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Department of Mechatronics Engineering

MR3461 SENSORS AND INSTRUMENTATION

LABORATORY MANUAL

Prepared By

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VISION AND MISSION OF THE INSTITUTION

VISION
To become a world-class institution for engineering education by imparting quality education that meets global standards, cultivating students who are academically excellent, possess a positive attitude, are ethically sound and socially committed.
MISSION
❖ To enhance academic excellence by educating students in engineering principles, thereby upgrading their knowledge and skills
❖ To empower students with a positive attitude and creative thinking to develop innovative techniques in engineering
❖ To educate and cultivate dedicated learners with ethical values who are socially responsible

VISION AND MISSION OF MECHATRONICS ENGINEERING DEPARTMENT

VISION
To achieve excellence in Mechatronics Engineering through quality education and industry collaboration by integrating mechanical, electronics, computer, and control systems, thereby developing professionally competent, innovative, and socially responsible engineers to contribute in the field of automation, robotics, and smart manufacturing..
MISSION
❖ To strengthen a learner-centric and industry-integrated environment by imparting technical knowledge and practical skills in Mechatronics Engineering, including automation, robotics, IoT, and intelligent systems
❖ To equip learners with industry-relevant tools, problem-solving abilities, and innovative thinking to address real-world engineering challenges across interdisciplinary domains
❖ To nurture learners with professional ethics, leadership qualities, communication skills, and entrepreneurial skills ensuring lifelong learning and adaptability to evolving industrial demands.

MR3461 SENSORS AND INSTRUMENTATION LABORATORY

L T P C

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.**LIST OF EXPERIMENTS**

1. Determination of Load, Torque and Force using Strain Gauge.
2. Determination of the characteristics of Pressure Sensor and Piezoelectric Force Sensor
3. Determination of Displacement using LVDT.
4. Determine the Characteristics of Various Temperature Sensors.
5. Determine the Characteristics of Various Light Detectors (Optical Sensors).
6. Distance Measurement using Ultrasonic and Laser Sensor.
7. Determine angular velocity of gyroscope,
8. Vibration measurement using Accelerometer.
9. Direction measurement using Magnetometer.
10. Speed, Position and Direction Measurement Using Encoders.
11. Force measurement using 3 axis force sensor.
12. Force Measurement using tactile sensors.
13. Data acquisition, visualization and analysis of signals.

TOTAL: 60 PERIODS

EX.No.1	Measurement of Strain and Load using Strain Gauge
Date :	

AIM:

To measure strain and load using Strain gauge.

APPARATUS:

Strain measuring trainer kit, Load measurement trainer kit and associated weights.

THEORY:

A Strain gauge is a sensor whose resistance varies with applied force; it converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. When external forces are applied to a stationary object, stress andstrain are the result. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the *gauge factor*.

Strain gauge takes advantage of the physical property of electrical conductance and its dependence on the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity such that it does not break or permanently deform, it will become narrower and longer, which increases its electrical resistance end-to-end. Conversely, when a conductor is compressed such that it does not buckle, it will broaden and shorten, which decreases its electrical resistance end-to-end. From the measured electrical resistance of the strain gauge, the amount of induced stress may be inferred.

A typical strain gauge arranges a long, thin conductive strip in a zig-zag pattern of parallel lines. This does not increase the sensitivity, since the percentage change in resistance for a given strain for the entire zig-zag is the same as for any single trace. A single linear trace would have to be extremely thin, hence liable to overheating (which would change its resistance and cause it to expand), or would need to be operated at a much lower voltage, making it difficult to measure resistance changes accurately.

- $Strain = e = \frac{\Delta L}{L}$
- *Poisson's ratio* = $\gamma = \frac{e_L}{e_T}$
- $GaugeFactor = G = \frac{\frac{\Delta R}{R}}{\frac{\Delta L}{e}} = \frac{\frac{\Delta R}{R}}{e}$
- $stress = \frac{-E}{A}$

Where,

$$F = force, e = strain, A = area, R = resistance, L = length.$$

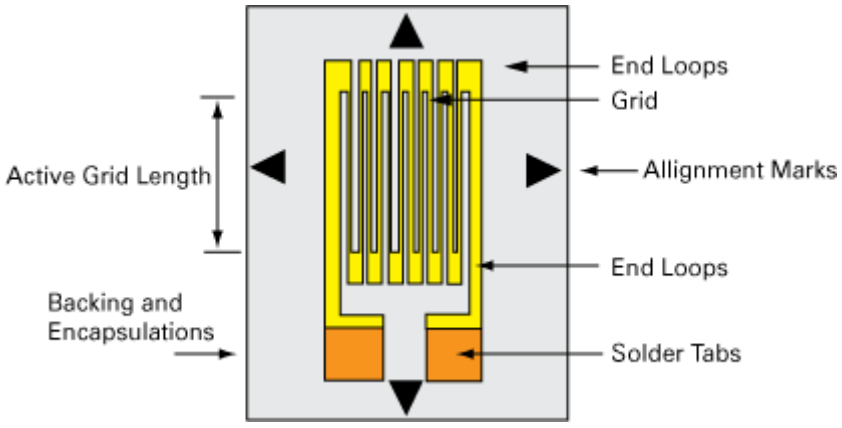


Figure 1. Strain gauge.

Load cell:

A load cell is a type of force gauge. It consists of a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various load cell types include hydraulic, pneumatic, and strain gauge.

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms when the material of the load cells deforms appropriately. Deformation of the strain gauge changes its electrical resistance, by an amount that is proportional to the strain. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (quarter bridge) or two strain gauges (half bridge) are also available.

CIRCUIT DIAGRAM:

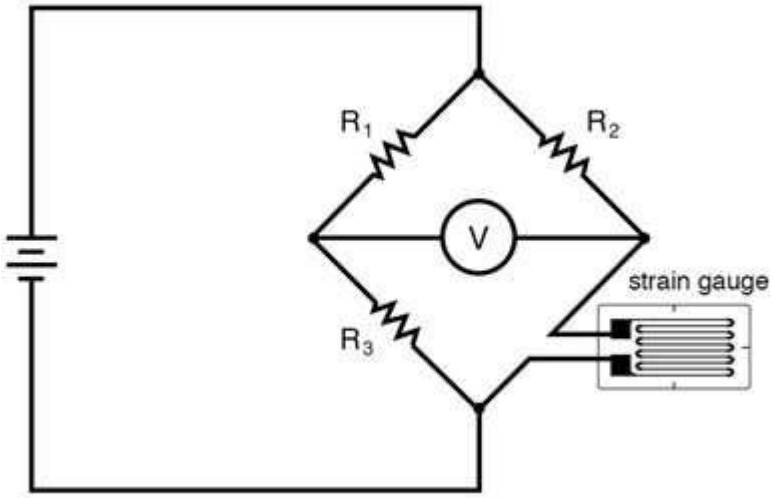


Figure 2. Quarter bridge circuit.

PROCEDURE:

1. Arrange the equipment.
2. Test the strain gauge in different load condition and do the calibration procedure.
3. Now unload it fully and calibrate.
4. Load the strain Gauge using assorted weight and received the reading.
5. After fully load, take the unloading readings.
6. Plot the graph and we may obtain straight line.

OBSERVATION:

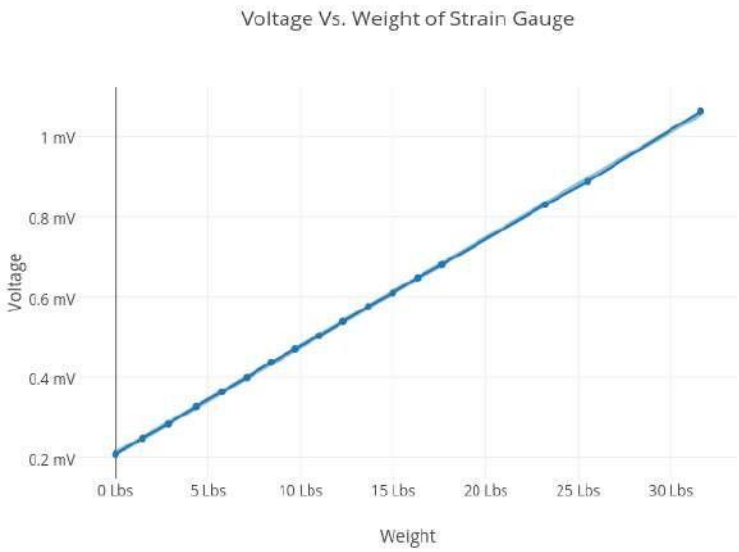
LOAD CELL:

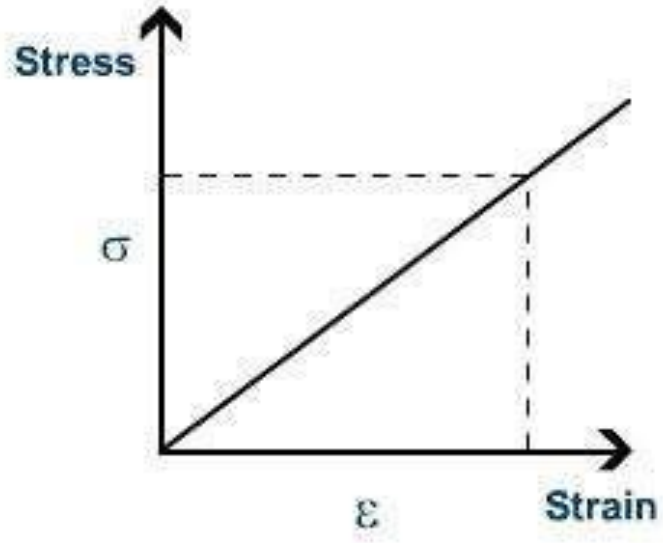
Sl.No.	Loading		Unloading		Average	
	Weight(m gm)	Voltage (mV)	Weight (m gm)	Voltage (mV)	Weight (m gm)	Voltage (mV)

Strain Measurements:

Sl.No.	Loading		Unloading		Average	
	Weight(m gm)	Strain ($\mu strain$)	Weight(m gm)	Strain ($\mu strain$)	Weight(m gm)	Strain ($\mu strain$)

Model Graph:





RESULT:

Strain and Load using strain gauge is measured and graph is plotted.

EX.No.2	Determination of the characteristics of Pressure Sensor and Piezoelectric Force Sensor
Date :	

AIM:

To measure the output voltage corresponding to pressure variation using pressure measurement trainer kit.

APPARATUS:

Pressure measurement trainer kit.

THEORY:

A piezoelectric sensor is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. The prefix *piezo*- is Greek for 'press' or 'squeeze'.

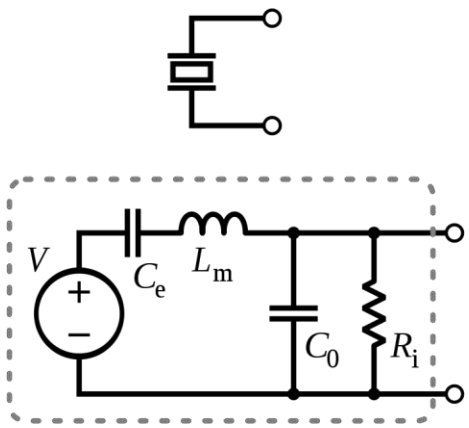


Figure 4. Schematic symbol and electronic model of a piezoelectric sensor

A piezoelectric transducer has very high DC output impedance and can be modeled as a proportional voltage source and filter network. The voltage V at the source is directly proportional to the applied force, pressure, or strain. The output signal is then related to this mechanical force as if it had passed through the equivalent circuit.

A detailed model includes the effects of the sensor's mechanical construction and other non- idealities. The inductance $L_m$is due to the seismic mass and inertia of the sensor itself. C_e is inversely proportional to the mechanical elasticity of the sensor. C_0 represents the static capacitance of the transducer, resulting from an inertial mass of infinite size. R_i is the insulation leakage resistance of the transducer element. If the sensor is connected to a load resistance, this also acts in parallel with the insulation resistance, both

increasing the high-pass cutoff frequency.

For use as a sensor, the flat region of the frequency response plot is typically used, between the high-pass cutoff and the resonant peak. The load and leakage resistance must be large enough that low frequencies of interest are not lost. A simplified equivalent circuit model can be used in this region, in which C_s represents the capacitance of the sensor surface itself, determined by the standard formula for capacitance of parallel plates. It can also be modeled as a charge source in parallel with the source capacitance, with the charge directly proportional to the applied force, as above.

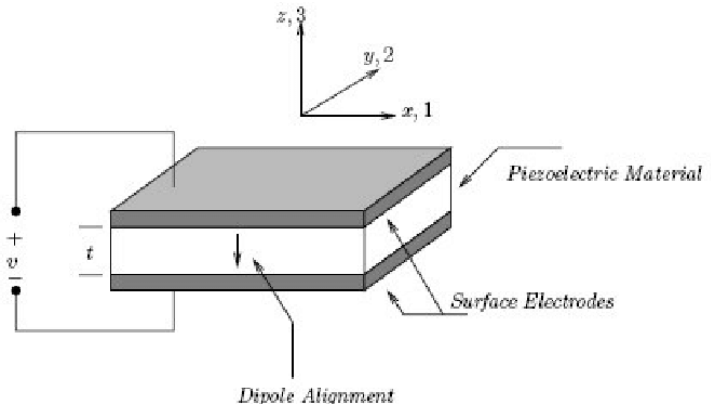


Figure 5. Schematic diagram of a piezoelectric transducer

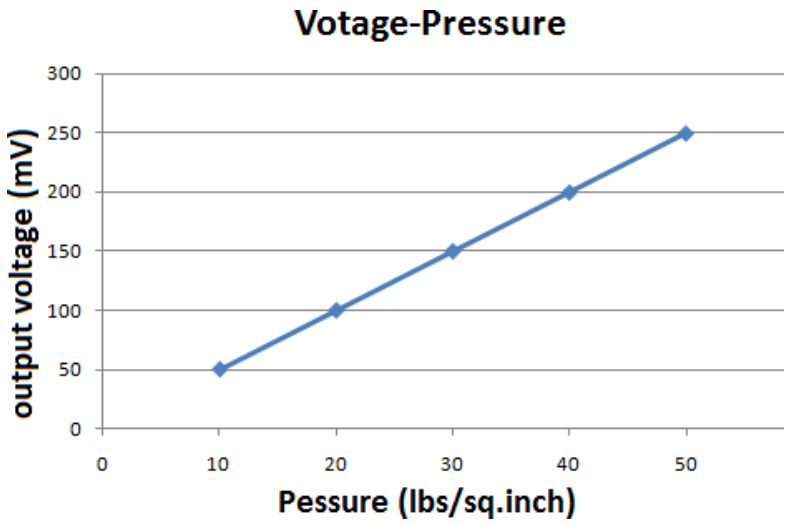
PROCEDURE:

1. Calibrate the device
2. Note the pressure and note the corresponding voltage values.
3. Plot the graph between pressure and corresponding voltage output.

OBSEVATION:

Pressure (lbf/square inch)	**Output Voltage (mv)**
10	
20	
30	
40	

Model Graph:

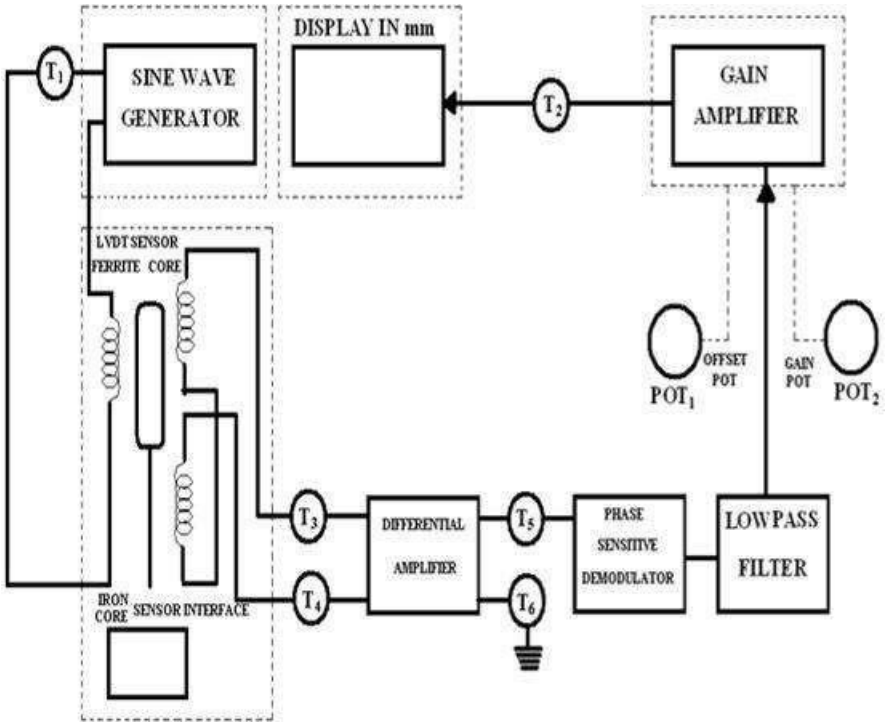


RESULT:

The characteristics of Pressure Sensor and Piezoelectric Force Sensor is verified.

CIRCUIT DIAGRAM:

Study of Displacement Transducer - LVDT



EX.No.3 Date :	Measurement of Displacement Of LVDT

AIM:

To study the displacement transducer using LVDT and to obtain its characteristics

APPARATUS REQUIRED:

Sl.No	Name of the Apparatus	Qty
1	LVDT Trainer kit	1
2	Connecting Wires	1
3	Digital Multimeter	1
4	Screw gauge	1

FORMULA USED:

%ERROR = [(Displayed Displacement – Actual Displacement)/ Actual Displacement] x100

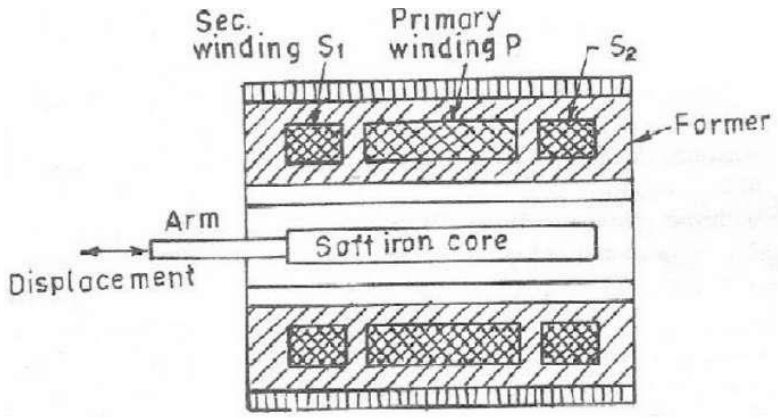
PRECAUTIONS:

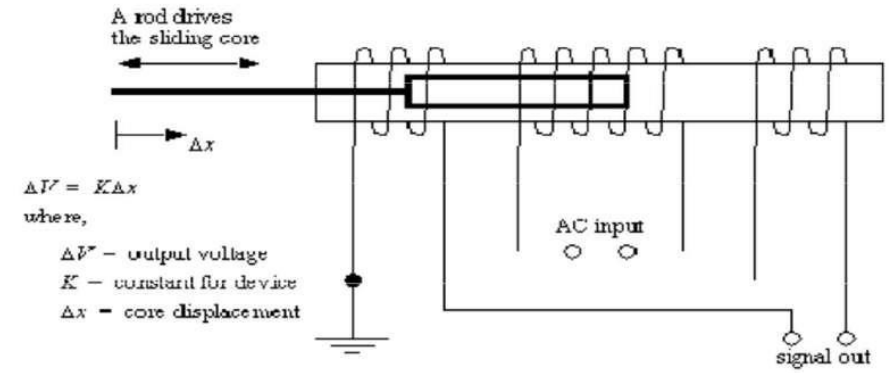
1. While taking reading on scale parallel error has to be avoided.
2. Smooth gradual movement of the core to be ensured.

PROCEDURE:

1. Switch on the power supply to the LVDT module.
2. Connect the CRO at T1 to check the input sine wave signal. Adjust the frequency to kHz.
3. Place the LVDT at the null position (10mm) and adjust the offset to display zero on the DVM (actual displacement).calibrated in displacement of the core. Gradually move the core of the LVDT in the positive direction (20mm) and Note the reading on the display (mm).It should be around 10mm, if it not adjust the gain to display 10mm.
4. Repeat step 4 in the opposite direction.

1. Tabulate the readings of actual displacement and displayed on the DVM. The LVDT core may be moved through a distance of 20mm.

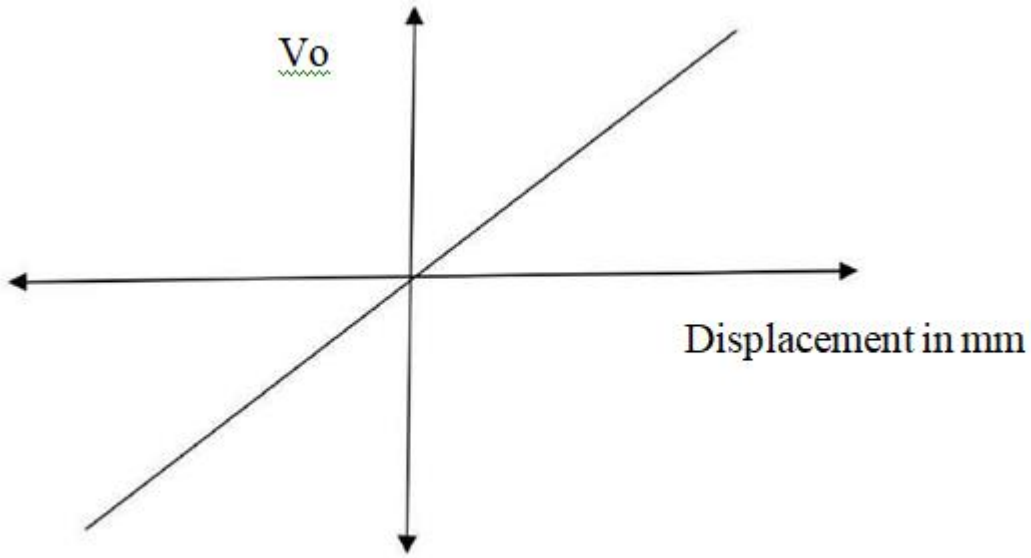




TABULATION:

ACTUAL DISPLACEMENT D_a(mm)	OUTPUT VOLTAGE Vo *Volts*	DISPLAYED DISPLACEMENT D_d (mm)	% ERROR
1			
2			
3			
4			

MODEL GRAPH:



RESULT:

Thus the displacement and characteristics of transducer are studied using LVDT.

EX.No.4	Characteristics of Resistance Temperature Detector
Date :	

AIM:

To study the characteristics of RTD.

APPARATUS:

1. RTD
2. Resistors 1KΩ - 5, 100Ω - 2
3. Op-amp IC 741
4. Thermometer
5. Electrical kettle
6. 5V power supply

THEORY:

Resistance Temperature Detector (RTD):

Resistance thermometers, also called resistance temperature detectors (RTDs), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature. As RTD elements are fragile, they are often housed in protective probes.

RTDs, which have higher accuracy and repeatability, are slowly replacing thermocouples in industrial applications below 600 °C.

The variation of resistance of metals with temperature is normally modeled in the form:

$$R_t = R_0[1 + \alpha(t - t_0) + \beta(t - t_0)^2]$$

Where R_t and R_0 are the resistance values at t and t_0 espectively;

α, β are constants that depends on the metal.

For a small range of temperature, the expression can be approximated as:

$$R_t = R_0[1 + \alpha(t - t_0)]$$

For Copper, $\alpha = 0.00427/$.

Copper, Nickel and Platinum are mostly used as RTD materials. The range of temperature measurement is decided by the region, where the resistance-temperature characteristics are approximately linear. The resistance versus temperature characteristics of these materials is shown in fig.1, with to as 0 Platinum has a linear range of operation upto 650 , while the useful range for Copper and Nickel are 120 and 300 respectively.

Construction :

For industrial use, bare metal wires cannot be used for temperature measurement. They must be protected from mechanical hazards such as material decomposition, tearing and other physical damages. The salient features of construction of an industrial RTD are as follows:

- The resistance wire is often put in a stainless steel well for protection against mechanical hazards. This is also useful from the point of view of maintenance, since a defective sensor can be replaced by a good one while the plant is in operation.

- Heat conducting but electrical insulating materials like mica is placed in between the well and the resistance material.

- The resistance wire should be carefully wound over mica sheet so that no strain is developed due to length expansion of the wire.

Signal conditioning :

The resistance variation of the RTD can be measured by a bridge, or directly by volt-ampere method. But the major constraint is the contribution of the lead wires in the overall resistance measured. Since the length of the lead wire may vary, this may give a false reading in the temperature to be measured. There must be some method for compensation so that the effect of lead wires is resistance measured is eliminated. This can be achieved by using either a three wire RTD, or a four wire RTD. Both the schemes of measurement are shown in figure. In three wire method one additional dummy wire taken from the resistance element and connected in a bridge (fig. 1) so that the two lead wires are connected to two adjacent arms of the bridge, thus canceling each other's effect. In fig.2 the four wire method of measurement is shown. It is similar to a four terminal resistance and two terminals are used for injecting current, while two others are for measuring voltage.

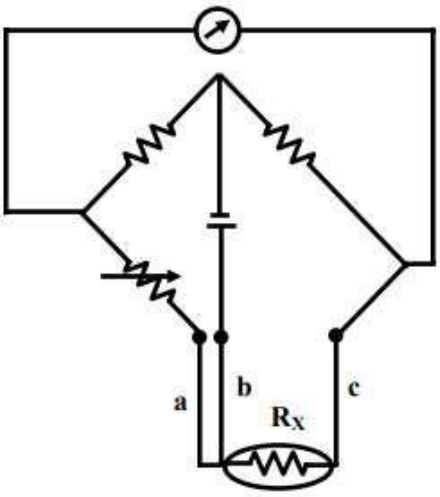


Figure 3. 3 wire configuration

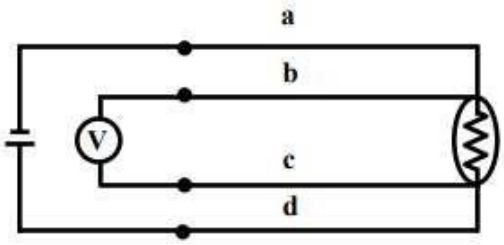


Figure 2. 4 wire configuration

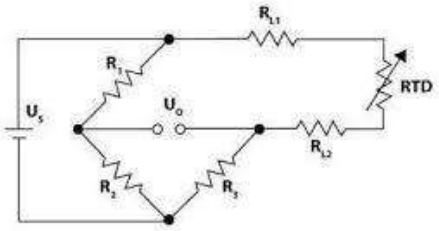
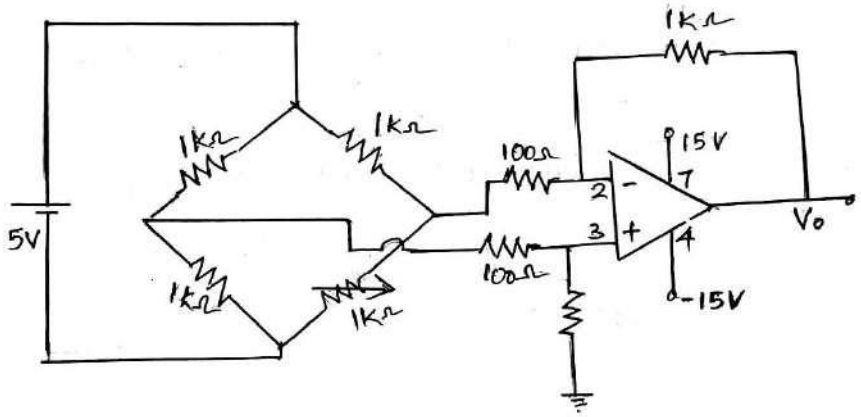


Figure 4. 3 wire configuration

CIRCUIT DIAGRAM:



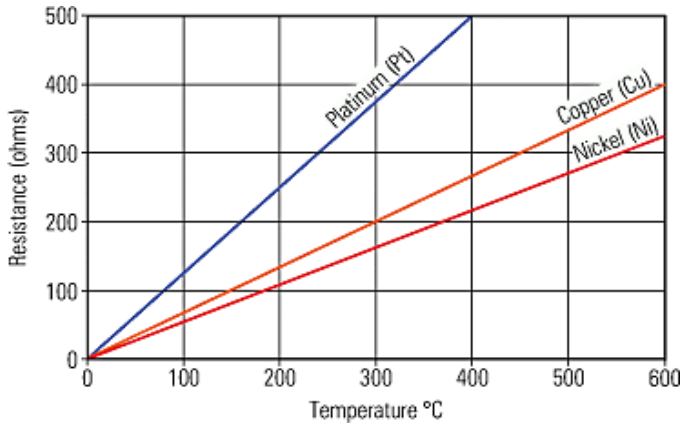
PROCEDURE:

1. Connect the circuit diagram as shown in figure. (Check the opamp using buffer circuit before using the circuit.)
2. Connect the kettle full with $\frac{1}{4}$ of the kettle and immerse the thermometer and RTD to it.
3. Note down the water temperature using the thermometer.
4. Note down the corresponding output voltage in the multimeter.
5. Similarly note down reading from multimeter for different temperature up to 100 .
6. Graph is plotted using the values obtained.
7. Observe the graph.

OBSEVATION:

Temperature (°C)	Output voltage (mV)
30	
35	
40	
45	
50	
60	
70	
80	
90	
100	

Model Graph:



RESULT:

The characteristics of RTD are studied and are plotted.

EX.No.5	Characteristics of Thermocouple.
Date :	

AIM:

To study the characteristics of thermocouple.

APPARATUS:

1. Thermocouple
2. Resistors 1KΩ - 1, 5.6KΩ - 1
3. Op-amp IC 741
4. Thermometer
5. Power Chord.
6. Digital multi meter

THEORY:

Theory Of Thermocouple :

The thermocouple is one of the simplest and most commonly used methods of measuring process temperatures. The operation of a thermocouple is based upon Seeback effect which states that when heat is applied to junction (hot junction) of two dissimilar metals, an emf is generated which can be measured at the other junction (cold junction). The two dissimilar metals form an electric circuit, and a current flows as a result of the generated emf asshown in Figure1.

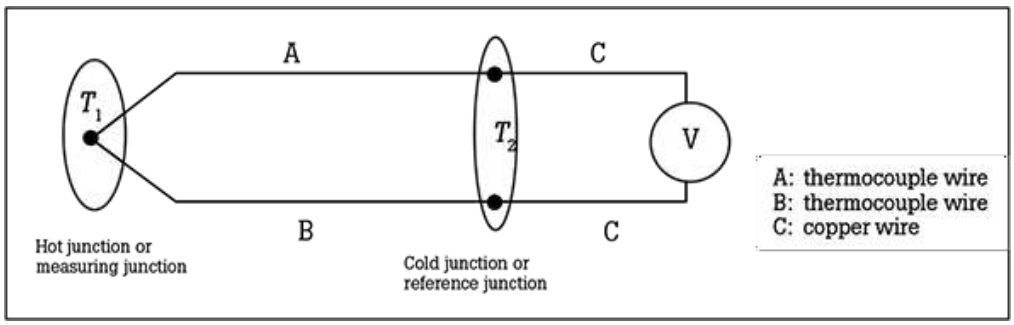


Figure 5. Schematic diagram.

The emf produced is function of the difference in temperature of hot and cold junctions and is given by: **$E = a\Delta\theta$**

Where a = photoelectric constant.

$\Delta\theta$ = difference between temperatures of hot and cold junctions.

J-type thermocouple :

This active transducer is made of Iron and Constantan metals. There are two junctions, one kept as a reference and the other is subjected to the temperature. Depending on the difference in the temperature of the two junctions, it develops an output voltage without the need of any excitation. Hence is called an active transducer on the principle of seeback effect. The output voltage is in millivolts. This voltage is suitably signal conditioned to give an output involts. The thermocouple senses the temperature from the temperature source (Water bath) in terms of millivolts. This millivolts output which is obtained from thermocouple is given to inverting amplifier for further amplification. This amplifier amplifies the given millivolts in the range of (0- 3.5) V.

Thomson effect :

The evolution or absorption of heat when electric current passes through a circuit composed of a single material that has a temperature difference along its length. This transfer of heat is superimposed on the common production of heat associated with the electrical resistance to currents in conductors.

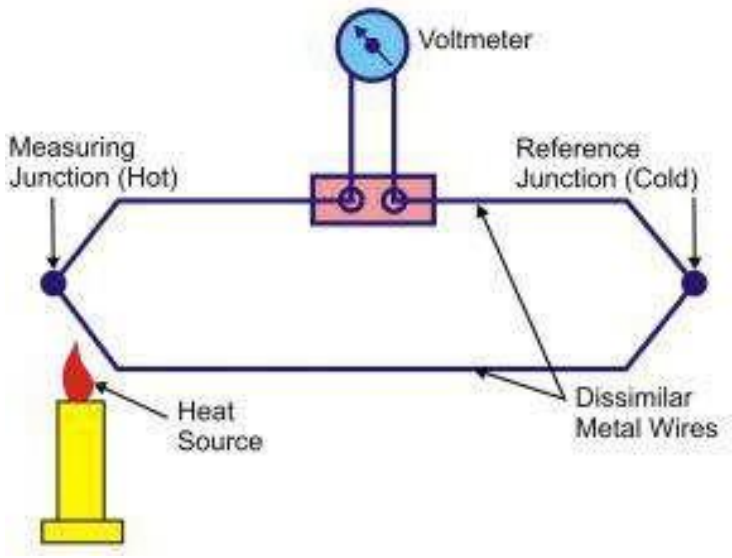
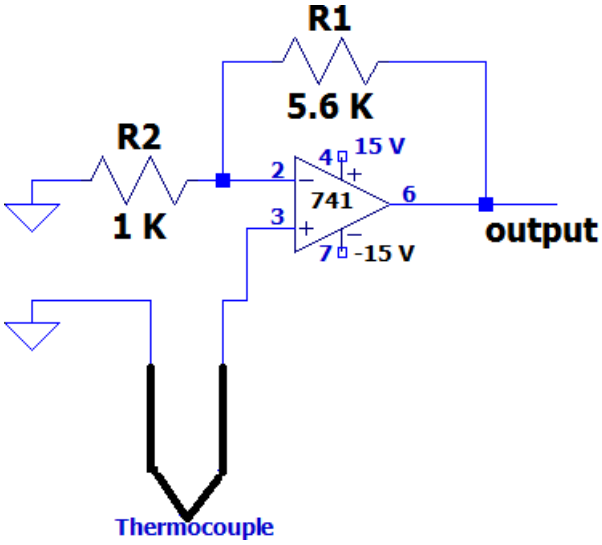


Figure 6. Circuit diagram.

CIRCUIT DIAGRAM:



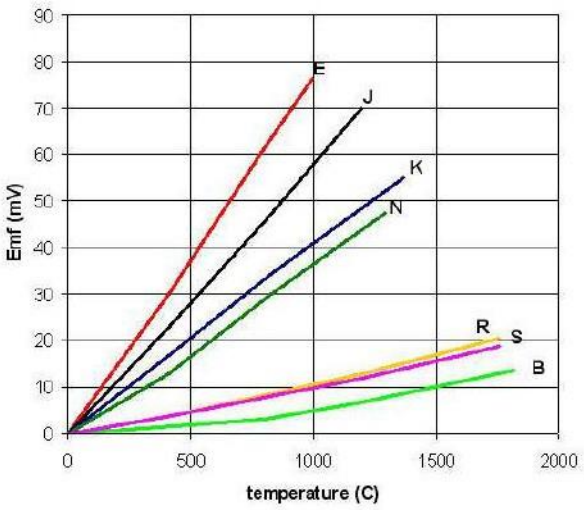
PROCEDURE:

- Set up the circuit as per the diagram.
- Check the op-amp by arranging buffer circuit (Gain = 1).
- Connect the kettle three-fourth of the kettle and immerse the thermometer and with thermocouplr to it.
- Note output voltage from multimeter for different temperature (up to 100).
- Draw the graph with temperature at x axis and output voltage as y axis

OBSEVATION:

Temperature (° C)	Output voltage (mV)
30	
40	
50	
60	
70	
80	
90	
100	

Model graph:



RESULT:

The characteristics of thermocouple is studied and is plotted.

EX.No.6	Characteristics of Thermistor
Date :	

AIM:

To study the characteristics of the given thermistor.

APPARATUS:

1. Thermistor.
2. Thermometer
3. Multimeter.
4. Heater.

THEORY:

The thermistor is also a temperature sensitive resistor. While the thermocouple is the most versatile temperature transducer and the PRTD is thus sensitive. Of the three major categories of sensors, the thermistor exhibits by far the largest parameter change with temperature. Thermistors are generally composed of semiconductor materials. Although positive temperature coefficient units are available, most thermistors have a negative temperature coefficient (TC); that is, their resistance decreases with increasing temperature. The negative T.C. can be as large as several percent per degree Celsius, allowing the thermistor circuit to detect minute changes in temperature which could not be observed with an RTD or thermocouple circuit. The price we pay for this increased sensitivity is loss of linearity. The thermistor is an extremely non-linear device which is highly dependent upon process parameters. Consequently, manufacturers have not standardized thermistor curves to the extent that RTD and thermocouple curves have been standardized.

PROCEDURE:

1. Thermistor and thermometer are dipped into a beaker containing water.

2. Water is heated using heater.

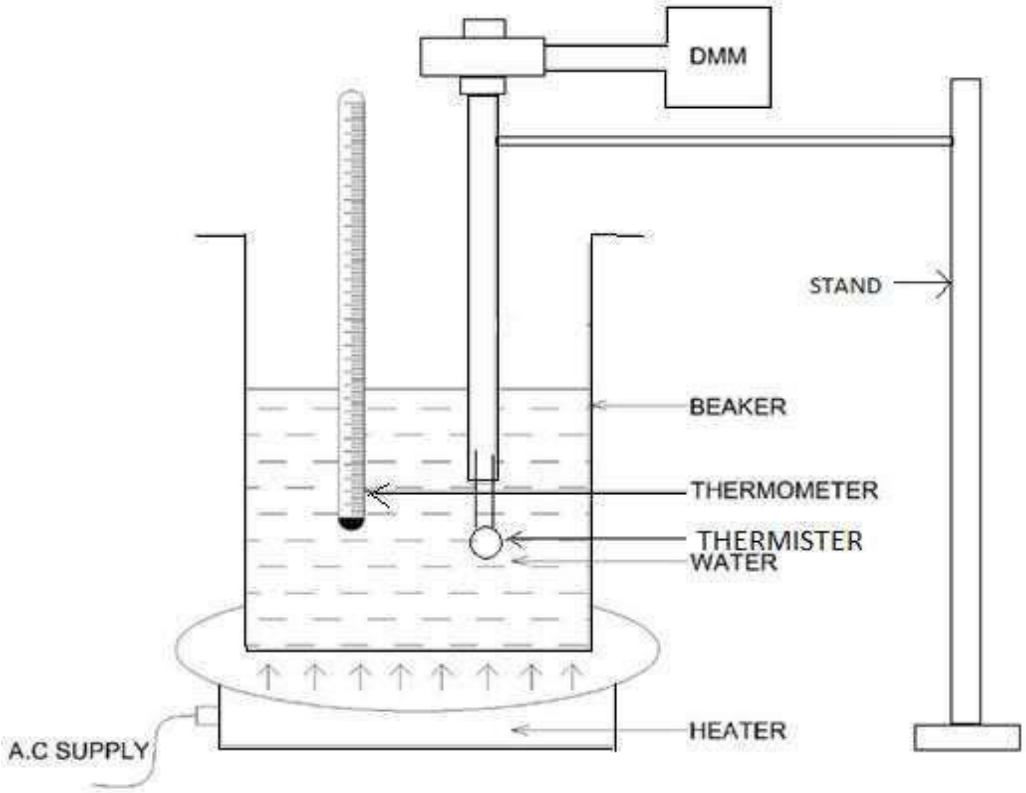
3. Thermistor is connected to digital multi-meter and kept in resistance mode.

4. Initially at 30^{o}C temperature resistance.

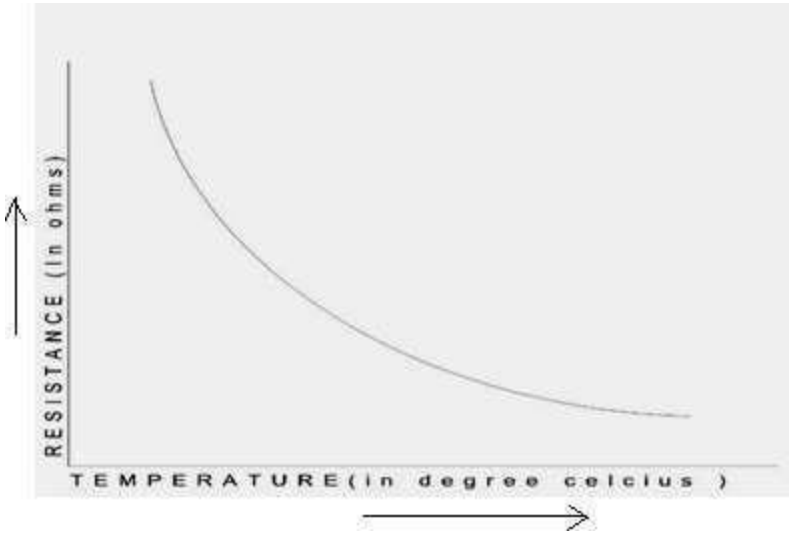
5. For every 5^{o}C increase, resistance is noted.

6. After taking reading till 80^{o}C water is cooled.

EXPERIMENTAL SETUP



MODEL GRAPH



OBSEVATION:

1. HEATING

S.no	Temperature (°c)	Resistance (kΩ)

2. COOLING

S.no	Temperature (°c)	Resistance (kΩ)

RESULT:

The characteristics of thermistor is studied and the graph is plotted.

EX.No.7 Date :	Determine angular velocity of gyroscope

AIM :- To determine the angular velocity gyroscopic couple on Motorized Gyroscope.

APPARATUS USED:- Four wheeler & two wheeler vehicle.

THEORY :- When a body moves along a curved path with a uniform linear velocity, a force in the direction of centripetal acceleration (known as centripetal force) has to be applied externally over the body, so that it moves along the required curved path. This external force applied is known as active force. When a body, itself, is moving with uniform linear velocity along a circular path, it is subjected to the centrifugal force radially outwards. This centrifugal force is called reactive force. The change in angular momentum is known as active gyroscopic couple(I.ω.ωp). When the axis of spin itself moves with angular velocity ωp, the disc is subjected to reactive couple whose magnitude is same (i.e.I.ω.ωp) but opposite in direction to that of active couple.

OBSERVATION :-

- Mass of the vehicle (m) =----------kg.
- Weight of the vehicle (W) =----------Newtons.
- Radius of the wheels (rw) = ---------- metres.
- Radius of curvature (R) = ---------- meters.
- Distance of centre of gravity, vertically above the road surface(h) = ----------metres,
- Width of track (x) = ---------- metres,
- Mass moment of inertia of one of the wheels(Iw) = ----------kg-m2
- Angular velocity of the wheels or velocity ofspin(ωw) = ----------rad/sec
- Mass moment of inertia of the rotating parts of the engine(IE) = ---------- kg-m2
- Angular velocity of the rotating parts of the engine (ωE) = ---------- rad/sec
- Gear ratio = ωE /ωw
- Linear velocity of the vehicle (ν) = rw ωw
- Angle of heal (θ) =---------rad.

CALCULATION :-

For 4-wheel drive:

- Gyroscopic couple due to 4 wheels, Cw = 4 Iw ωw ωp where, (ωp =ν/R)
- Gyroscopic couple due to the rotating parts of the engine, , CE = IE ωE ωp = Iw.G. ωw. ωp
- Net Gyroscopic couple, C = Cw ±CE

  For 2-wheel drive:
- Gyroscopic couple, C1 = ν (2 Iw ± IE..G) cosθ /R. rw

PRECAUTIONS :-

- When rotating parts of the engine rotate in opposite directions, then negative sign is used.
- When CE ›Cw, then C will be negative. Thus the reaction will be vertically downwards on the outer

wheels and vertically upwards on the inner wheels.

- The gyroscopic couple will act over the vehicle outwards i.e. in the anticlockwise direction when seen from the front of the vehicle. The tendency of this couple is to overturn the vehicle in outward
- direction.

RESULT :-

- Gyroscopic couple of four wheel drive is = ----------N-m.
- Gyroscopic couple of two wheel drive is =---------- N-m.

VIVA – QUESTIONS :-

- Write a short note on gyroscope.
- What do you understand by gyroscopic couple ? Derive a formula for its magnitude.
- Explain the application of gyroscopic principles to aircrafts.
- Discuss the effect of the gyroscopic couple on a two wheeled vehicle when taking a turn.
- When the pitching of a ship is upward, the effect of gyroscopic couple acting on it will be to movethe ship towards port side or to move the ship towards star-board.

EX.No.8 Date :	Determine the Characteristics of Various Light Detectors (Optical Sensors).

AIM:

To study the characteristics of optical transducer - LDR.

APPARATUS:

1. LDR
2. Resistors 1KΩ - 1, 10KΩ - 1
3. Op-amp IC 741
4. DSO
5. Function generator
6. Multimeter

THEORY:

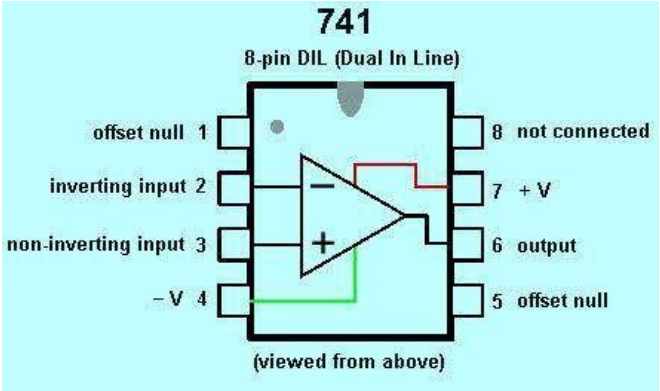
Transducer is a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa. The optical transducer convert light into electrical quantity. They are also called as photoelectric transducers. The optical transducer can be classified as photo emissive, photoconductive and photovoltaic transducers. The photo emissive devices operate on the principle that radiation falling on a cathode causes electrons to be emitted from the cathode surface.

The photoconductive devices operate on the principle that whenever a material is illuminated, its resistance changes. The photovoltaic cells generate an output voltage that is proportional to the radiation intensity. The radiation that is incident may be x-rays, gamma rays, ultraviolet, infrared or visible light.

An optical transducer converts light rays into an electronic signal. The purpose of an optical transducer is to measure a physical quantity of light and, depending on the type of transducer, then translates it into a form that is readable by an integrated measuring device.

A photoresistor (or light-dependent resistor, LDR, or photo-conductive cell) is a light- controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light-activated and dark-activated switching circuits.

CIRCUIT DIAGRAM:



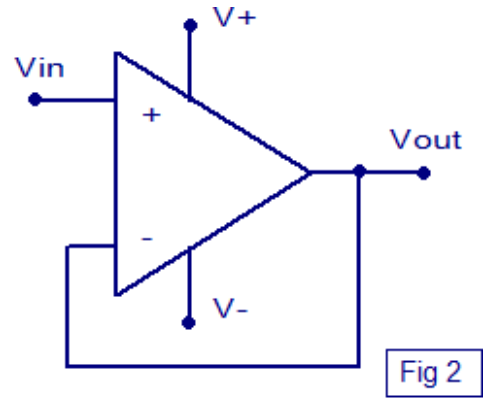
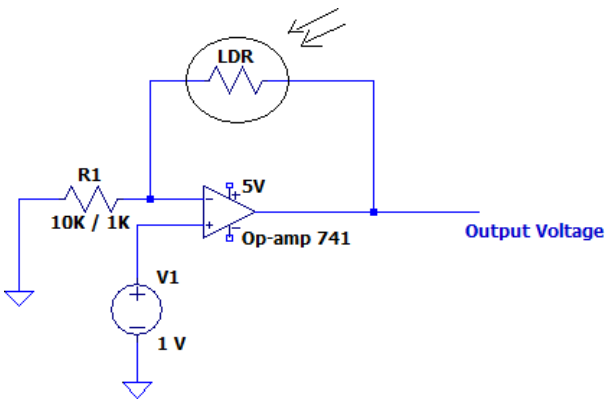


Fig 2

Voltage follower using opamp

CIRCUIT DIAGRAM:



PROCEDURE:

1. Setup a buffer circuit (voltage follower) circuit using Op-amp.
2. Input is given (a sinusoidal wave of 1 Vpp and 1KHz) and the output is displayed on CRO.
3. Check whether the gain is one if not opamp is should be replaced.
4. Then set up the circuit as given.
5. Connect LDR and 10KΩ resistor to 2 terminal (inverting terminal). One end of LDR to terminal 6 (output terminal)
6. Connect 1V DC from DC source to terminal 3 (non inverting)
7. Connect V^+ and V^- to 7 and 4 respectively.
8. Output is given to terminal 6 and input is grounded.
9. Measure output voltage for different lighting condition (Dark, Ambient, High).
10. Verify the gain by measuring resistance..

OBSEVATION:

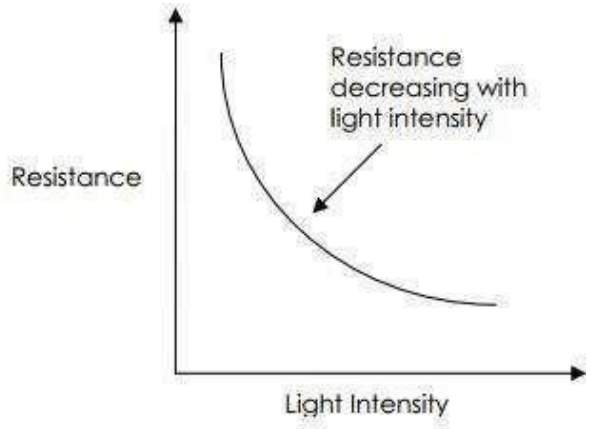
R = 10KΩ

Lighting Condition	**Output voltage (V)**
Dark	
Ambient	
Light	

R = 1KΩ

Lighting Condition	**Output voltage (V)**
Dark	
Ambient	
Light	

Model Graph:



RESULT:

Characteristics of optical transducer LDR is studied and the variation of resistance with lightintensity is plotted.

EX.No.9 Date :	Distance Measurement using Ultrasonic Sensor

Aim : To measure distance using ultrasonic sensor, determine the measurement errors,resolution and sensitivity of the measurement.

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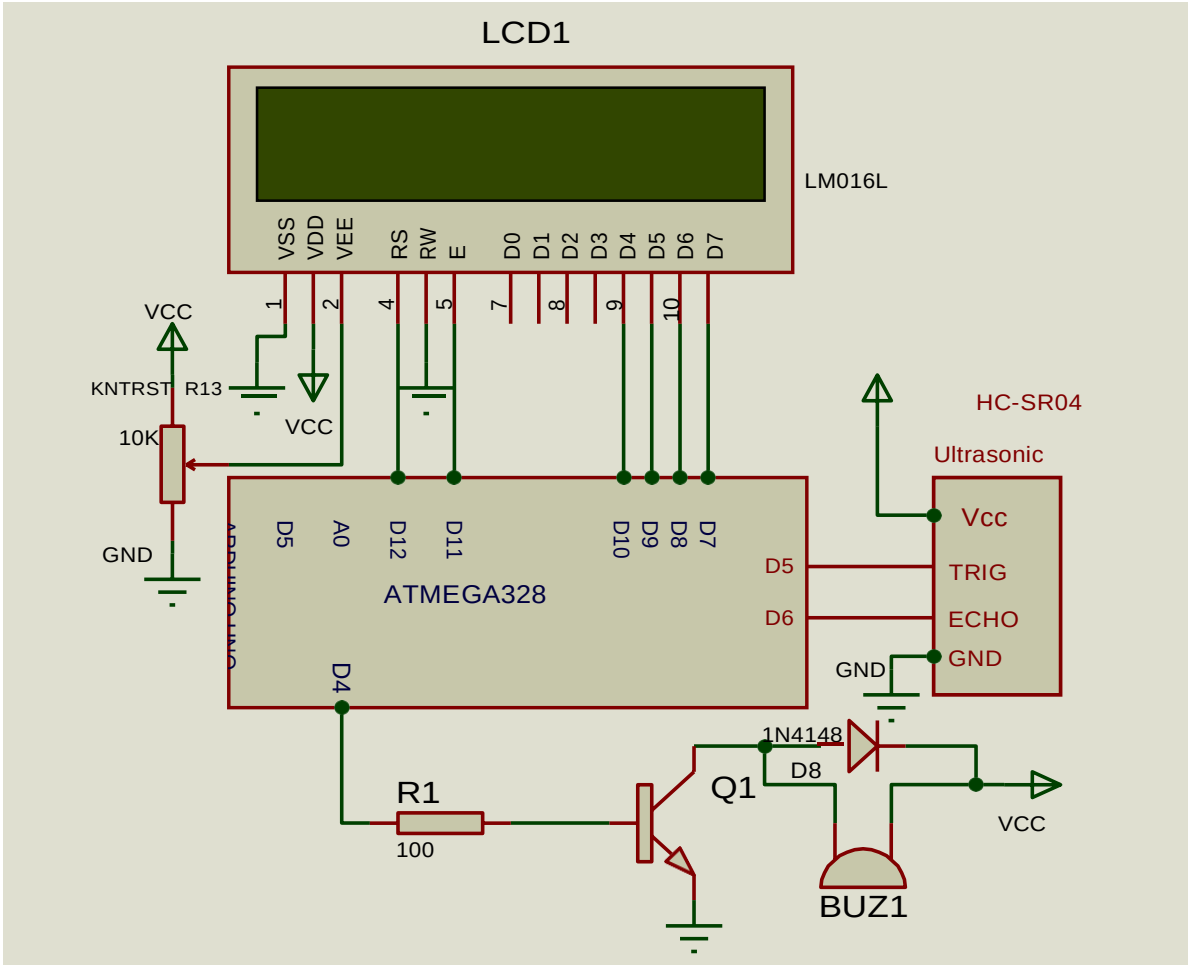
Experimental Materials:

1. EDS-1 Experimental Board
2. Arduino Uno card
3. LM016 2x16 LCD display: Contrast adjustment: R13 10 K Pot
4. HC0 - SR04 Ultrasonic sensor
5. Buzzer
6. BC337 NPN transistor



CIRCUIT DIAGRAM

Preliminary work:

1. Study and understand the analog and digital I/O features and the connections of the Arduino Uno card to drive the ultrasonic sensor and the LCD display for distance measurements using the experimental circuit diagram.
2. Write an arduino program to measure distance using the ultrasonic sensor.
3. Include a function in your code to trigger an alarm when the distance is less than 15cm

Experimental Work:

1. Make the connections of the LCD, ultrasonic sensor and of the buzzer, using the above circuit diagram. The GND, 5V supply and the contrast pins of the LCD and thetransistor and diode connections are pre-wired on the board.
2. Make the 5V supply connection of the ultrasonic sensor by switching ON the 5th switch of the SWDIP5 dipswitch. The GND pin of the ultrasonic sensor is alreadyconnected to the common ground of the EDS1 experimental board.
3. Connect the TRIG pin of the ultrasonic sensor to the D5 pin of the the arduino and the ECHO pin to D6. Connect the BZ input pin of the buzzer on the J27 male header to D4 pin of the arduino.
4. Connect the EDS-1 experimental card to the PC via the USB connector.
5. Start the arduino IDE and upload your program to the arduino UNO card.
6. Measure the distances from the ultrasonic sensor to a target of variable length on the LCD. Measure the same distances by using a ruler simultaneoulsly.
7. Determine the sensing region of the utrasonic sensor by moving the target sideways at various distances and draw the sensing region in 3D.
8. Notice that the buzzer will produce an alarm sound when the distance is less than the value specified in your program.
9. Change the distance in 5 cm lengths and record the distances measured on the LCD, as well as the actual distances that you measure with a ruler.

Step	Sensor Value	Actual Value	Error	% Error
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

10. Calculate and record the measurement error of the sensor and the percent error inthe table.
11. Draw the graph of the percent error of the sensor vs distance.
12. Determine a method to calibrate the sensor with respect to the actual values. Embedthis method into your arduino program and repeat the steps 1, 11 and 12 by changing the target distance in 4 cm lenghts to see the effect of calibration on the results

Result :

Distance using ultrasonic sensor, and the measurement errors, resolution and sensitivity of the measurement is measured and determined.

EX.No.:10 Date :	Vibration Measurement using Accelerometer.

Aim:

To study and measurement of Vibration amplitude at various loads using accelerometer

Apparatus:

Signal generator, Amplifier, Shaker, Vibration meter, accelerometer

Theory:

Many methods have been developed to measure linear and angular displacements, velocities, and accelerations. Displacements and accelerations are usually measured directly, while velocities are often obtained by integrating acceleration signals. The definitions of velocity and acceleration suggest that any convenient quantity can be measured and the other can be obtained by integrating or differentiating the recorded signal. Since the integration process is an error -smoothing process, while the differentiation process is an error-amplifying process, only the integration process is widely used for practical application. Displacement measurements are most frequently made in manufacturing and process-control applications, while acceleration measurement is made in vibration, shock, or motion-measurement situations.

Piezo-electric material, an electric potential; appears across certain surfaces of a crystal. If the dimension of the crystal are changed by the application of a mechanical force. This potential is produces by the displacement of charges. This effect is reversible and is known as piezo-electric effect. Elements exhibiting piezo-electric quality are often referred as electro-resistive effects.

When a force F is applied to a piezo-electric crystal it develops a charge Q = d * F Coulomb where is the charge sensitivity of the crystal in N/C. By incorporating a mass M in direct contact with the crystal, we get essential components of an accelerometer.

By applying varying acceleration to the mass-crystal assembly, the crystal experiences a varying force which according to Newton's second law.. This force produces a varying charge given by

$Q = d \times F = d\,Ma$

Where a is the acceleration

If the crystal has a capacitance C, the no load output voltage is

$Vo = Q/C = (d \times F)/C = d\,(Ma/C)$

Thus the output voltage is a measure of the acceleration. The accelerometer is quit small in size and weight. The natural frequency is high of the order 100 kHz and hence can be used for any vibration and shock.

THE SETUP:

Vibration Demo is designed as a laboratory set up which can be used to demonstrate the principles of Vibration measurement. It consists of a shaker and control unit. The shaker is of the Electro- magnetic type; The control unit consist of a signal generator, power amplifier and vibration-meter. The sinusoidal output from the signal generator is amplified by the amplifier and applied to the shaker, which generates vibrations on the spindle. The Accelerometer may be attached to the spindle through the M-5 stud. (supplied with the accelerometer). Signal output from the accelerometer is connected to the vibration meter, which gives direct read out of acceleration velocity or displacement.

SPECIFICATIONS:

01. SHAKER :

Force rating : 5 Newton (maximum) Frequency Range : 50Hz to 1KHz.

(Max. Static load on shaker spindle : 100gm)

02. CONTROL UNIT:

POWER OSCILLATOR:-

Frequency range : 50Hz to 1000Hz. Output Voltage : 0-10V (p-p) Distortion :<2%.

VIBRATION METER:

Frequency Range : 10Hz to 10KHz. Input impedance : 10,000 M ohms. Display : 3.5 digit LCD.Source Capacitance: 30,000 pF.

INSTALLATION:

For Test Purpose the Shaker and Control Unit may be on a laboratory table. The Accelerometer should be mounted on the shaker spindle using the M-5 stud supplied with the accelerometer. Connect the accelerometer output to the input connector on the control unit using the 1mtr long low noise cable supplied. Connect the co-axial cable attached to the socket to the amplifier output connector on the control unit, and the power cable to a 230 V, 50 Hz .

.Fig: Vibration measurement setup

Precautions:

- All connections should be neat and clean.
- Digital indicator reading has to be noted accurately.
- To check the power source, it should be 230V ⍰10%, 50 Hz. to avoid over voltage hazards.

To get best performance, you have to put the instrument at dust proof and humidity free environment.

- Do not try to open the instrument or repair it

Procedure:

1. Connect the sensor to the instrument through the BNC socket provided on the Back Panel mentioned SENSOR.

2. Connect the Vibration generator to the instrument through the cable provided at the rear panel of the instrument marked EXCITER.

3. Connect the instrument to the 230V 50Hz. Supply through cable provided at the rear panel.

4. Keep the FREQ. Pot and the VOLT pot in the minimum position.

5. Switch on the instrument, the display glows to indicate the power is on. In this Position Press the Tare button to make the readings Zero.

6. Turn the VOLT pot to the max position.

7. Now turn the FREQ pot in steps of 100 Hz. And note down the readings of Acceleration, Velocity, Displacement.

8. Tabulate the readings in the tabular column. Experiment can be repeated for different voltages settable through VOLT knob provided.

Observation table:

Sl. No.	Frequency(Hz)	Indicator Reading		
		Acceleration ($m/s^{2)}$	Velocity(m/s)	Displacement(mm)
1	50	79.3	17.8	1.606
2	100			
3	200			
4	300			
5	400			
6	500			
7	600			
8	700			
9	800			
10	900			

Graphs :

Graph can be plotted for Frequency V/s Acceleration, Velocity and displacement.

Result:

Measurement of Vibration amplitude at various loads using accelerometer is done .

Pre viva questions:

1. What is linear motion, angular motion?
2. What is displacement, velocity, acceleration
3. What is Jerk?
4. What is vibrometer ?
5. What is accelerometer?

Post viva questions:

1.Causes of vibration.

2.Types of accelerometers

3. What is seismic accelerometer?
4. Name the transducers used for measurement of seismic instruments output.

5.Name the applications of vibrometer.

EX.No.:11	Data acquisition, visualization and analysis of signals.
Date :	SAMPLE AND HOLD CIRCUIT

AIM:

To write , design and test the sample and hold circuit.

TOOLS REQUIRED:

- TC9400 IC
- IC Trainer kit
- Patch cords

THEORY:

- A sample and hold (S&H) circuit is an analog device that is used to take the voltage of a constantly changing analog signal and locks its value at a stablelevel for a particular least period of time.
- These circuits are the basic analog memory devices. They are normally used in ADC (analog-to-digital converters) to get rid of differences in the input signal that can damage the change process.
- A typical circuit of the sample and hold stores electric charge in a capacitorand holds at least one switching device like a field effect transistor switch and usually one op-amp (operational amplifier).
- To sample the i/p signal the switch unites the capacitor to the o/p of a buffer amplifier.
- This amplifier amplifies the capacitor so that the voltage across the capacitor is almost equal, or proportional to input voltage. In hold form, theswitch separates the capacitor from the buffer.
- The capacitor is always discharged by its own outflow currents and helpfulload currents, which makes the circuit essentially unstable, but the voltagedrop in a particular hold time remains within a suitable error margin.

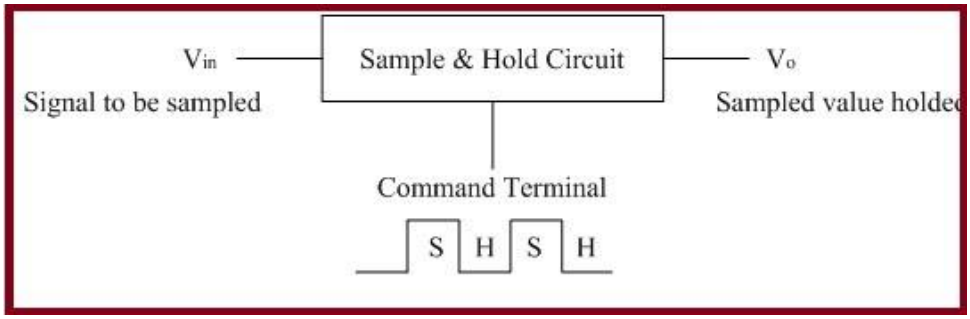


Fig 1: Sample and hold circuit

- Generally, the sampling time is between 1µs-14 µs while the holding time can expect any value as necessary in the application.
- It will not be wrong to state that capacitor is the core of sample and hold circuit.
- This is because the capacitor exhibit in it charges to its peak value when the switch is opened, i.e. during sampling and holds the inspected voltage when the switch is shut.

SAMPLE AND HOLD CIRCUIT WORKING:

- The working of this circuit can be simply understood using its components working. The main components to build the sample and hold circuit include an N-channel Enhancement type MOSFET, a capacitor, and a high accuracy operational amplifier.

- As a switching element, the N-channel Enhancement MOSFET is used. Theinput voltage is given via its drain terminal and control voltage is also giventhrough its gate terminal. When the positive pulse of the control voltage is applied, the MOSFET will be activated state.
- And it performs as a closed switch. On the opposing, when the control voltage is nothing then the MOSFET will be deactivated state and works asthe open switch

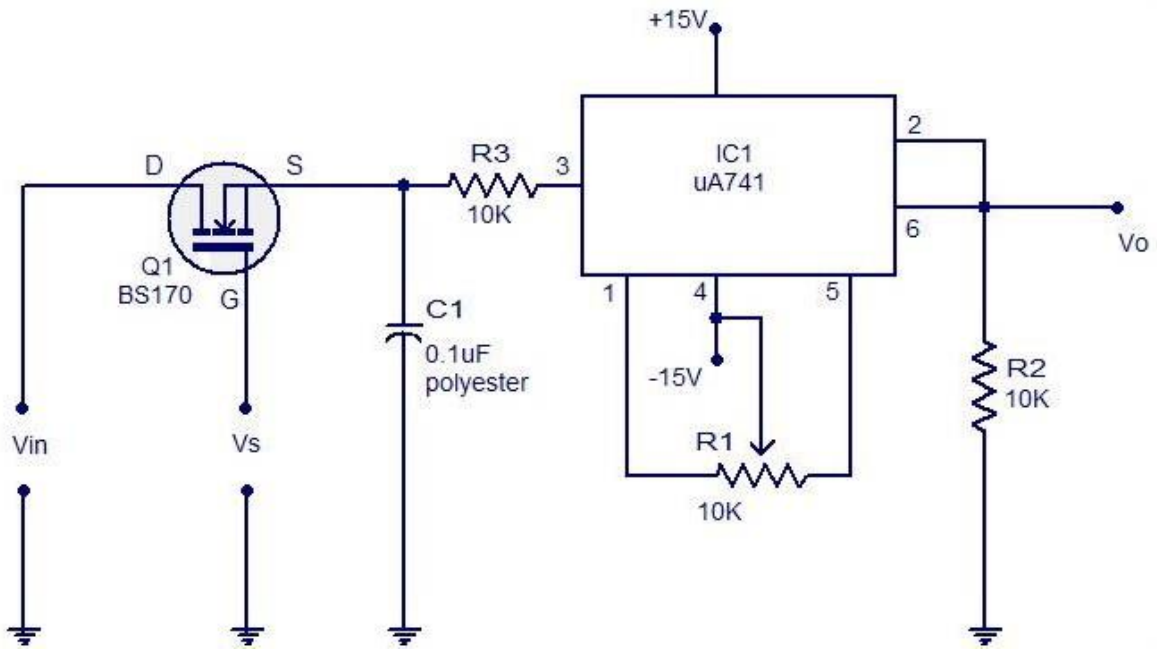


Fig 2: Circuit diagram of sample and hold

- When the MOSFET works as a closed switch, the analog signal given to itthrough the drain terminal will be fed to the capacitor.

- Then the capacitor will charge to its peak value. When the switch is released, then the capacitor discontinues charging. Due to the high impedance op-amp connected at the circuit end, the capacitor will knowledge high impedance due to this it cannot get discharged

- This directs to the holding of the charge by the capacitor for the exact amount of time. This can be referred as holding period. And the time in which samples of i/p voltage is produced is named sampling period. The o/p processed by op-amp throughout the holding period. So, holding periodholds implication for Op-Amps.

INPUT & OUTPUT WAVEFORMS:

The waveforms of the sample and hold circuit as explained in the following diagram. It is clear from the waveform of the circuit, that during the ON period what will be the voltage at the o/p. Throughout the OFF period the voltage that exists at the o/p of the op-amp.

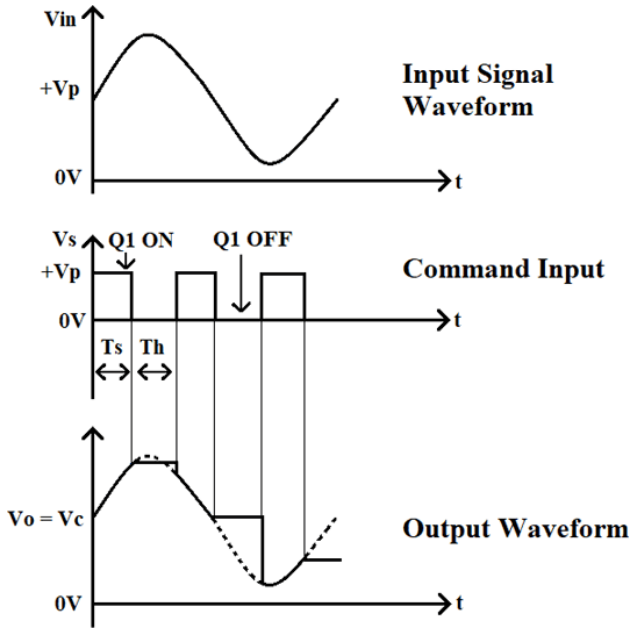


Fig 3: sample graph of sample and hold

RESULT:

Thus the sample and hold circuit was designed and tested successfully.