at standard conditions., one micron is  $10^{-3}$  torr through common usage the term vacuum refers to any pressure below atmosphere (760mm Hg).this pressure region is divided into 5 segments.

Low vacuum      760 torr to 25 torr

Medium vacuum   25 torr to  $10^{-3}$  torr

High vacuum       $10^{-3}$  torr to  $10^{-6}$  torr

Very high vacuum  $10^{-6}$  torr to  $10^{-9}$  torr

Ultra high vacuum  $10^{-9}$  torr and beyond

The pressure measuring devices for low pressure (vacuum) measurement can be classified into 2 groups

**Direct measurement**

Where in displacement deflection costs by the pressure is measured and correlated to the applied pressure. This principle is incorporated in nanometers, spiral bourdon tube; flat and corrugated diaphragms and capsules, manometers and gauges are suitable to about 0.1 torr, bourdon gauges to 10 torr and diaphragm gauges to  $10^{-3}$  torr. Below these ranges, that use of indirect vacuum gauges is resorted.

### Indirect measurement

(Inferential) gauges wherein the low pressure is detected to measurement of a pressure controlled property such as volume, thermal conductivity etc., the inferential gauge include McLeod vacuum meters attention would be concentrated here on low pressure measurement by the inferential gauges only.



### McLeod gauge

The unit comprises a system of glass tubing in which a known volume of gas at unknown pressure is trapped and then isothermally compressed by raising mercury. This amplifies the unknown pressure and allows it is measurements by conventional man metric means.

### Tabulation:

S.No.	McLeod Gauge Reading
1	
2	
3	
4	
5	
6	

**Result:** Thus Low pressure measurement is calibrated by using McLeod gauge

## 6. ANGULAR DISPLACEMENT DEMONSTRATION SET UP

**Aim:** To study of capacitance transducer for measuring displacement.

**Apparatus required:** Digital displacement indicator, capacitance pickup.

**Procedure:**

1. Keep the movable capacitance transducers at  $0^{\circ}$  points and make 0 by help of minimum pot.
2. Take the readings to move from  $0^{\circ}$  to  $300^{\circ}$  angle.
3. Make a graph Protractor reading Vs Indicated reading.

### CONTROLS

Capacitance sensor: Yellow color sockets provided to connect the capacitance pickup.

Zero : 10k single turn potentiometer provided to initiate the Max calibration.

CAL : 10 K single turn potentiometer provided to adjusts the Max calibration.

Power on : 2 position toggle switch to select the instrument ON or OFF.

Power chord : 3 pin provided at back side connect the instruments to the 230V by 50Hz AC supply.

Fuse : 500 mA fuse is provided at the back side to protect instruments from the short circuit.

D.P.M. : Red color segment LED display read out for digital read out directly in cms.

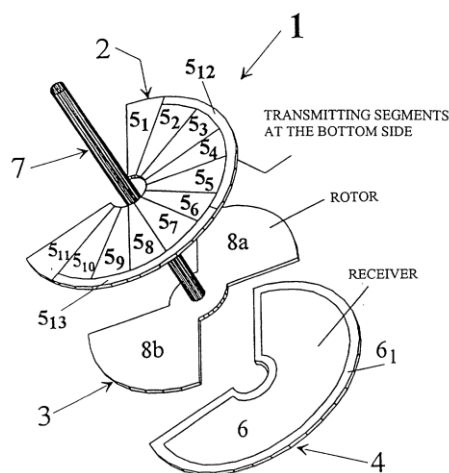
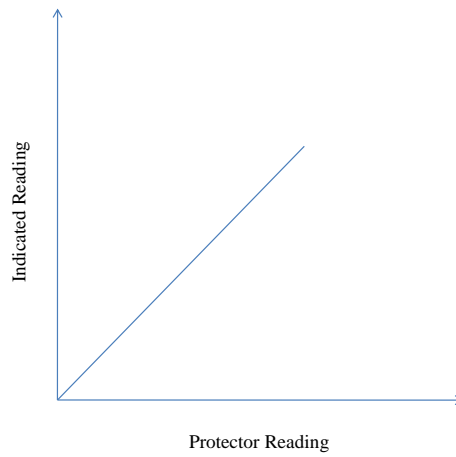


Fig. 3

**Tabulation:**

S.No.	Indicated Reading	Protractor Reading
1		
2		
3		
4		
5		
6		

**Model graph:**



**Result :** Thus the displacement is calibrated by using capacitance transducer.



## 7. VIBRATION ANALYSER

**AIM :** Measurement of vibration parameters.

**Apparatus Required :** Vibration analyser, vibration pickup

**Procedure:** Connect vibration pickup cable to the vibration analyser sensor socket.

**Controls for Vibration meter:**

Power on : SPDT switch supplied AC mains into indicator.

Recorder : Screw type connecting terminals to measure the analog readout and recording purpose.

Sensor : Three pin socket is provided to connect the sensor cable

Function switch : (a) Keep the function switch in to Acc and can be read acceleration 0 to 200 mts/Sec<sup>2</sup>

(b) Keep the function switch in to Vel and can be read velocity 0 to 200 mm/sec

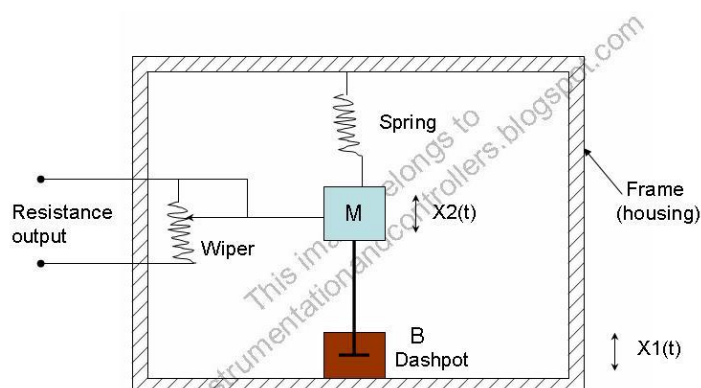
(c) Keep the function switch in to displacement and can be read displacement 0 to 2000 microns.

Power Cable : 3 pin 3 core cable interconnect the 230 Volts/ 50 Hz AC mains into the instruments.

Fuse : 500 MA fuse to protect the instrument from the short circuit.

Output : Analog meter shows according to the function switch kept position reading displacement or Velocity or Acceleration.

**Vibration measuring Instrument :** The instrument which is used to measure the displacement velocity or acceleration of a vibrating body are called vibration measuring instruments. Vibration measuring devices having a mass, spring, dashpot etc., are known as seismic instruments. The quantities to be measured are displayed on a screen in the form of electric signal which can be readily amplified and recorded. The output of the electric signal of the instrument will be proportional to the quantity which is to be measured.



The above figure shows the potentiometric type accelerometer. The seismic mass is attached to the wiper arm of resistance potentiometer. The mass is connected to the source of vibration whose characteristics are to be determined. Relative motion of mass with respect to the transducer frame is sensed either as a change in resistance or as a change in voltage output if the potentiometer is used as potential divider. The damping is provided by dash pot. Proper damping is necessary because it increases the range of frequencies over which the transducer may be used.

**Vibration measuring principle :**

The vibrating probe is stimulated by a piezo and oscillates at its mechanical resonance frequency. If the probe comes into contact with material, the oscillation is dampened and this is electronically registered, and sent out as a signal. Once the probe is no longer comes in contact with material, the probe can oscillate again and a new output signal is generated.

**Tabulation :**

S.No.	Displacement microns	Velocity mm/sec	Acceleration mt/sec <sup>2</sup>
1			
2			
3			
4			
5			
6			

## 8 ROTOMETER CALIBRATION

**AIM :** To calibrate the rotometer by using Rotometer experimental setup

**Apparatus Required :** Rotometer setup, Stop watch , 2lts capacity collecting jar, control valve, water circulating system etc.,

- Procedure:
1. Fill the water in storage container
  2. Connect the submersible water pump and motor unit to the AC supply
  3. Set the regulator for initial flow.
  4. Switch on the power supply.
  5. Adjust the volume flow rate of water to a certain value by regulating valve and collect water in 2lts jug
  6. Note down the time consumption for collection of 2lts water by using stop watch
  7. Calculate theoretical discharge for the above measured flow by  
Using  $Q = \frac{60}{t} \times 2 \left( \frac{\text{lts}}{\text{min}} \right)$   
where t = time consumption for 2 lts
  8. Repeat above 5 or 6 times by increasing the flow at each time and note down the time consumption.
  9. Compare the theoretical flow rate with actual flow rate.
  10. Plot the graph between theoretical discharge with actual discharge.

### Theory :

The rotometer consists essentially a tapered metering glass tube, inside a float which is located in the Rotameters. The tube is provided with suitable inlet and outlet connecting the float or bob having a specific gravity higher than that of fluid to be metered. In these devices, the falling and rising action of a float in a tapered tube provides a measure of flow rate . Rotameters are known as gravity-type flow meters because they are based on the opposition between the downward force of gravity and the upward force of the flowing fluid. When the flow is constant, the float stays in one position that can be related to the volumetric flow rate. That position is indicated on a graduated scale. Note that to keep the full force of gravity in effect, this dynamic balancing act requires a vertical measuring tube.

The tapered tube's gradually increasing diameter provides a related increase in the annular area around the float, and is designed in accordance with the basic equation for volumetric flow rate:

$$Q = kA\sqrt{gh}$$

where:

$Q$  = volumetric flow rate, e.g., Lts per minute

$k$  = a constant

$A$  = annular area between the float and the tube wall

$g$  = force of gravity

$h$  = pressure drop (head) across the float

(OR)

$$Q = C_d a_2 \sqrt{2 \cdot g \cdot \frac{H(\rho_f - \rho)}{A_f \cdot \rho}}$$

$C_d$  = Coefficient of discharge

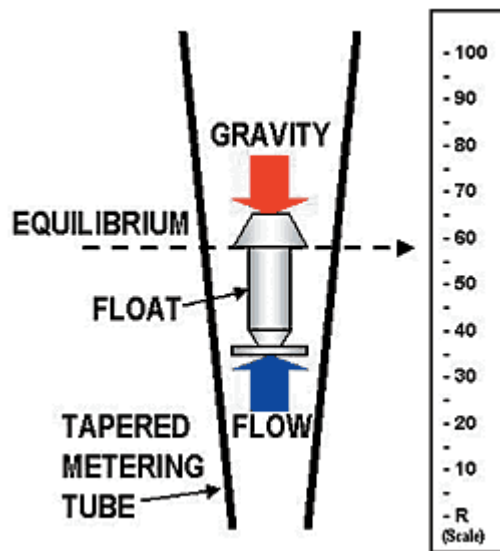
$V_f$  = Volume of float

$\rho_f$  = Density of float

$\rho$  = Density of fluid

$a_2$  = Annular area between float and tube

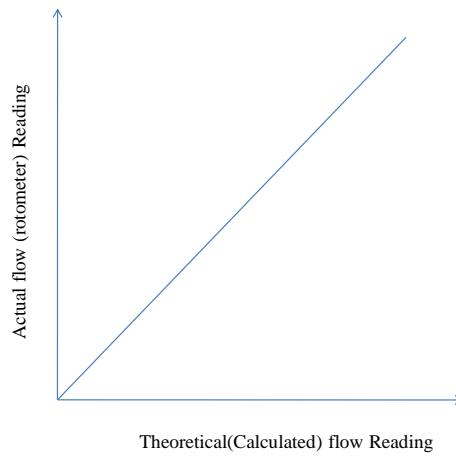
$A_f$  = Maximum cross sectional area of the tube



**Tabulation :**

Sl. No.	Actual flow	Theoretical flow
1		
2		
3		
4		
5		

**Model Graph :**



**Result :** Thus the rotometer is calibrated with theoretical value