Department of

Electrical Engineering

LAB MANUAL

Instrumentation and Measuring Device LAB

B.Tech–IV Semester

KCT College OF ENGG AND TECH.

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INDEX

Experiment-1

Study of the characteristics of Piezo-resistive Pressure Sensor for Pressure Measurement of a Liquid in a Tank.

Objective:

1. To know what is a **Piezo-resistive Pressure Sensor**.
2. To know how to convert the Piezo-electric Pressure Sensor Signal Into Pressure and find the calibration equation

Apparatus:

MT001-003 Multi0Process Variable Measurement Trainer

Theory:

Pressure *P* is defined as the force *F* exerted per unit area *A*.

$$P = \frac{F}{A}$$

The SI unit for pressure is *Pascal (N/m2)*. Other commonly used units are *Pounds per square inch (psi), atmospheric pressure (atm.) and mmHg etc*

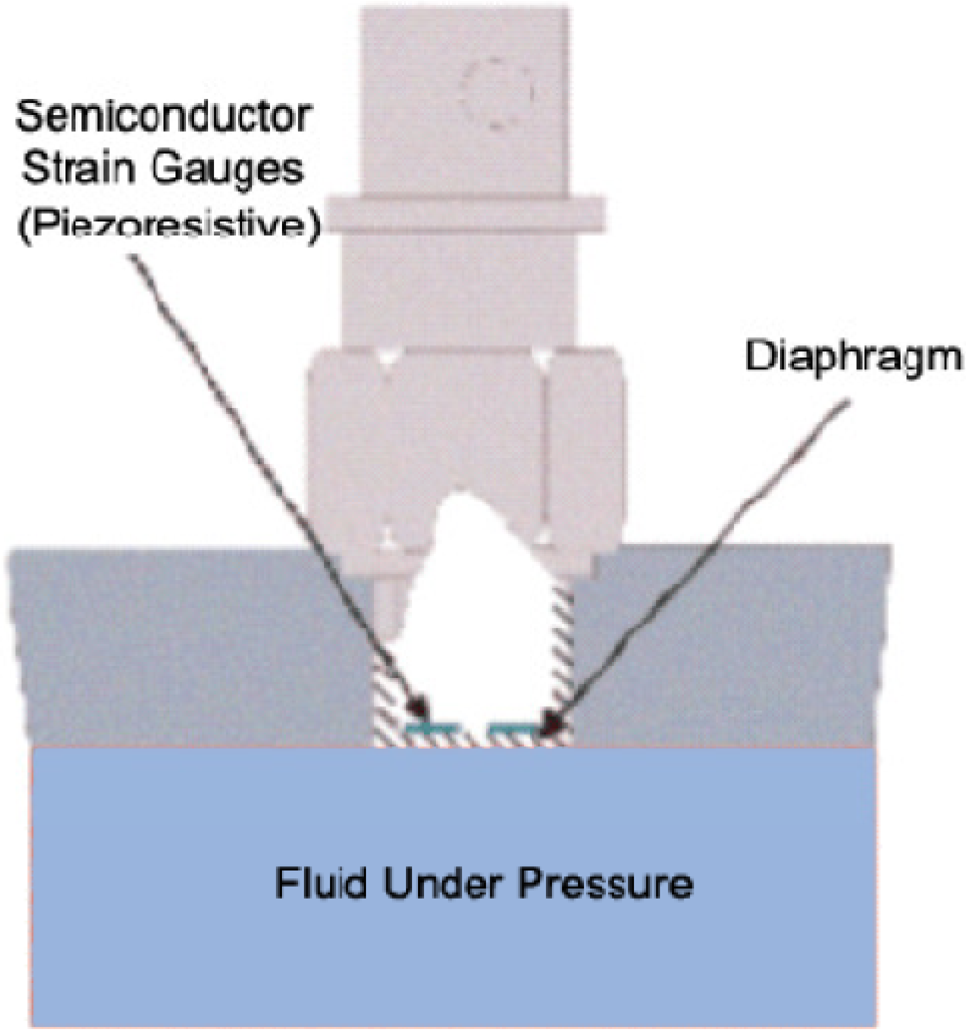


Figure 1: A Piezo-resistive pressure sensor

Show a piezo-resistive sensor measuring the pressure of a fluid at Certain point in a tank. The Piezo-resistive effect describes the changing Electrical resistance of a material due to applied mechanical stress. Diaphragm of the sensor experiences a pressure due to which its Resistance is changed, thereby changing the voltage across it when Connected to an electric circuit.

Pressure Measurement:

The natural output of a pressure transducer is a voltage. Most strain based pressure transducers will output a small **mV**
Voltage. This small signal requires several signal conditioning

Considerations. Additionally, many pressure transducers will output a conditioned 0-5**V** signal or 4-20 **mA** current. Both of these outputs are linear across the working range of the transducer. For example both 0 **V** and 4 **mA** correspond to a 0 pressure measurement. Similarly, 5 volts and 20 **mA** correspond to the Full Scale Capacity or the maximum pressure the transducer can measure. The 0-5**V** and 4-20 **mA** signals can easily be measured by Multi-function Data Acquisition (DAQ) hardware.

Experiment Procedure:

1. Open the "MT001-003 Level Measurement" window as shown in figure 2.
2. Study the front panel carefully and observer the buttons on the screen.
3. Make sure that **Tank2** is almost empty.
4. Observe the reading of the pressure in **mbar** and the current in **mA**.
5. Turn the **Pump** ON by pressing the **Pump** picture in the front panel.
6. Observe the **Pressure – Current graph**, and see the change of pressure and current with the change of level. 7. Press **[Hold Values]** button to take a reading. The reading will appear in the **Held Values Table**.
8. Close the **Flow Control Valve** by dragging the **Valve Opening Slide** to **0%**.
9. Observe how the **Feedback Slide** responds to the change in the **Valve Opening Slide**.
10. Wait until the **Flow Control Valve** reaches the **"Fully Closed"** state (when the **Feedback** slide almost reaches 0 and the **Flow meters indicators** read 0 **l/s**).
11. Turn the **Pump** OFF by pressing the Pump picture in the front panel.
12. Notice that the Level in **Tank2** should not change.
13. Take the level of the water in **Tank2** and the reading of the pressure sensor in (**mbar**) and write them down.

a) Water Level = …………………………………(**m**)
b) Pressure from the Pressure sensor = ………..(**mbar**)
Use the below equation to find the actual Pressure _=___ Where:
P: *Pressure Calculated* **(pascal)**
: *Water Density* **(kg/m3)**
g: *Gravity Acceleration* **(m/s2) = 9.81**
h: *Water Level* **(m)**

14. Divide the calculated pressure on (1 105) to convert it to **bar**.
15. Compare the result with the value you have taken above. 17.
16. Compare the calculated pressure value with the actual pressure value that you have taken from the **Held Values table**, is it the same?
17. Observe the transformation equation and the **Pressure-Current graph**, and answer the following questions:

a) Is the equation Linear? If no, why?
b) Does the plot in the **Pressure-Current graph** represent the transformation equation? If no, why?

18. Change the state of the **Flow Control Valve** to **"Fully Open"** by dragging the **Valve Opening slide** to **100%**.

19. Observe the change in the value of the **Feedback Slide**. 20. 20. Observe the **Pressure – Current graph**, and see the change of pressure and current with the change of level.
21. Notice that the **Flow Meter** should start measuring the Flow.
22. Wait until **Tank2** becomes almost empty.
23. Press **[Save]** button if you want to save the experiment.
24. Press **[Clear Chart]** button if you want to clear the chart(s).
25. Stop the process and press **[Return]** to go back to the **“Process Variables Experiments”** screen.

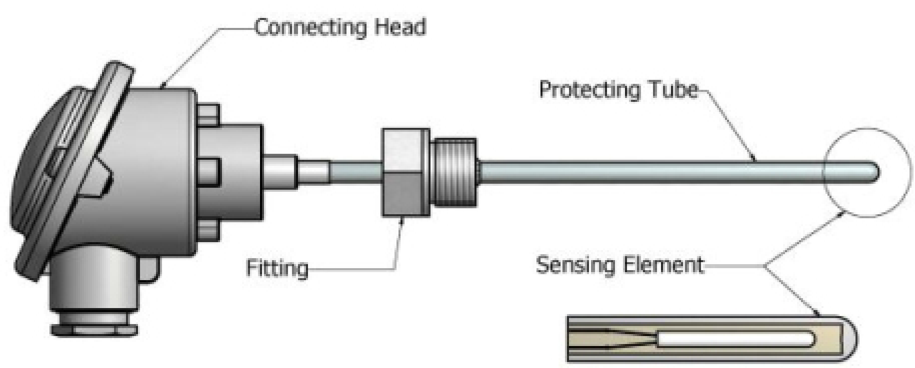
EXPERIMENT-2

Study of the characteristics of Resistance Temperature Detector (RTD).

Aim: To study resistance temperature detector and its characteristics.

Apparatus required: RTD pt-100, voltmeter, power supply, connecting wires.

Introduction:



The resistance temperature detector is made up of transducers and electric circuits. Its purpose is to measure temperature that causes changes in resistance. The most common electric arrangement related to these connections is four arm bridges.

RTD is mainly resistive sensitive element that exhibits i.e. increase in the resistance with increase in the temperature characteristics. Hence this device is namely the positive temperature coefficient of resistance. They are constructed of Pt, Ni, Cu and Nicol iron.

Working principle of resistance temperature detector (RTD):

The principle employed in this method of temperature measurement is the electrical resistance of temperature sensing element varies with any change in temperature of the material.

Theory:

Resistance thermometer provides absoluter temperature in sense that no reference junctions are involved. They are simple and stable, sensitive RTD having temperature coefficient of R

1) RTD should be fabricated in convenient size.

2) Its normal coefficient of resistance should be high for large output.

3) Output should be linear.

4) It should be free from residual stress.

5) For good repeatability, RTD material should be having good purity.

General expression for RTD material is given by,

$R(t)=Ro[1+\alpha(t-to)]$

Where,

R(t)=resistance measured at t degree Celsius.

Ro=resistance measured at 0 degree Celsius.

α = RTc per degree Celsius = 0.0039 per degree Celsius.

α is called as resistance temperature coefficient per degree centigrade.

Construction of RTD:

RTD Arrangement

The resistance element should be wire wound or photo attached. Figure shows the simple wire wound RTD arrangement. The time constant of this type of RTD is of order of milliseconds.

Advantages of RTD:

1) Wide range of temperature from -200 C to 850 C.

2) Extremely accurate temperature sensing.

3) No rise recites of temperature compensation.

4) Large size of RTD as compared with thermistor.

Range of temperature:

It is the limiting values up to which RTD will remain good in working condition. Temperature range of RTD pt-100 is -200 C to 850 C.

Accuracy:

Degree of exactness or closeness to true values from RTD Pt-100 is 0.6 C to 800 C

Procedure:

1) Take water in container and place a heater to heat water.

2) Immerse RTD and thermometer in water bath.

3) Switch on the power supply.

4) Measure the temperature on the thermometer from room temperature (30 C) to 98 C and corresponding resistance of RTD at that temperature.

5) Switch off the power supply, and then take reading in decreasing order of temperature in an interval of 10 C.

6) Plot a graph of temperature on X-axis and Resistance on Y-axis.

Observation Table:

Sr. No.:	Temp in degree Celsius	Resistance (Uploading)	Resistance (Downloading)

Calculations:

To calculate temperature coefficient (α) of given RTD , we have,

$\alpha = [(R(t)/Ro)-1]/(t-to)$

to is the room temperature.

Conclusion:

Thus we have studied RTD and its characteristics which are linear in nature Pt-100 is having positive temperature coefficient of resistance.

Result:

The temperature coefficient (α) of Pt-100 is 0.003556 per degree Celsius

EXPERIMENT-3

Study of the characteristics of Thermocouples.

Objective:

1. To know what is a **Thermocouple**.
2. To know how to convert the Thermocouple Signal into Temperature and find the calibration equation

Apparatus:

MT001-003 Multi-Process Variable Measurement Trainer

Theory:

Thermocouple (TC) is created whenever two dissimilar metals touch and the contact point produces a small open-circuit voltage as a function of temperature. This thermoelectric voltage is known as the **Seebeck voltage**, named after Thomas Seebeck, who discovered it in 1821. The TC has been the popular choice over the years for a variety of reasons. Thermocouples are relatively inexpensive and can be produced in a variety of sizes and shapes. They can be of rugged construction and can cover a wide temperature range. However, TCs produce a very small microvolt output per degree change in temperature that is very sensitive to environmental influences. Electromagnetic interference (EMI) from motors and electrical distribution and especially radio frequency interference (RFI) from walkie-talkies can produce dramatic errors in measuring circuits in these instruments. As mentioned above any two dissimilar metals may produce a TC, however, there are some standard thermocouples which have calibration tables and assigned letterdesignations which are recognized worldwide, Such as, J-type (Iron / Constantan), K-type (Chromel / Alumel), E-type (Chromel / Constantan), N-type (Nicrosil / Nisil), B-type (Platinum / Rhodium), R-type (Platinum / Rhodium) and S-type (Platinum / Rhodium). In order to select the suitable TC for an application, sensitivity and temperature range should be taken into consideration, because each one of these thermocouples has a different temperature range and sensitivity. Further details and operation of TCs can be found in the text book.

Experiment Procedure:

1. Open the "MT001-003 Level Measurement" window as shown in figure 1.
2. Study the front panel carefully and observe the buttons on the screen.
3. Notice the 4 different tabs on the front panel; **Thermocouple**, **RTD, Thermistor** and **Trends.** Press **Thermistor.**
4. Make sure that **Tank2** is almost empty.
5. Turn the **Heater** ON by pressing the **Heater** picture in the front panel.
6. Keep taking readings by pressing the tab **Hold Value** while heater is ON.
7. Wait until the Temperature go up between **(7-10)** degrees from the initial temperature.
8. Turn the **Heater** OFF by pressing on the **Heater** picture in the front panel (**Cooling Mode**).
9. Turn the **Pump** on by pressing the **Pump** picture on the front panel.
10. Keep taking readings by pressing **[Hold Values]** button.
11. Press **[Clear Chart]** button if you want to clear the chart(s).
12. Press **[Return]** button to return to the **"Process Variables Experiments"** screen.

EXPERIMENT-4

Study of the characteristics of Capacitor Level Sensor for Level Measurement of a Liquid in a Tank.

Objective:

1. To know what is a **Capacitance Level Sensor**.
2. To know how to convert the Capacitance Level Sensor Signal into Level and find the calibration equation

Apparatus:

MT001-003 Multi0Process Variable Measurement Trainer

Theory:

Capacitance *C*, of a capacitor is described by the following Equation

$$\epsilon = \epsilon_o \epsilon_r \qquad C = \frac{\epsilon A}{d}$$

Where _
_is the dielectric constant of air and __ is the relative dielectric constant of the medium. *A* is the area of the plates of a capacitor and *d* is the distance between the two plates of a capacitor. In order to understand the working principle of a capacitance probe level sensor, consider figure 1, which show a capacitance probe level sensor inserted into a tank with conduction walls. As indicated, Wall of the tank and the probe constitute two plates of a capacitor. Any change of liquid level in the tank causes the change of dielectric medium between the two plates and thus changes the capacitance, giving a measure of the liquid level.

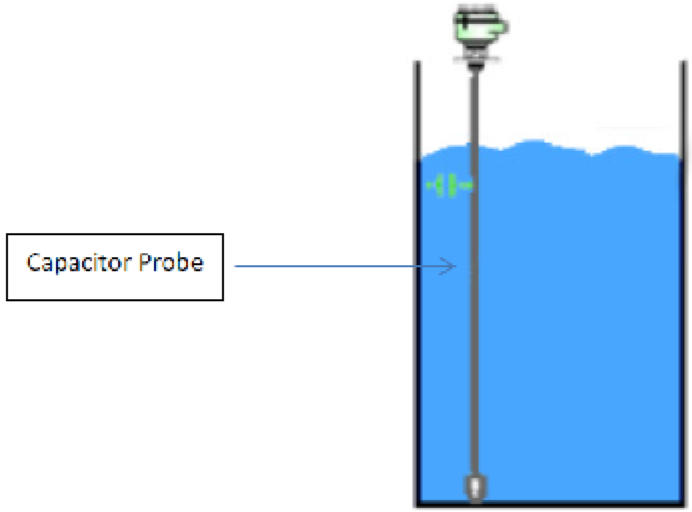


Figure 1: Capacitor Probe in a conducting Tank

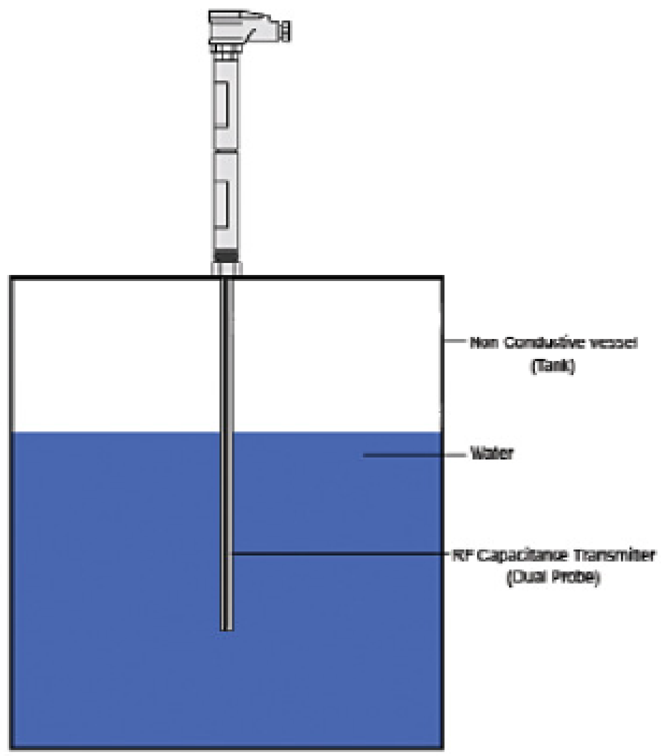


Figure 2: Dual Capacitor Probe in a non-conducting Tank

should be noted that since the tanks in MT003-001 are made of Plexiglas which is a non-conducting material, therefore the scheme of figure 1 cannot be used. Instead as seen in figure 2, a dual capacitor probe consisting of two concentric cylinders is used. The two concentric cylinders constitute the two plates of a capacitor and a change of liquid level between the two plates causes an ultimate change in the capacitance this is then calibrated into level of the liquid in the tank.

Experiment Procedure:

1. Open the "MT001-003 Level Measurement" window as shown in figure 3.
2. Make sure that **Tank2** is almost empty.
3. Observe the reading of the Level in **cm** and the Current in **mA**.
4. Turn the **Pump** ON by pressing the Pump picture in the front panel.
5. Observe the **Level – Current graph**, and see the change of level and current with the change of water level.
6. Press **[Hold Values]** button to take a reading. The reading will appear in the **Held Values Table**.

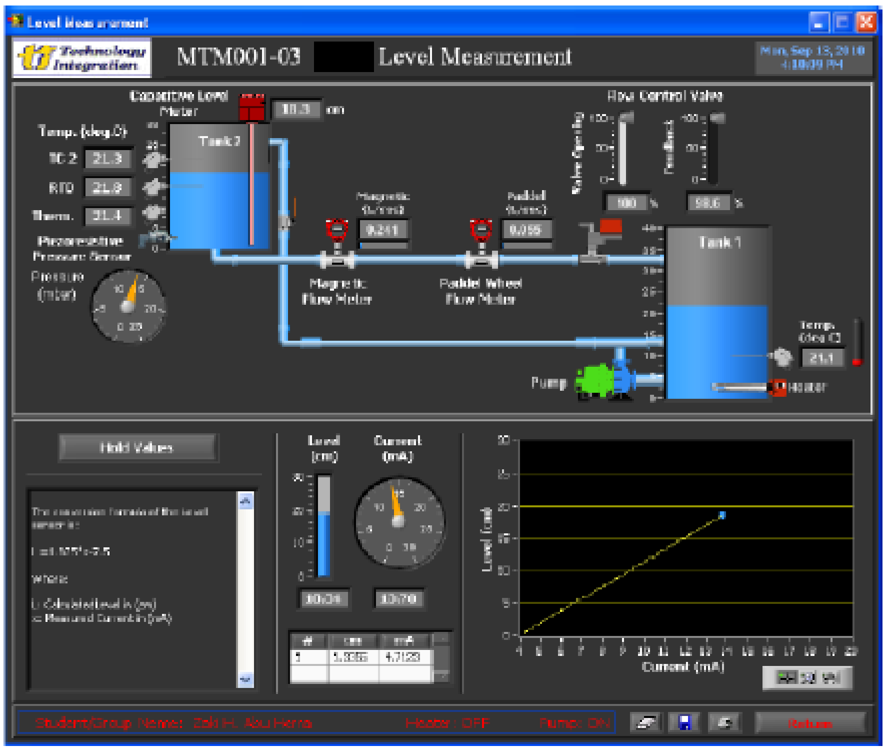


Figure 3: Level Measurement Experiment Window

7. Observe how the **Feedback Slide** responds to the change in the **Valve Opening Slide**.
8. Wait until the **Flow Control Valve** reaches the **"Fully Closed"** state (when the **Feedback** slide almost reaches **0** and the **Flow meters indicators** read **0 l/s**).
9. Turn the **Pump** OFF by pressing the Pump picture in the front panel.
10. The level in **Tank2** should not change.
11. Take the reading of the water level from the ruler at the front side of the tank, the level from the level sensor indicator and the current reading and write them down

a. Water Level from ruler = ………………….**(cm)**
b. Water Level from sensor = ………………..**(cm)**
c. Current reading = ………………………….**(mA)**

a. Compare the reading of the ruler with the reading of the sensor, are they the same? If no, why?
12. Observe the plot in the **Level- Current graph**, is it Linear?
13. Take the current(**mA**) reading which you have taken above (step
11) and apply it in the following equation:
=.__ _−_. Where:
L*: Calculated Level (***cm***)*
I*: Current (***mA***)*
14. Compare the calculated level from the above equation with the level of the sensor you have taken in step 14, are they the same?
15. Observe the plot in the **Level – Current graph**, is it Linear?
16. Does the level transformation equation mentioned in step 17 describe the behavior of this plot? If not, why?
17. Change the state of the **Flow Control Valve** to **“Fully Open”** by dragging the **Valve Opening slide** to **100%**. Observe the change in the value of the **Feedback Slide**.
18. Observe the **Level – Current graph**, and see the change of level and current with the change of water level.
19. Notice that the **Flow Meter** should start measuring the Flow.
20. Wait until **Tank2** becomes almost empty.
21. Press **[Save]** button if you want to save the experiment.
22. Press **[Clear Chart]** button if you want to clear the chart(s).
23. Stop the process and press **[Return]** to go back to the **“Process Variables Experiments”** screen.

EXPERIMENT-5

Study of the characteristics of Thermistors.

Objective:

1. To know what is a **Thermistor**.
2. To know how to convert the Thermistor Signal into Temperature and find the calibration equation

Apparatus:

MT001-003 Multi-Process Variable Measurement Trainer

Theory:

Thermistors, like RTDs, are thermally sensitive semiconductors whose resistance varies with temperature. Thermistors are manufactured from metal oxide semiconductor material encapsulated in a glass or epoxy bead. Also, thermistors typically have much higher nominal resistance values than RTDs (anywhere from 2,000 to 10,000 _) and can be used for lower currents. Each sensor has a designated nominal resistance that varies proportionally with temperature according to a linearized approximation. Thermistors have either a negative temperature coefficient (NTC) or a positive temperature coefficient (PTC). The first, which is more common, has a resistance that decreases with increasing temperature while the latter exhibits increased resistance with increasing temperature. Thermistors typically have a very high sensitivity (~200 **_/°C**), making them extremely responsive to changes in temperature. Though they exhibit a fast response rate, thermistors are limited in their use up to the 300 °C temperature range. This, along with their high nominal resistance, helps to provide precise measurements in lower temperature applications. In **MTM001-03** we use an NTC thermistor this has a temperature range from 13-85 oC. In order to measure temperature with the thermistor, you only need to measure the resistance of the thermistor, and then substitute the resistance value in the following equation :

_ =
1
’+ ()*(_) + +[ln (_)]0

Where:

T *: Calculated temperature in (***Kelvin***)*

R*: Measured resistance in (***Ohm***)*

a, b *and* **c** *are Steinhart-Hart Constants that have the following values*

a *= 1.2407635*10-3*

b *= 2.3612017*10-4*

c *= 8.97975*10-8*

Using the above equation you will get the temperature in **Kelvin**. The value of **a**, **b** and **c** differs from one type of thermistor to another.

Experiment Procedure:

1. Open the "MT001-003 Level Measurement" window as shown in figure 1.
2. Study the front panel carefully and observe the buttons on the screen.

3. Notice the 4 different tabs on the front panel; **Thermocouple**, **RTD, Thermistor** and **Trends.** Press **Thermistor.**
4. Make sure that **Tank2** is almost empty.
5. Turn the **Heater** ON by pressing the **Heater** picture in the front panel.
6. Keep taking readings by pressing the tab **Hold Value** while heater is ON.
7. Wait until the Temperature go up between **(7-10)** degrees from the initial temperature.
8. Turn the **Heater** OFF by pressing on the **Heater** picture in the front panel (**Cooling Mode**).

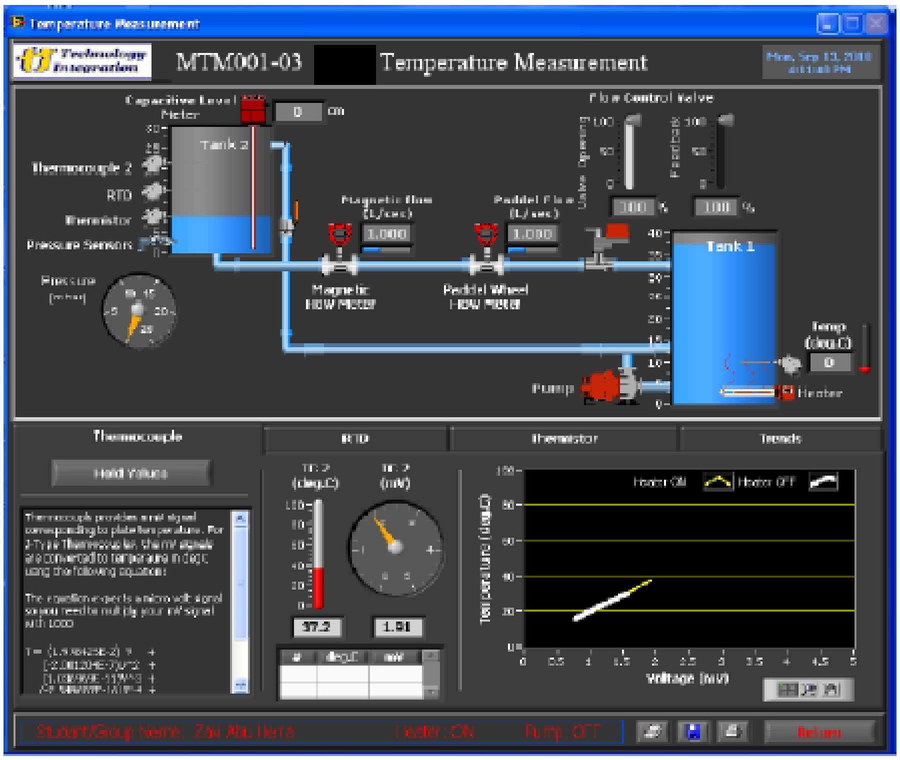


Figure 1: Temperature Measurement Window

9. Turn the **Pump** on by pressing the **Pump** picture on the front panel.
10. Keep taking readings by pressing **[Hold Values]** button.
11. Press **[Clear Chart]** button if you want to clear the chart(s).
12. Press **[Return]** button to return to the **"Process Variables Experiments"** screen.

EXPERIMENT-6

Study of the characteristics of Electromagnetic Flowmeter.

Objective:

1. To know what is an **Electromagnetic Flowmeter**.
2. To know how to convert the Electromagnetic Flowmeter. Signal into Flow rate and find the calibration equation

Apparatus:

MT001-003 Multi-Process Variable Measurement Trainer

Theory:

An **Electromagnetic Flow Meter** is a volumetric flow meter which does not have any moving parts and is ideal for wastewater applications or any dirty liquid which is conductive or water based. Magnetic flow meters don't work in non-aqueous solutions, neither with hydrocarbons, nor distilled water. Magnetic flow meters are also ideal for applications where low pressure drop and low maintenance are required.

Principle of Operation

The operation of a magnetic flow meter is based upon **Faraday's Law**, which states that: **"The voltage induced across any conductor as it moves at right angles through a magnetic field is proportional to the velocity of that conductor."**

Faraday's Formula:

E is proportional to **V** X **B** X **C**

where;

E = *voltage generated in a conductor*
V = *velocity of the conductor*
B = *magnetic field strength*
D = *length of the conductor*

To apply this principle to flow measurement with a magnetic flow meter, it is necessary to state that the fluid being measured must be electrically conductive for the Faraday principle to be applies successfully.

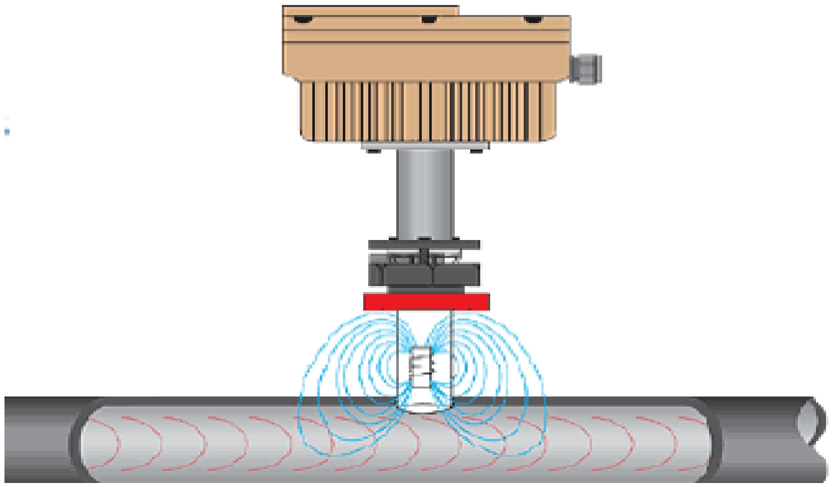
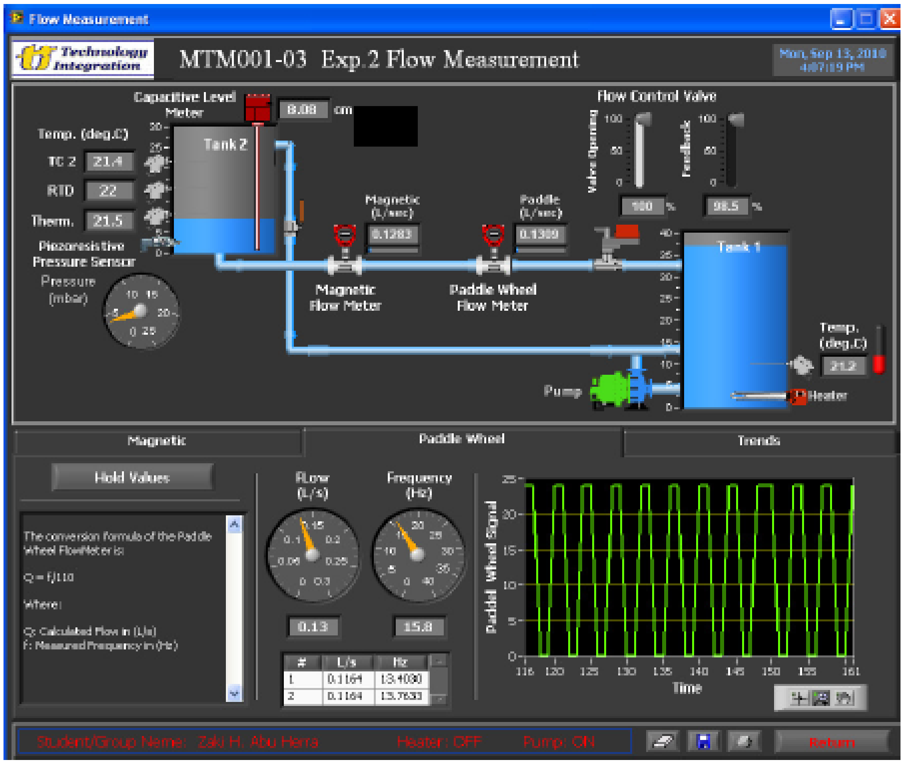


Figure 1: Electromagnetic Flowmeter Operation Principle

As applied to the design of magnetic flow meters, Faraday's Law indicates that signal voltage **(E)** is dependent on the average liquid velocity **(V)** the magnetic field strength **(B)** and the length of the conductor **(D)** (which in this instance is the distance between the electrodes). Here the magnetic field is considered as the measuring element of the magnetic flow meter, it can be seen that the measuring element is exposed to the hydraulic conditions throughout the entire cross-section of the flow meter. (Figure 1) Where to use Magnetic Flow meters? Where there is High percentage of solids, obstruction less measurement, very corrosive liquids, and conductive liquids.

Experiment Procedure:

1. Open the "MT001-003 Level Measurement" window as shown in



. Figure 2: Flow-rate Measurement Window

2. Study the front panel carefully.
3. observe the buttons on the screen.
4. Make sure that **Tank2** is almost empty.
5. Observe the readings of the **Flow Meters** on the front panel.
6. Press the **[Magnetic]** tab.
7. Close the **Flow Control Valve** by dragging the **Valve Opening Slide** to **0%**.
8. Observe how the **Feedback Slide** responds to the change in the **Valve Opening Slide**.
9. Wait until the **Flow Control Valve** reaches the **"Fully Closed"** state (when the **Feedback** slide almost reaches **0**).
10. Turn the **Pump** ON by pressing the Pump picture in the front panel.
11. Wait until the water level in **Tank2** reaches 20 **cm**.
12. Turn the **Pump** OFF by pressing the Pump picture in the front panel.
13. Open the **Flow Control Valve** by dragging the **Valve Opening Slide** to **100%**.
14. Observe the readings of the **Feedback Slide** and the readings of the **Flow Meters**.
15. Press the **[Hold Values]** button when the **Feedback Slide** reaches **25%**, **50%** &**75%** of its value, and write the values below:

Held Value 25%

Level = ………………………………..**cm**

Flow = …………………………………**L/s**

Current = ……………………………**mA**

Held Value 50%

Level = ………………………………..**cm**

Flow = ……………………………………**L/s**
Current = ……………………………….**mA**
Held Value 75%
Level = ………………………………..**cm**
Flow = ……………………………………**L/s**
Current = ……………………………….**mA**

16. From the previous step take the **Current** reading in **mA** for the value of **25%** and apply it in the following equation:

1= 2.22_×_−0.2425

Where:

Q :*Calculated Flow (***L/s***)*
I :*Current (***mA***)*

17. Compare the calculated flow in step 15 with the measured flow in step 16.
18. Repeat the same steps (16-17) for the values of **50%** and **75%**.
19. Press **[Clear Chart]** button if you want to clear the chart(s).
20. Stop the process and press **[Return]** to go back to the **“Process Variables Experiments”** screen.

EXPERIMENT-7

Study of the characteristics of a photo reflective sensor for speed measurement.

Introduction:

The number and variety of light-operated or light-controlled devices and equipment produced is tremendous. Photoelectric controls and sensors are only a small part of this vast product spectrum. Photoelectric sensors include; thru-beam, retro reflective scans, and diffuses scan sensors. Important parameters to consider when looking for photoelectric sensors include sensing mode, detecting range, position measurement window, minimum detectable object, and response time. Sensing modes can be presence or absence and position measurement.

Objectives:

- To know what is a **Photoelectric Sensor**.
- To know how to convert the Photoelectric Signal into Speed.

Theory:

Photoelectric Sensor

Photoelectric presence sensors utilize photoelectric emitters and receivers to detect presence, absence, or distance of target objects.

Reflective and retro reflective scan are two names for the same technique. The emitter and receiver are in one unit. Light from the emitter is transmitted in a straight line to a reflector and returns to the receiver. A normal or a corner cube reflector can be used. When a target blocks the light path the output of the sensor changes its state. When the target no longer blocks the light path the sensor returns to its normal state. Our photoelectric sensors emits a light directed towards the shaft when it sees the reflective tape (which is placed over the shaft) it gives a signal (the tape acts as the reflector) otherwise it changes its state; each signal means that the shaft has completed one turn.

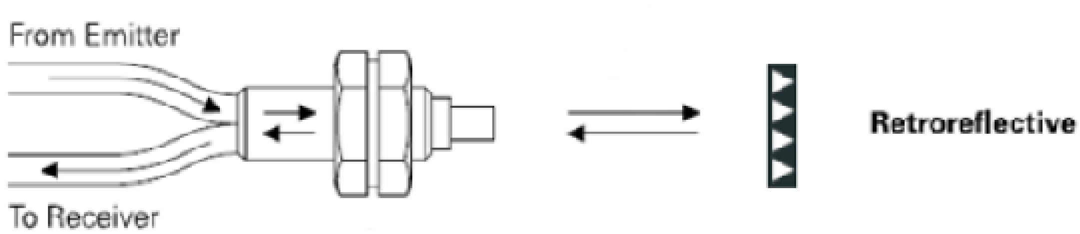


Figure 38 - Photoelectric sensor

Experiment Procedure:

1. Refer to **Running the Experiments** procedure in page 80.
1. From the **"Welcome to MTM001-04"** screen choose **[Speed Measurement Trainer]** button**.**

2. From the **"Speed Measurement Experiments"** screen choose
.

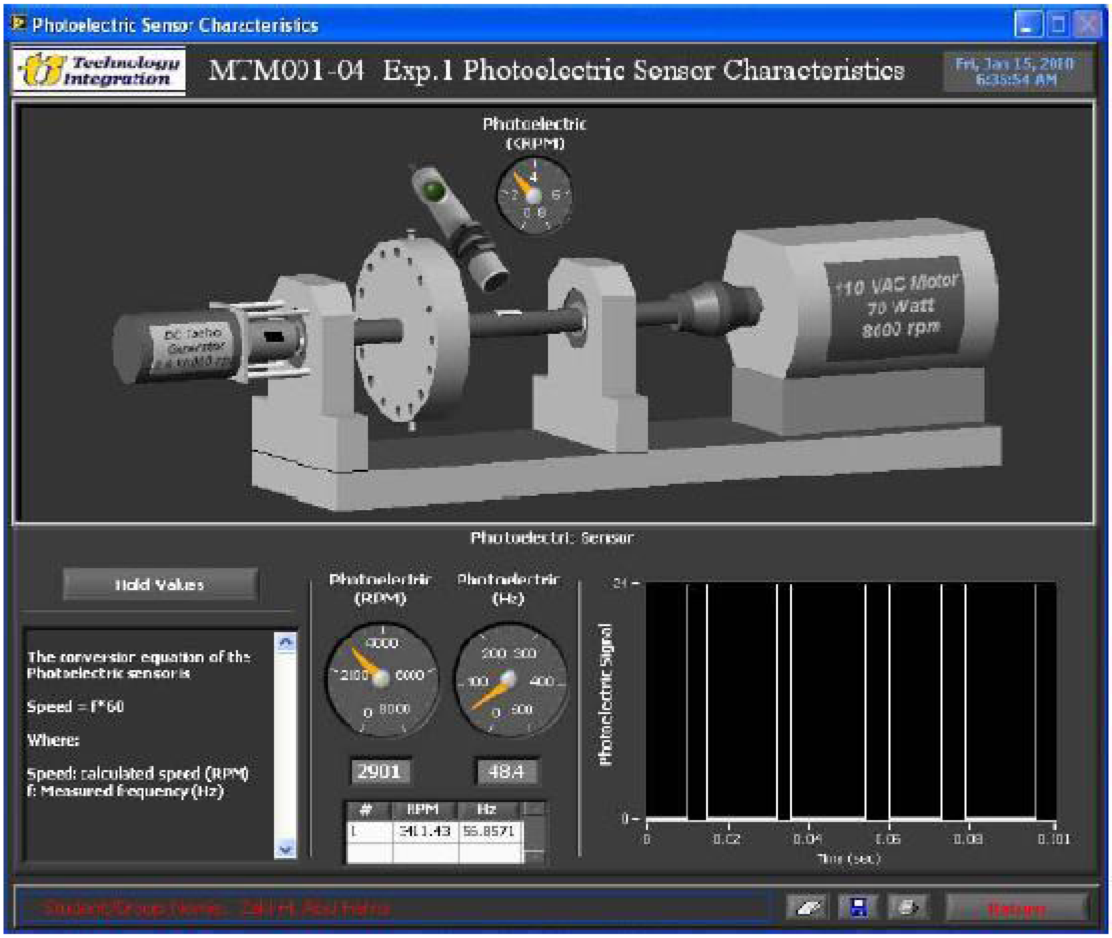


Figure 39 - Photoelectric characteristics Experiment Screen

3. Study the front panel carefully and observe the buttons on the screen.
4. Make sure the **Speed Measurement Trainer** is turned ON by pressing the **[Power]** button on the electrical box.
5. On the digital screen of the **VFD (variable frequency driver)** the word **"Stop"** will appear.
6. To start the motor, press the **[Start]** button on the **VFD**. The **VFD** reading will be **"H 50.0",** and it will start going down until it reaches **"H 0.0"**.
7. Press the **[UP]** button on the **VFD** to increase the frequency, keep increasing until the motor starts slowly.
8. Observe how the status **LED** on the "**Photoelectric"** sensor turns ON when the reflective tape faces the sensor, and turns OFF when it goes away from the sensor.
9. Can you predict the shape of the signal produced from the **Photoelectric** sensor? Draw it down.
10. Do you expect the signal produced from the sensor to be periodic? Why?
11. If the signal is periodic, what does each cycle of the signal represent?
12. Observer the front panel of the **"Photoelectric Sensor Characteristics"** experiment carefully.

13. On the chart appears on the front panel of the experiment, you will see the actual signal produced from the **Photoelectric** sensor.
14. Compare the signal on the chart with the signal you have drawn in step 9 .
15. Press the **[Hold Values]** button to save the current speed (**RPM**) and frequency (**Hz**). Write the values down: Speed=………………….. (**RPM**) Frequency=……………… (**Hz**)
16. From step 15 take the Frequency and find the period of the signal

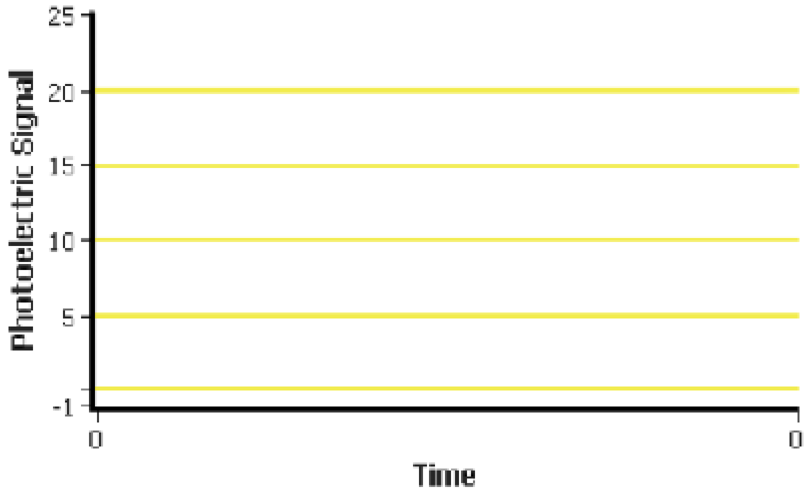


Figure 40 - Photoelectric vs Time Graph

17. Is the period (**T**) that you have calculated in the previous step reflected in the **Photoelectric-Time** graph?
18. Apply the frequency that you have taken from step 15 in the following equation to find the rotating speed of the shaft:

$$rotating\ speed = f \cdot 60$$

Where:
Rotating speed = *the rotating speed of the shaft (***RPM***)*
f = *Frequency (***Hz***)*
19. Compare the calculated speed from the previous step with the speed you have taken in step 15.
20. Increase the speed of the motor by pressing the **[UP]** button on the **VFD** until it reaches 40 Hz. Observe the behavior of the **LED** on the sensor, and the signal and the shaft speed behavior in the front panel.
21. Press the **[Hold Values]** button and write the values down:
Speed=………………. (**RPM**)
Frequency=…………... (**Hz**)
- To study the **"sensing distance"** of the sensor, do the following

$$T = \frac{1}{f}$$

using the following equation: Where:
T=*Period (s)*
f= *Frequency (Hz)*

22. Turn the motor OFF by pressing the **"Stop"** button on the **VFD**; observe how the frequency goes down till it reaches the minimum frequency and the motor goes OFF.
23. Wait till the motor stops completely, and then open the cover of the setup.
24. Adjust the **Shaft Position** so that the reflective tape faces the photoelectric sensor and the status **LED** on the on the sensor turns ON.
25. Increase the distance between the sensor and the tape by dragging the sensor backwards (rotate the sensor CCW), without changing the position of the shaft.
26. Is the status **LED** on the **Photoelectric sensor** still on? Why?
27. Close the cover of the setup.
28. Press the **[Start]** button on the **VFD**, and increase the frequency till it shows 40 Hz.
29. Wait 2-3 seconds then press **[Hold Values]** button and write the values down:

Speed=………………. (**RPM**)
Frequency=…………… (**Hz**)

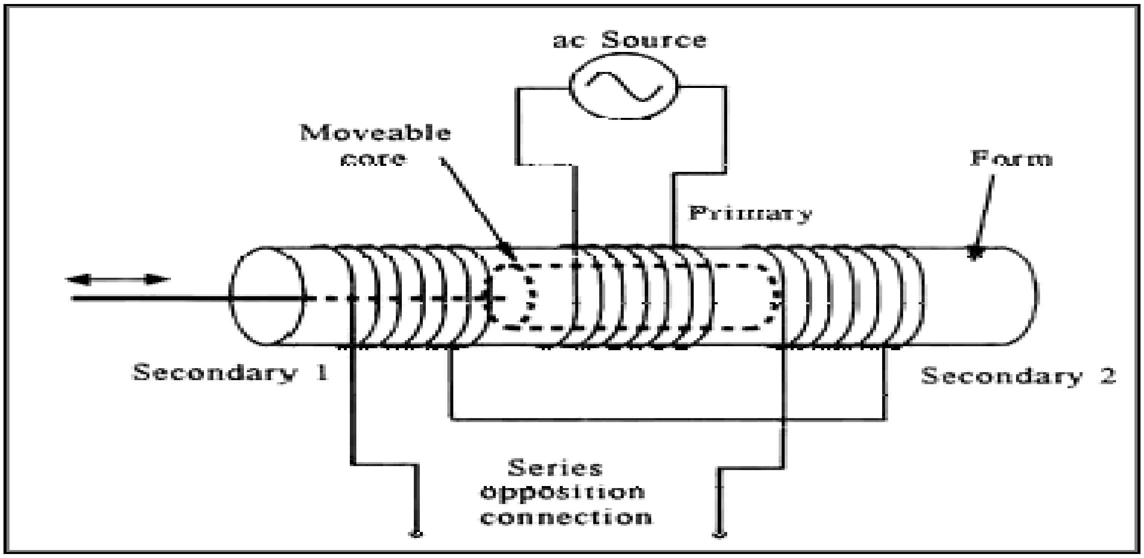
30. Compare the held values in step 29 with the held values in step 21. Is there any difference between the values?
31. Does changing the distance affect the response of the sensor?
32. Turn the motor OFF by pressing the **[Stop]** button on the **VFD**.
33. If the width of the reflective tape changed (increased or decreased) how will it affect the signal? Draw the signal below.

34. Turn the trainer OFF by pressing the **[Power]** button on the electrical box.
35. Press **[Save]** button if you want to save the experiment.
36. Press **[Clear Chart]** button if you want to clear the chart(s).
37. Press **[Return]** button to return to the "**Speed Measurement Experiments"** screen.

EXPERIMENT-8

To Measure Displacement using LVDT.

Apparatus:
LVDT
Micrometer for lvdt
voltmeter



Principle and working :
LVDT stands for linear variable differential transformer. It works on the principle of mutual induction LVDT illustrated in figure consist of three symmetrically spaced coils bound out and illustrated bobbin. A magnetic core , which moves through the bobbin, provides a path for magnetic flux linkage between coils. The position of the magnetic core control the mutual inductance between the primary coils and two secondary coils.
When a carrier excitation is applied to the primary coil, voltage is induced in the two secondary coils that are wired in series opposing circuit. When the core is centered between the two secondary coils, the voltage induced in secondary coils are equal but cut of phase by 180° with series opposing circuit, the voltage in two secondary coils contact cancels each other and the O/P voltage is zero. When the core is moved from the centre position, an in-balance in the mutual inductance between the primary and secondary coils occur and an o/p voltage develops. The o/p voltage is linear function of core position as long as the motion of the core is within the operating range of LVDT. The direction of motion can be determined from the phase of o/p voltage.

Features :

1. The frequency of voltage applied to the primary winding can range from 50-25000 kHz.
2. Dynamic measurement is possible is the carrier frequency is 10 times greater than the highest frequency component in dynamic signal.
3. The I/P ranges from 5 – 15 watts / amp i.e. volts.
4. The power required is less than 1 watt.
5. Range of sensitivity is from 0.02 – 0.2 V / nm.
6. Available in operating range ±2 to ±150 mm.
7. Like LVDT rotary variable differential transformer (RVDT) is used for angular measurement.

Advantages :

1. There is no contact between the core and the coils. Hence infinite resolution and no hysteresis
2. Non-contact ensures long life with no significant deterioration of performance.
3. Sensitivity is high as 40 mV/mm
4. Power consumption is less than 1 W.
5. better linear characteristics.

Disadvantages :

1. The mass of core and the friction limits the capabilities of sensor for dynamic measurement.
2. Performance of transducer is affected by temperature. **Procedure :**

Make the connection between LVDT sensor and the digital display unit as directed in manual . Switch ‘ON’ the circuit. Advance the LVDT core on one side. With the R/n I/P. Record the o/p. Repeat the procedure for possible range i/p in regular steps on one side. Withdraw the LVDT core to the null position in same steps it was advanced. Take o/p while drawing i/p. Repeat same on other side of null.

Plot I/P vs O/P graph using least square fit method. Calculate linearity of instrument.

Result :

From graph, it is clear that O/P varies linearly with I/P in both sense i.e. forward and backward.

Right hand sensitivity = 0.949 & Linearity = 00453

Left hand sensitivity = 0.949 & Linearity = 0.0488