AMIRAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

INDUSTRIAL INSTRUMENTATION

SUBJECT CODE: 2170913

ELECTRICAL ENGINEERING DEPARTMENT

B.E. 7TH SEMESTER

NAME:____

ENROLLMENT NO: ________________________________

BATCH NO: ____________________________________

YEAR: _______________________________________

Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

COLLEGE OF ENGINEERING & TECHNOLOGY

Amiraj College of Engineering and Technology,

Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

CERTIFICATE

This is to certify that Mr. / Ms. ____ Of class____________________ Enrolment No ___________________________has Satisfactorily completed the course in _____________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of Electrical Engineering in the Academic year_________.

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Faculty Name and Signature

(Subject Teacher)

Head of Department

(Electrical)

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List of Experiments

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remarks
1	To measure the strain using strain gauge.				
2	To verify the operation of LVDT.				
3	To measure and control Temperature using RTD.				
4	To measure and control Temperature using Thermistor.				
5	To measure and control Temperature using Thermocouples.				
6	To perform the operation of Load Cell using Demonstrator.				
7	To perform the operation of a Piezo Resistive Pressure Transducer using Demonstrator.				
8	To perform the Synchros as an Error Detector.				
9	Calibration Of Pressure Gauge.				
10	Study & Calibration of Rotameter for flow measurement.				

EXPERIMENT NO: -1

Date: / /

AIM: To measure the strain using strain gauge.

- **Specific Objectives:**

After performing this experiment, one should able to:

- Measurement of Strain
- Know the applications of the strain gauges.

- **Equipment:**

- Strain Gauge demonstrator
- Voltmeter (0 – 10 mV, DC)

- **Theory:**

If a metal conductor is stretched or compressed, its resistance changes on account of the fact that both length and diameter of conductor changes. Also, there is a change in the value of the resistivity of the conductor when it is strained and this property is called *piezo electric effect*. Therefore, resistance strain gauge is used for measurement of strain and associated stress in experimental stress analysis. Secondly, many other detectors and transducers, notably the load cells, torque meters, diaphragm type gauges, temperature sensors, flow meters employ strain gauges as secondary transducers.

$$\text{Strain} = E = \Delta L / L$$

$$\text{Gauge Factor (GF)} = \Delta R/R \, / \, \Delta L/L$$

where,

L	=	Length of strain gauge
ΔL	=	Change in L
R	=	Resistance of strain gauge
ΔR	=	Change in resistance

Strain is usually expressed in micro-strain.

Characteristics of Strain Gauge:

- Strain gauges should have high value of gauge factor GF. A high value of gauge factor indicates a large change in resistance for a particular strain resulting in a high sensitivity.
- The resistance of strain gauge should be as high as possible since this minimizes the effect of undesirable variation of resistance in the measurement circuit.
- The strain gauge should have a low resistance temperature coefficient. This is essential to minimize errors on account of temperature variations which effects the accuracy of measurement.
- The strain gauge should not have any hysteresis effect in its response.
- In order to maintain constancy of calibration over the entire range of strain gauge it should be linear. Characterization, that is, variation in resistance should be linear function of strain.

Types of Strain Gauge:

- Wire wound strain gauges.
- Semiconductor strain gauges.
- Foil type strain gauges.

- **Strain Measurement:**

The complete circuit diagram is engraved on the front panel. It consists of 3 fixed resistances of 350 each, which forms three, arms of a Wheatstone bridge whereas the fourth arm is a strain gauge of 350 ohms. This bridge is called QUARTER BRIDGE as only one arm is active.

- **Circuit Diagram:**

- **Procedure:**

- Connect the strain gauge terminals to the arm R_g of the bridge.
- Plug in two pin power chord to mains supply of 230 V, 50 Hz.
- Adjust the bridge balance knob on front panel till you obtain 0000 on the digital strain indicator.
- Now put some weight on the cantilever beam on which strain gauge is fixed. Measure and note the micro strain as indicated by digital indicator and voltage at the output of the amplifier.
- Repeat the above steps by putting different weights on cantilever beam and note down each reading in observation table.

- **Observation Table:**

Sr. No.	Weight (gm)	Micro Strain	O/P of Amplifier (mV)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

- **Conclusion:**

- **Answer the following Questions:**

Q – 1. Define the following: Strain, Stress, Piezo Resistive Effect, Gauge Factor, Young's Modulus, Gauge sensitivity and Poisson's Ratio.
Q – 2. Give the detailed classification of the Strain Gauges.
Q – 3. List out the materials used in resistance elements, backing element and bonding element of the strain gauge.
Q – 4. How does temperature affect the operating characteristics of strain gauges? Under what condition is a dummy strain gauge is used? Give the function of this gauge.
Q – 5 Compare the three types of strain gauges. Give their merits and demerits.
Q – 6 List out the application of the strain gauges.

<u>EXPERIMENT NO</u>: 2

Date: / /

AIM: To verify the operation of LVDT.

- **Specific Objectives:**

  After performing this experiment, one should able to:

  - Know application of LVDT for measurement of liner displacement.

- **Equipment:**

  - LVDT Trainer kits
  - LVDT
  - Patch Cords

- **Theory:**

The most widely used inductive transducer to translate the linear motion into electrical signal is the linear variable differential transformer (LVDT). The basic construction of LVDT is given in circuit. The transformer consists of a single primary winding P1and two secondary windings S_1 and S_2 wound on a cylindrical former. The secondary windings have equal number of turns and are identically placed on either side of the primary windings. The primary winding is connected to an alternating current source. A movable soft iron core is placed in side former. The displacement to be measured is applied to an arm attached to the soft iron core. In practice the core is made of iron alloy, which is slotted longitudinally to reduce eddy current losses. When the core is in its normal (null) position equal voltages are induced in two secondary windings. The frequency of a.c. applied to primary windings may be between 50 Hz to 20 KHz.

The output voltage of secondary S_1, is E_{S1} and that of secondary S_2 is E_{S2}. in order to convert the outputs from S_1 & S_2 into a single voltage signal the two secondaries S_1 and S_2 are connected in series opposition as shown. Thus the output voltage of the transducer is the difference of the two voltages. Differential output voltage. $E_0 = E_{S1}-E_{S2}$.

When the core is at its normal (null) position, the flux linking with both the secondary windings is equal and hence equal e.m.f.s are induced in them. Thus at null position $E_{S1}=E_{S2}$. Since the output voltage of the transducer is the different if the two voltages the output voltages E_0 is zero at null position.

Now if the core is moved to the left of the null position, more flux links with winding S_1 and less with winding S_2. Accordingly output voltage of secondary winding S_1 is more than E_{S2}, the output voltage of secondary winding S_2. The magnitude of output voltage is thus $E_{S1}-E_{S2}$ and the output voltage is in phase with E_{S1}. Similarly, if the core is moved to the right of the null position, the flux linking with winding S_2 becomes larger than that linking with winding S_1. These results in E_{S2} becoming larger than E_{S1}. The output voltage in this case $E_0 = E_{S1}-E_{S2.}$ and is in phase with E_{S2} i.e. the output voltage of secondary winding S_2.

The amount of voltage change in either secondary winding is proportional to the amount of movement of the core. Hence, we have an indication of amount of linear motion. By noting which output voltage is increasing or decreasing. We can determine the direction of motion. In other words any physical displacement of the core causes the voltage in one secondary winding to increase while simultaneously reducing the voltage in the other secondary winding.

- **Circuit Diagram:**

- **Procedure:**

  - Connect the trainer kit to the mains supply and switch it "ON".
  - Connect output signal to the input of the LVDT Transducer primary.
  - Short the secondary terminals of LVDT shown by doted lines.
  - Now connect the output of LVDT Point A, B & C at the LVDT detector, and circuit with the help of patch cords. Calibrate the output of LVDT by adjusting the output potentiometer of the detector circuit.
  - Connect the output of LVDT detector circuit to the displacement indicator digit meter.
  - Observe and record the output of LVDT by moving the shaft of the LVDT.

- **Observation Table:**

Sr. No.	Distance Measured by Scale mm	Output D.C. Voltage mV
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

- **Conclusion:**

- **Answer the following Questions:**

Q – 1. Explain the working principles of inductive transducers used for linear displacement measurement.
Q – 2. Explain the working principles of inductive transducers used for angular displacement measurement.
Q – 3. Explain the working principle of LVDT. Give the working frequency range.
Q – 4. Write merits and demerits of the LVDT.
Q – 5 State the applications of the LVDT.
Q – 6 Explain the RVDT.

EXPERIMENT NO: 3

Date: / /

AIM: To measure and control Temperature using RTD.

- **Specific Objectives:**

  After performing this experiment, one should able to:

  - Know the applications of the RTD for measurement of temperature.

- **Equipment:**

  - Instrumentation Tutor Part – II
  - Heating Unit
  - RTD

- **Theory:**

RTD (Resistance Temperature Detector):

The resistance temperature detector or RTD operates upon the fact that almost all pure metals have the property of varying their resistance with temperature, and change in resistance is almost directly proportional to the change in the temperature. The range of temperature over which this is valid is decided by the temperature coefficient of resistance, chemical inertness and its crystal structure which should not undergo permanent changes within this range.

The resistance with temperature is represented by an expression of the form,

$$R_t = R_o (1 + \alpha * t)$$

Where, R_t = Resistance in Ω at temperature t

R_o = Resistance in Ω at reference temperature (at 0 ^oC)

α = Temperature co-efficient of resistance in Ω/Ω/^oC

The RTD is applicable for measurement of small temperature changes as well as wide ranges of temperature. The main drawback of an RTD is its large size and sophisticated instrumentation.

The RTD does not generate its own voltage. So a voltage source is required to be incorporated into the measuring circuit. Wheatstone bridges are usually employed for measurement of variation in resistance, owing to changes in temperature, arising in RTDs. The bridges are usually calibrated for indicating the temperature that caused the variation in resistance than the resistance variation itself.

Materials used for RTD

Platinum, Nickel and Copper are the most commonly used resistance materials. These materials provide a definite resistance value at each temperature within its range. The resistance material is selected according to the intended applications.

Gold and **silver** are rarely used due to low resistivities. **Tungsten** has relatively large resistivity but its use is limited for high temperature applications, as it is extremely brittle and difficult to work. **Copper** has slightly high temperature coefficient of resistance than platinum. But its use is limited to low range industrial applications because of low resistivity and tendency toward oxidation at higher temperature.

Nickel wire provides good reliability and repeatability in temperature range of - 70 ^{o}C to 150 ^{o}C. Nickel is less expensive than platinum and has a higher temperature coefficient and higher tensile strength but it is more non linear.

Platinum is the most suitable material for RTDs for laboratory work and industrial measurements of high accuracy as it has optimum characteristics for service over a wide temperature range. Platinum is relatively stable under different environmental conditions, and its resistance temperature curve is linear over a wide range of temperature (- 263 ^{o}C to + 545 ^{o}C) with high precision. It can withstand high temperatures while maintaining excellent stability. The common value of resistance for a platinum resistance thermometer ranges from 10Ω for the bird cage model to several thousand ohms for the film of RTD. The most common value is 100Ω at 0 ^{o}C with temperature coefficient of resistance of 0.00391 per ^{o}C.

- **Circuit Diagram:**

- **Procedure:**

  - Connect the RTD to the connector provided on panel.
  - Put the selector switch on RTD side so that RTD is connected in the circuit.
  - Connect the heating unit to the appropriate terminals.
  - Connect the output terminals to the meter provided on the panel. This will indicate the actual temperature.
  - Connect the required supply and switch on the panel.
  - Set the set temperature to about 40ºC.
  - Keep the sensor in the heating unit and observe the actual temperature rise.
  - Observe what happens when the actual temperature reaches the 40ºC. You will see that the heater turns off.
  - Let the unit cool down and observe whether it maintains the set temperature reaches bellow 40ºC. You will see that the heater turns on.

- **Conclusion:**

- **Answer the following Questions:**

Q – 1. Define Transducer & Electrical Transducer. List the advantages and disadvantages of electrical transducer over mechanical transducer.
Q – 2. Give the detailed classification of Transducers.
Q – 3. Explain the principle of working and construction of an electric resistance thermometer.
Q – 4.Write merits and demerits of the RTD.
Q – 5 List out the materials used for RTD with their characteristics.
Q – 6 State the applications of the RTD.

EXPERIMENT NO: 4

Date: / /

AIM: To measure and control Temperature using Thermistor.

- **Specific Objectives:**

  After performing this experiment, one should able to:

  - Know the applications of the Thermistor for control of temperature.

- **Equipment:**

  - Instrumentation Tutor Part – II
  - Heating Unit
  - Thermistor

- **Theory:**

Thermistor:

Thermistors are also called the thermal resistors and the name is derived from the thermally sensitive resistors, as the resistance of a thermistor varies as a function of temperature. Thermistors are essentially semiconductor devices that behave as resistors with high negative temperature coefficient and are at least 10 times as sensitive as the platinum resistor thermometer. Thermistor has very non-linear resistance-temperature relation.

Thermistors are manufactured form the oxides of metals like manganese, nickel, cobalt, copper, iron, zinc, aluminum, titanium, magnesium and uranium.

Types of Thermistor:

Bead Type
Probe Type
Disc Type
Rod Type

Applications of Thermistors:

Measurement of Temperature
Control of Temperature
Temperature Compensation
Measurement of thermal conductivity
Measurement of level, flow and pressure of gases
Vacuum measurement

- **Circuit Diagram:**

- **Procedure:**

  - Connect the Thermistor to the connector provided on panel.
  - Put the selector switch on Thermistor side so that Thermistor is connected in the circuit.
  - Connect the heating unit to the appropriate terminals.
  - Connect the output terminals to the meter provided on the panel. This will indicate the actual temperature.
  - Connect the required supply and switch on the panel.
  - Set the set temperature to about 40ºC.
  - Keep the sensor in the heating unit and observe the actual temperature rise.
  - Observe what happens when the actual temperature reaches the 40ºC. You will see that the heater turns off.
  - Let the unit cool down and observe whether it maintains the set temperature reaches bellow 40ºC. You will see that the heater turns on.

- **Conclusion:**

- **Answer the following Questions:**

Q – 1. Draw the block diagram of an instrumentation system and explain the function of different functional elements.
Q – 2. State the static and dynamic characteristics of the transducers.
Q – 3. Explain the working principle of the thermistors.
Q – 4. Which materials are used in the construction of the thermistors?
Q – 5. List the merits and demerits of the thermistors.
Q – 6. State the applications of the thermistors.

EXPERIMENT NO: 5

Date: / /

AIM: To measure and control Temperature using Thermocouples.

- **Specific Objectives:**

  After performing this experiment, one should able to:

  - Know the applications of the Thermocouple for control of temperature.

- **Equipment:**
  - Instrumentation Tutor Part – II.
  - Heating Unit.
  - Thermocouples.

- **Theory:**

Thermocouples are simple and most widely used devices for measurement of temperature. It essentially consists of two dissimilar metal wire insulated from each other but welded or brazed together at their ends measuring instrument, it becomes an accurate and sensitive temperature measuring instrument.

The operation of thermocouples is based on Seedbeck effect i.e. if two wires of different metals are joined together at each end and form a complete electric circuit then current flows in the circuit when the two junctions are kept at different temperatures. The current is caused by an emf, called the thermo-electric emf, set up in the circuit and is a function of temperature difference of the two junctions. The thermoelectric emf so setup is the same for any particular pair of metals with two junctions at a particular temperature and is not affected by the conductor area in contact of the method of joining them.

The output of the thermocouple is in mili volt so it is amplified and given to an indicator to indicate the temperature.

Thermo Electric Laws:

The application of heat to a single homogeneous metal is in itself not capable of producing or sustaining an electric current.

A thermo electric emf is produced when the junctions of two dissimilar homogeneous metals are kept at different temperature.

In a circuit consisting of two dissimilar homogeneous metals having the junctions at different temperatures, the emf developed will not be altered when a third homogeneous metal is made a part of the circuit, provided the temperature of its two junctions are the same. This is called Law of Intermediate Metals.

The thermal emf produced when a circuit of two homogeneous metals exists between a first temperature and a second and thermal emf produced when the same circuit exists between the second temperature and a third are algebraically equal to the thermal emf produced when the circuit exists between first and third temperature. This is called Law of Intermediate Temperature.

- **Circuit Diagram:**

- **Procedure:**

  - Connect the thermocouple to connector provided on the front panel.
  - Connect the heating unit to the terminals given on the board.
  - Connect the output terminals to the meter provided on the panel
  - This will indicate the actual temperature.
  - Connect the terminals and switch on the unit. Make sure the supply indicator glows on.
  - Set the set temperature to say about 40^0 C.
  - Keep the sensor in the heating unit and observe the actual temperature rise.
  - Observe what happen when actual temperature reaches 40^0 C. you will see that heater will turn off.
  - Let the unit be cool down and observe what happens when the temperature reaches below 40^0 C. You will see that heater will turn on.
  - Let this process be on and observe whether it maintains the set temperature.

- **Conclusion:**

<u>EXPERIMENT NO</u>: 6

Date: / /

AIM: To perform the operation of Load Cell using Demonstrator.

- **Specific Objectives:**

  After performing this experiment, one should able to:

  - Know the applications of the Load cell for measurement of Weight.

- **Equipment:**

  - Load Cell Demonstrator Kit
  - Digital Voltmeter
  - Different Weights up to 4 Kg

- **Theory:**

The load cell is an electromechanical sensor employed to measure static and dynamic forces. The load cell derives its output from the deformation of an elastic member having high tensile strength. A load cell transducer converts mechanical pressure into corresponding electrical signal. The electrical output of load cell has very good linear response.

A load cell comprises of four nos. of strain gauges connected in Wheatstone bridge. Two out of these four strain gauges are bonded to a cantilever type metallic stand (R1 and R2). R3 and R4 strain gauges are for temperature compensation. The cell is given ± 5 volt or 10 volt D.C. excitation voltage. The output of the load cell is given to the instrumentation amplifier. When pressure is applied on the lad cell, it generates differential signals in microvolt. These signals are amplified by the amplifier circuit.

The output of difference amplifier is given to another op amp for further amplification and calibration. The second op amp is calibrated to get output corresponding to the weight up to 4 Kg. The output of the second op amp is given to the A.D. converter.

Different types of load cell configurations are: Column Type Devices, Proving Rings, Cantilever Beam and Shear Type Load Cell

- **Circuit Diagram:**

- **Procedure:**

  - Connect the Demonstrator kit to 230 V mains supply and switch it ON.
  - Connect the Load Cell to the socket marked as LOAD CELL INPUT.
  - Connect the digital voltmeter in milli volts range at the output of first op amp.
  - Ensure that there is no weight on the load cell.
  - Now adjust the Zero Adj. Potentiometer to get zero indication on digital mill voltmeter when there is no weight on the load cell.
  - Observe the indication on D.P.M. of the panel. It will also give zero reading.
  - Now put weight of different weight and observe the output on digital display of the panel.
  - Record the output in observation table.

- **Observation Table:**

Sr. No.	**Load in Kg.**	**Output in mV**	**Reading on Display**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

- **Conclusion:**

EXPERIMENT NO: 7

Date: / /

AIM: To perform the operation of a Piezo Resistive Pressure Transducer using Demonstrator.

- **Specific Objectives:**

  After performing this experiment, one should able to:

  - Know the applications of the Piezo Resistive Pressure Transducer.

- **Equipment:**

  - Pressure Transducer Demonstrator Kit
  - Digital Voltmeter
  - Air Pressure Source(Feet Pump)

- **Theory:**

Pressure transducers are classified into gravitational and elastic types. In gravitational type, the manometer is the simplest device. In elastic transducers, the pressure exerts a force over the area of an elastic device. The force responsive elastic member is in the form of a diaphragm, capsule bellows or bourdon tube. The resultant displacement or strain developed is measured with an appropriate electrical sensor.

The conversion of this mechanical phenomenon to an equivalent electrical signal is achieved by a variety of linkage mechanisms. The transduction principles used are deflection measurements with resistive, inductive and capacitive principles or measurement of change in natural resonance frequency of a stretched member. They are potentiometric, bonded and unbounded strain gauge, piezo resistive, inductive, capacitive, piezo electric, linear variable differential transformer or vibrating element types.

The circuit diagram shown on the front panel of kit has internal circuit of Pressure Transducer, Op-amp Difference amplifier and Op-amp inverting amplifier. 4 nos. of 1K piezo resistive elements are mounted inside the pressure sensor.

They are active elements and in bridge form. ±5V supply is given to the bridge circuit, whose output is varying in accordance to the pressure applied to the inlet of the pressure sensor. The output signal is fed to a difference amplifier, which is in unity gain configuration.

The output of this amplifier is given to an inverting amplifier, which has gain of 2. The output of the op-amp is finally given to the A.D. converter based digital voltmeter to indicate the pressure in terms of P.S.I. The output can be calibrated by adjusting the output Adj. potentiometer.

- **Circuit Diagram:**

- **Procedure:**

  - Connect the Trainer kit of pressure transducer to mains supply & switch.
  - Take the foot pump & connect a suitable nozzle at the tube of the pump.
  - Now couple the nozzle of the pump to the pressure provided on the panel of the kit.
  - Press the foot pump to transmit the Air Pressure. The foot pump is provided with gauge meter.
  - Select the pressure of 10, 20, 30 or 40 P.S.I. & adjust the Gain Adj. Potentiometer of the pressure transducer amplifier.
  - Measure the excitation voltage of the pressure transducer of the digital voltmeter. Also measure the output of pressure transducer.

- **Conclusion:**

EXPERIMENT NO: 8

Date: / /

AIM: To perform the Synchros as an Error Detector.

- **Specific Objectives:**

  After performing this experiment, one should able to:
  - Know the applications of the Synchros.

- **Equipment:**
  - Synchros Transmitter
  - Synchros Receiver or control transformer
  - 100 V AC source
  - Voltmeter 0 – 100 V

- **Theory:**

A synchro is an electromagnetic transducer which is commonly used to convert the angular position of a shaft into an electric signal. There are two types of synchro systems:

Control or error detecting type

Torque transmission type

Torque transmission type of systems is used only to drive very light loads, such as pointers. The torque transmission systems have very little output torque.

Control Type Synchro System

These systems are used as error detectors in positional control systems. The synchro system consists of two units: (1) A synchro transmitter and (2) A synchro receiver. The construction of synchro transmitter is similar to that of a three phase alternator. The construction of synchro receiver is similar to that of synchro transmitter except that the rotor of a synchro receiver is not of salient pole type but is cylindrical in construction.

Synchros as Torque Transmitter

In instrumentation systems, synchros are used in the torque transmission mode. Initially transmitter and receiver units are placed identical to each other in such a way that voltage of the tow units is balanced. When the rotor of the transmitter unit is moved to a new position, the voltage balance is disturbed. So the rotor of receiver changes its position in such a way that voltage balance between transmitter and receiver is again restored.

- **Circuit Diagram:**

- **Procedure:**

    - Connect the S_1, S_2 and S_3 terminals of the synchro transmitter to the corresponding S_1, S_2 and S_3 terminal of the synchro receiver.
    - Connect the voltmeter across the rotor terminals R1 and R2 of the synchro receiver.
    - Connect 100 V supply.
    - Keep the rotor positions of the synchro transmitter and control transformer at 0^0 position.
    - Change the rotor angle or the synchro transmitter.
    - Plot a graph between the position of the synchro transmitter and error voltage.

- **Observation Table:**

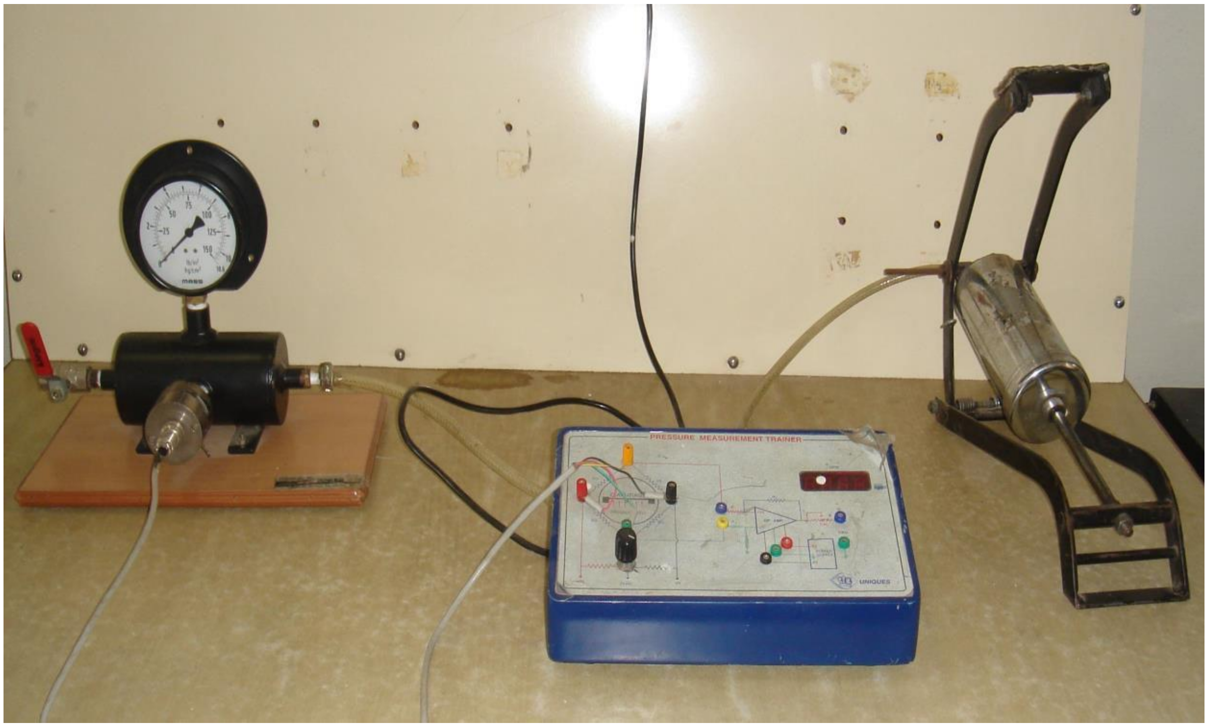
Sr. No.	**Position of Synchro Error Generator θ^0**	**Voltage across R_1 & R_2 of Control Transformer(Error Voltage) Volts**
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

- **Conclusion:**

EXPERIMENT NO 9

CALIBRATION OF PRESSURE GAUGE

Pressure measurement using Pressure cell



C O N T E N T S

THE INSTRUMENT

UNIQUE Digital pressure measuring setup comprises of pressure indicator and pressure cell with loading system. Pressure indicator is a strain gauge signal conditioner and amplifier used to measure pressure due to load applied on the pressure cell. The strain gauge are bonded on the diaphragm and are connected in the form of whetstones bridge. A foot pump of capacity 7Kg/cm^2 is provided to load the Pressure cell UNIQUES Pressure measuring setup in a complete system which can be used to conduct measurement of pressure applied on the Pressure cell. The pressure indicator is provided with zero balancing facility through adjustable potentiometer. Digital display will enable to take error free readings.

The digital indicator comprises of four parts.
1. Power supply 2. Signal conditioning 3. Amplifier
4. Analog and digital converter.
The inbuilt regulated power supply used will provide sufficient power to electronic parts and also excitation voltage to the strain gauge bridge transducers. The signal conditioner Buffers the output signals of the transducers. Amplifier will

amplifies the buffered output signal to the required level where it is calibrated to required unit. Analog to digital converter will convert the calibrated analog out put to digital signals and display through LED's.

THEORY:

Transducers that measure force, torque or pressure usually contains an elastic member that converts the quantity to be measured to a deflection or strain. A deflection sensor or, alternatively, a set of strain gauges can be used to measure the quantity of interest (force, torque or pressure) indirectly. Characteristics of transducers, such as range, linearity and sensitivity are determined by the size and shape of the elastic member, the material used in its fabrication.
A wide variety of transducers are commercially available for measuring force. Torque and pressure the different elastic member employed in the design of these transducer include link, columns, rings, beams, cylinders, tubes, washers, diaphragms, shear webs and numerous other shapes of special purpose applications. Strain gauges are usually used as sensors; however linear variable differential transformers (LVDT) and linear potentiometers are some time used for static or quasistatic measurement.

PRESSURE MEASUREMENT (PRESSURE CELL).

Pressure cells are divisors that convert pressure into electrical signal through a measurement of either displacement strain or Piezoelectric response. Diaphragm type pressure transducers with strain gauges as sensor is used here for measurement of pressure.

This type of pressure transducers uses diaphragm as the elastic element. Diaphragms are used for low and middle pressure ranges. Strain gauges are bonded on the diaphragm and the pressure force is applied to the specimen the material gets elongated or compressed due to the force applied i.e., the material get strained. The strain incurred by the specimen depends on the material used and its elastic module. This strain is transferred to the strain gauges bonded on the material resulting in change in the resistance of the gauge. Since the strain gauges are connected in the form of whetstones bridge any change in the resistance will imbalance the bridge. The imbalance in the bridge will intern gives out the output in mV proportional to the change in the resistance of the strain gauge.

C I R C U I T E X P L A N A T I O N

The circuit comprises of three parts.

1. POWER SUPPLY
2. SIGNAL CONDITIONING AND AMPLIFYING
3. ANALOG TO DIGITAL CONVERTER.

1. POWER SUPPLY:

Inbuilt power supply use power to all electronic devices inside the circuitry. High stable regulated Power supply is used for better performance
There are two different power supply inside the unit
+12 – 0 -12V 500mA to drive digital integrated circuitary.
+5 – 0 - -5V 250mA to drive A to D converter.

2. SIGNAL CONDITIONING AND AMPLIFYING

Signal conditioner will process the output of transducer and presents a linear DC voltage to the amplifier. This circuit will also buffers the inputs signal given to the differential amplifier. The operations amplifier is used as a differential amplifier where the signal gets amplified to required level. The amplifier gives out the analog output.
This output is controlled and calibrated to get the linear to micro strain. This analog output is sed to the A to D converter.

3. ANALOG TO DIGITAL CONVERTED.

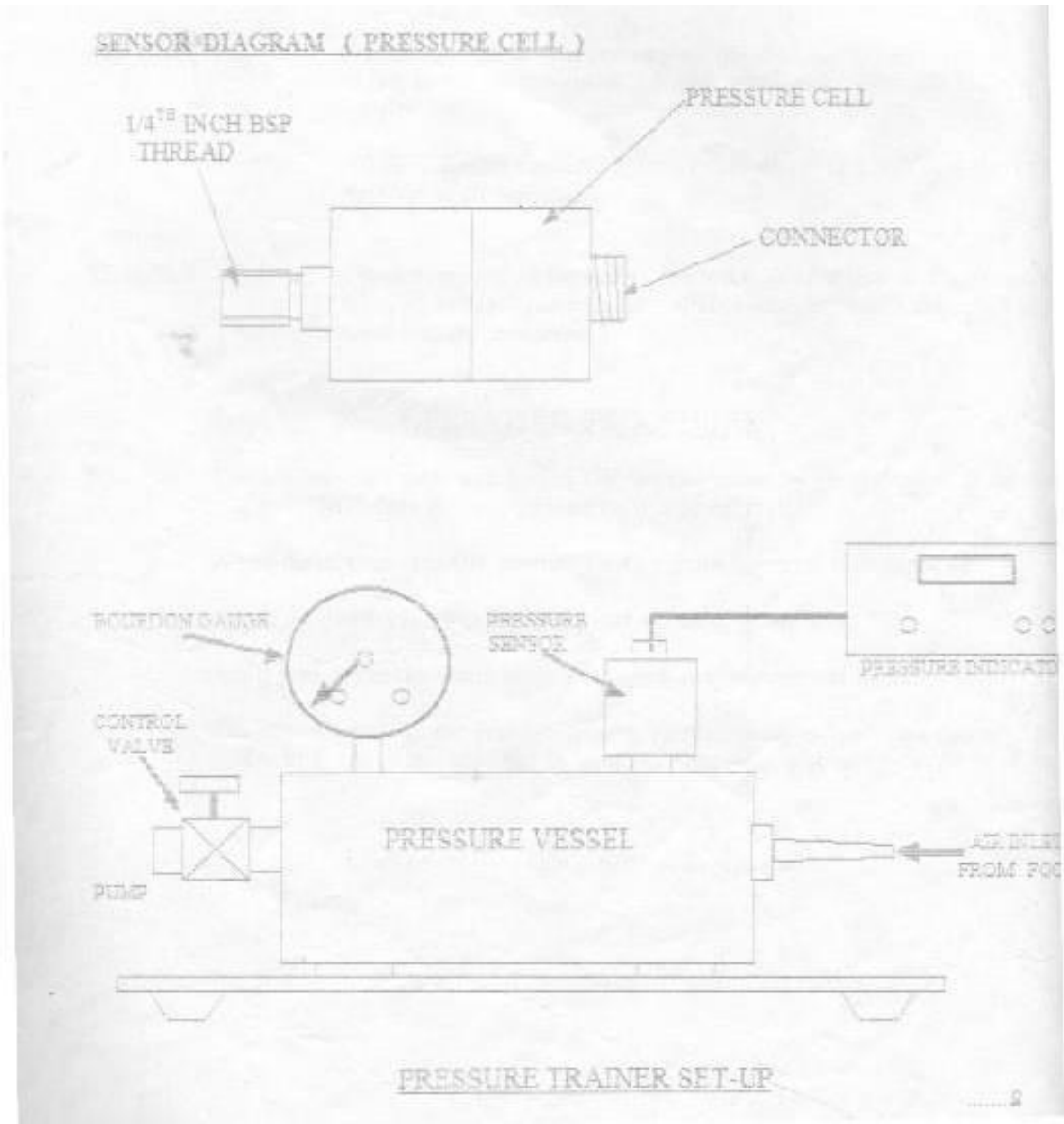
The output from the amplifier is a linearised analog DC voltage. This analog output is converted into digital output with the help of IC 7107 3.5 digit 200mV A to D converter. Then it is displayed through seven segmented LED's.

S P E C I F I C A T I O N S
MEASUREMENT OF PRESSURE

PRESSURE CELL	:	
SENSOR	:	strain gauges bonded on steel diaphragm for pressure measurement.
TYPE	:	Diaphragm
RANGE	:	10 Kg/cm^2
CONNECTION	:	Through four cure shielded cable with the connector Attached
EXCITATION	:	10V DC
ACCURACY	:	1%
LINEARITY	:	1%
MAX OVER LOAD	:	150%
MECHANICAL CONNECTION	:	1/4 INCH BSP thread.

INDICATOR:

DISPLAY	:	3 ½ digit seven segment LED display is used for the indicator of 200mV full scale deflection to read +/- 1999’
EXCITATION	:	10 V DC
ACCURACY	:	1%
TARE	:	Front panel zero adjustment through Potentiometer
POWER SUPPLY	:	230 V +/- 10% 50 Hz



CONNECTION DETAILS

POWER : 3 pin mains cable is provided with the instrument.
Connect the 3 pin socket to the instrument at the rear panel and to the AC mains 230v supply.

NOTE : Before connecting ensure the voltage is 230 V and the Power switch is in off position.

SENSOR : Connect one end of the cable attached with connector to the sensor and the other end to the instrument. While connecting match the colors of the wires with the connectors.

OPERATING PROCEDURE

- * Check connection made and switch ON the instrument by rocker switch at the front panel. The display glows to indicate the instrument is ON.
- * Allow the instrument in ON Position for 10 minutes for initial warm-up.
- * Adjust the Potentiometer in the front panel till the display reads “000”
- * Apply pressure on the sensor using the loading arrangement provided.
- * The instrument reads the pressure coming on the sensor and display through LED. Readings can be tabulated and % error of the instrument, linearity can be calculated.

EXPERIMENTS AND TABULAR COLUMN

Experiments can be conducted on the instrument as per the Operating Instruction given and various parameters like Linearity. Accuracy, Hysteresis etc of the Pressure indicator can be calculated. The readings can be tabulated and graphs can be plotted to calculate the above parameters.

TABULAR COLUMN

EXPERIMENT-1

1 **SL.NO.**	**2** **ACTUAL PRESSURE** **Kg cm^2**	**3** **INDICATOR READING** **Kg/cm^2**	**4** **3-2 ERROR**	**5** **% ERROR**

% Error = $\frac{Column No.4}{Max Load} X100$

Graphs: Actual reading V/s indicator Reading

SPECIMEN READINGS

1 SL.NO.	2 ACTUAL PRESSURE Kg/cm^2	3 INDICATOR READING Kg/cm^2	4 3-2 ERROR	5 % ERROR
1	1.0	0.9	-0.1	
2	2.0	2.0	0	
3	3.0	3.0	0	
4	4.0	4.0	0	
5	5.0	5.1	0.1	
6	6.0	6.1	0.1	
7	7.0	7.1	0.1	

EXPERIMENT NO 10

STUDY AND CALIBRATION OF A ROTAMETER FOR FLOW MEASUREMENT.

ROTAMETER

The obstruction is a float that rises in a vertical tapered column. The lifting force and thus the distance to which the float rises in the column is proportional to the flow rate. The lifting force is produced by the differential pressure that exists across the float, because it is a restriction in the flow. This type of sensor is used for both liquids and gases. A moving vane flow meter has a vane target-immersed in the flow region, which will be roted out of the flow as the flow velocity increases. The angle of the vane is a measure of the flow rate.

FLOW CONTROL SYSTEM

TURBINE METER:

The turbine flow meter consists of a multi-bladed rotor that is supported centrally in the pipe along which the flow occurs. The fluid results in rotation of the rotor. The angular velocity bring approximately proportional to the flow rate. The rate of revolution of the rotor can be determined using a magnetic pick-up. The pulses are counted and so the number of revolutions of the rotor can be determined.

FLOW CONTROL SYSTEM

Control & Operations:

1. Press flow: This is a D.P.D.T Switch to set the required flow rate.
2. Flow Control: This is a potentiometer to set the flow rate.

Operation:

1. Connect the turbine flow sensor with indicator marked as flow sensor input.
2. Connect the two pin of the motor to the instrument.
3. Now vary the flow control potentiometer to any required set level.
   Note: While controlling the flow make sure the pointer in Rotometer floats.
4. Compare the Rotameter reading and digital reading with set reading.
5. Take reading for different set of flows rate.
6. Plot the graph of Rotameter Reading with Digital Indicator Reading.

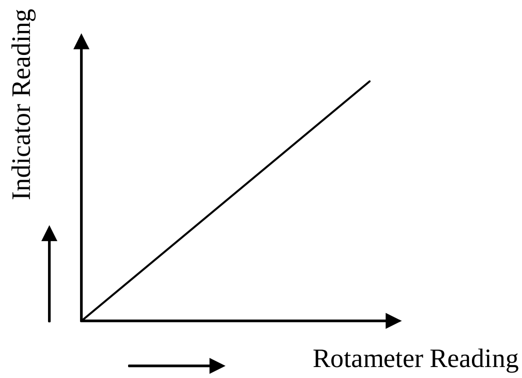
Description Rotameter:

The air source is centrifugal blower which controlled by the set valve of flow of air measured in L.P.M. The flow is measured directly on the rotameter. The turbine flow meter senses the flow rate and through microprocessor based signal conditioner. The flow is measure din digital form and acts us a set point controller also.

Tabular Column

Sl.No.	Set Flow in L.P.M.	Rotameter Reading in L.P.M.	Digital Reading	Error Between Rotameter & Digital reading

Note: **<u>The range of Flow is 30 L.P.M. to 100 L.P.M</u>**



BLOCK DIAGRAM OF THE SYSTEM