

**DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

**COLLEGE OF ENGINEERING, THIRUVANANTHAPURAM**

**COURSE CODE- AEL204**

**TRANSDUCERS & MEASUREMENTS LAB**

**LAB MANUAL**



**DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

**COLLEGE OF ENGINEERING, THIRUVANANTHAPURAM**

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**DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING  
COLLEGE OF ENGINEERING, THIRUVANANTHAPURAM**



**CERTIFICATE**

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Exp No: 1

Date:

## **Characteristics of Optical transducer - LDR.**

### **AIM:**

To study the characteristics of optical transducer - LDR.

### **APPARATUS:**

1. LDR
2. Resistors  $1K\Omega$  - 1,  $10K\Omega$  - 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:**

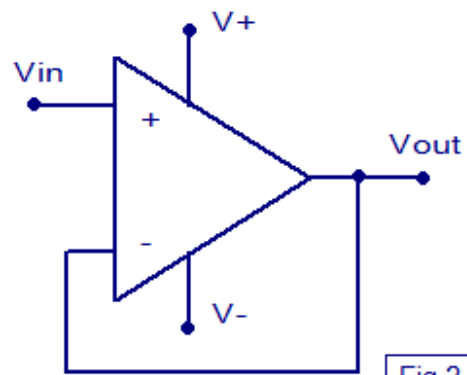
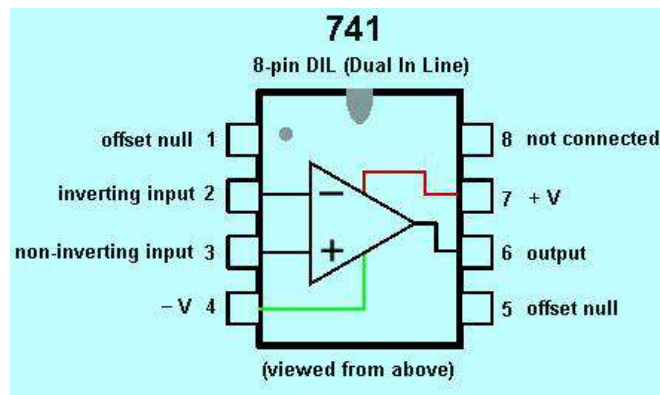
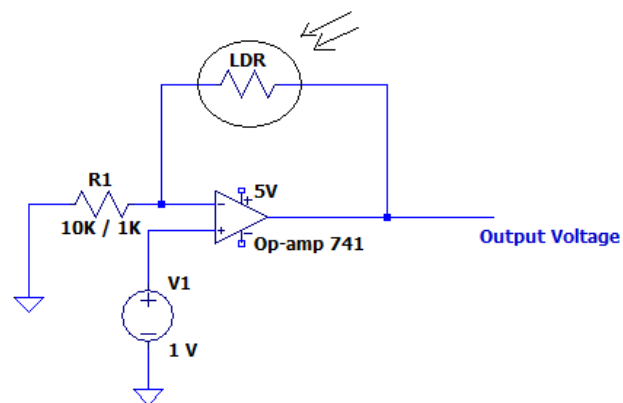


Fig 2

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 10K $\Omega$  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..

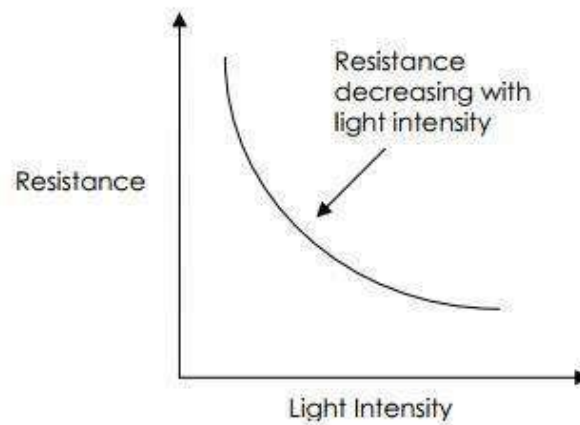
**OBSEVATION:****R = 10K $\Omega$** 

Lighting Condition	Output voltage (V)
Dark	
Ambient	
Light	

**R = 1K $\Omega$** 

Lighting Condition	Output voltage (V)
Dark	
Ambient	
Light	

**Model Graph:**



**RESULT:**

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

Exp No: 02

Date:

## **Characteristics of LVDT.**

### **AIM:**

To study the characteristics of LVDT

### **APPARATUS:**

1. LVDT
2. Resistors  $4.7\text{K}\Omega$  - 3
3.  $10\text{K}\Omega$  POT - 1
4. DMM
5. Signal generator

### **THEORY:**

Linear variable differential transformers (LVDT) are used to measure displacement. LVDTs operate on the principle of a transformer. LVDT consists of a coil assembly and a core. The coil assembly is typically mounted to a stationary form, while the core is secured to the object whose position is being measured. The coil assembly consists of three coils of wire wound on the hollow form. A core of permeable material can slide freely through the center of the form. The inner coil is the primary, which is excited by an AC source as shown. Magnetic flux produced by the primary is coupled to the two secondary coils, inducing an AC voltage in each coil. The main advantage of the LVDT transducer over other types of displacement transducer is the high degree of robustness. Because there is no physical contact across the sensing element, there is no wear in the sensing element.

Because the device relies on the coupling of magnetic flux, an LVDT can have infinite resolution. Therefore the smallest fraction of movement can be detected by suitable signal conditioning hardware, and the resolution of the transducer is solely determined by the resolution of the data acquisition system.

The LVDT closely models an ideal zeroth-order displacement sensor structure at low frequency, where the output is a direct and linear function of the input. It is a variable-reluctance device, where a primary center coil establishes a magnetic flux that is coupled through a center core (mobile armature) to a symmetrically wound secondary coil on either side of the primary. Thus,

by measurement of the voltage amplitude and phase, one can determine the extent of the core motion and the direction, that is, the displacement. Figure shows the linearity of the device within a range of core displacement. Note that the output is not linear as the core travels near the boundaries of its range. This is because less magnetic flux is coupled to the core from the primary. However, because LVDTs have excellent repeatability, nonlinearity near the boundaries of the range of the device can be predicted by a table or polynomial curve-fitting function, thus extending the range of the device.

#### CIRCUIT DIAGRAM:

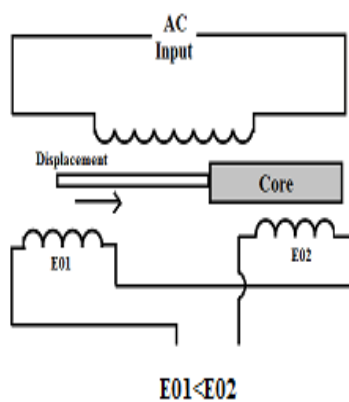
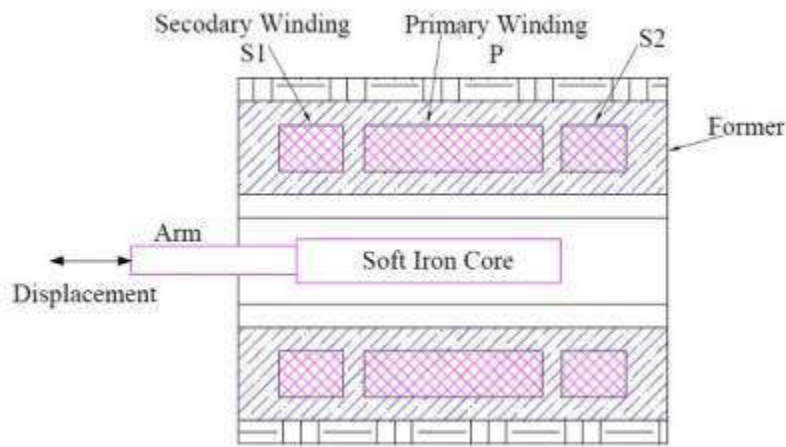


Figure 1

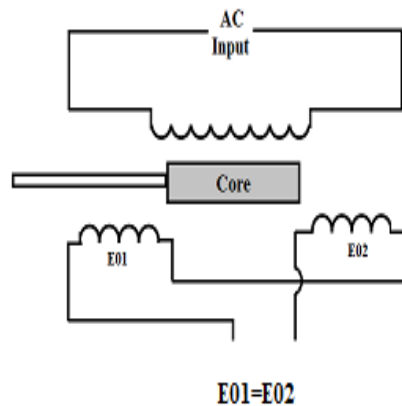


Figure 2

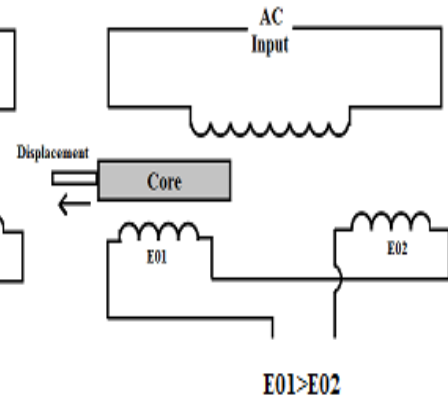


Figure 3

### PROCEDURE:

1. Rig up the circuit as shown in figures.
2. Internally set the core of an LVDT at center position and observe the residual voltage of null position.
3. Minimize the residual voltage with external balance circuit.
4. Change the core displacement 1mm in one direction and observe the output voltage in digital multimeter.
5. Repeat the step 4 until the displacement is 5 mm, and observe the corresponding output voltage for various displacements in steps of 1mm etc.
6. Now it is moved towards other direction and repeat step 5.
7. Draw the graph for displacement Vs output voltage.

#### CASE I

When the core is at null position (for no displacement) When the core is at null position then the flux linking with both the secondary windings is equal so the induced emf is equal in both the windings. So for no displacement the value of output  $e_{out}$  is zero as  $e_{01}$  and  $e_{02}$  both are equal. So it shows that no displacement took place.

#### CASE II

When the core is moved to upward of null position (For displacement to the upward of reference point)

In the this case the flux linking with secondary winding  $S_1$  is more as compared to flux linking with  $S_2$ . Due to this  $e_{01}$  will be more as that of  $e_{02}$ . Due to this output voltage  $e_{out}$  is positive.

#### CASE III

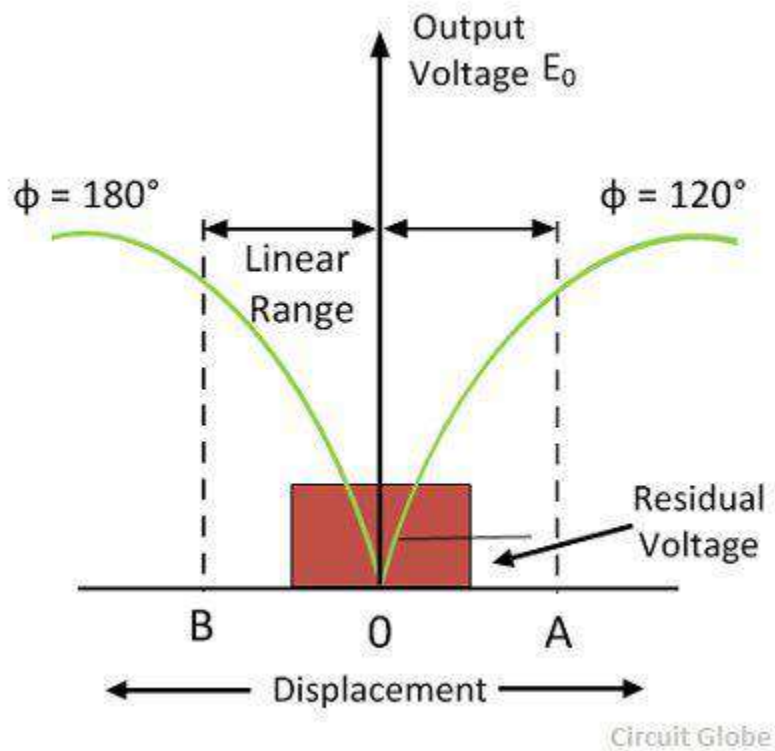
When the core is moved to downward of Null position(for displacement to the downward of the reference point). In this case magnitude of  $e_{02}$  will be more as that of  $e_{01}$  . Due to this output  $e_{out}$  will be negative and shows the output to downward of the reference point.

### OBSERVATION:

Distance (mm)	Output voltage (mV)
-5	
-4	
-3	
-2	
-1	
0	

1	
2	
3	
4	
5	

# **MODEL GRAPH:**



# **RESULT:**

LVDT characteristics are observed and studied.

Exp no: 03

Date:

## Measurement of Strain and Load using Strain Gauge.

### 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 and strain 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.

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

Where,

$F = \text{force}, e = \text{strain}, A = \text{area}, R = \text{resistance}, L = \text{length}.$

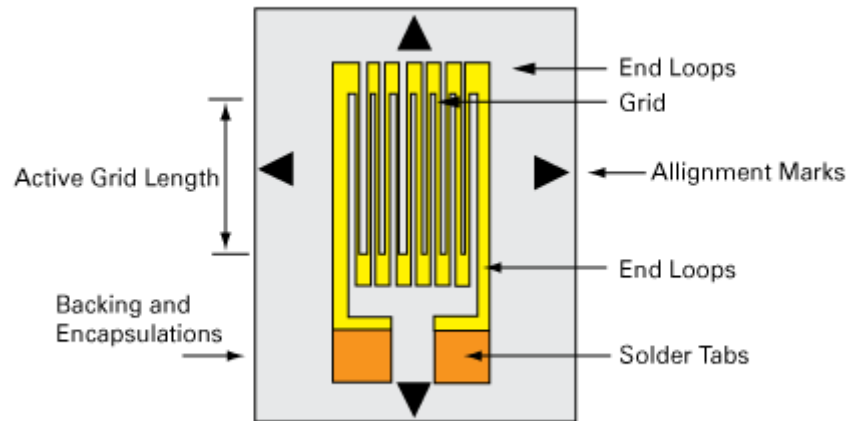


Figure 1. Strain gauge.

#### 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:

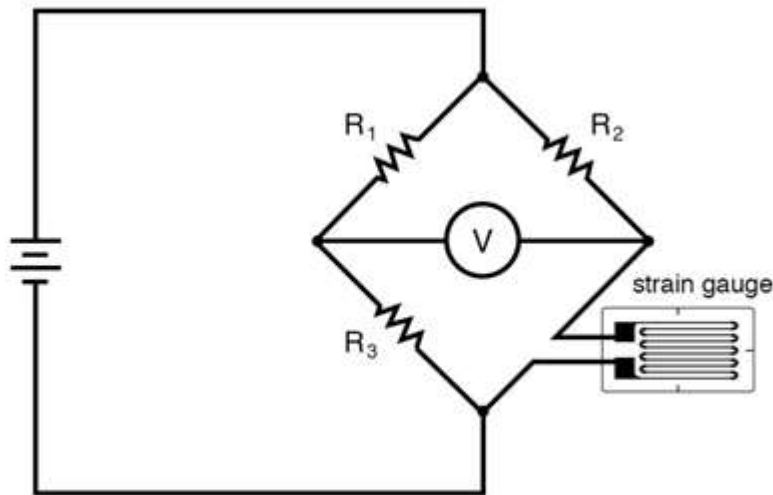


Figure 2. Quarter bridge circuit.

### 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.

### OBSEVATION:

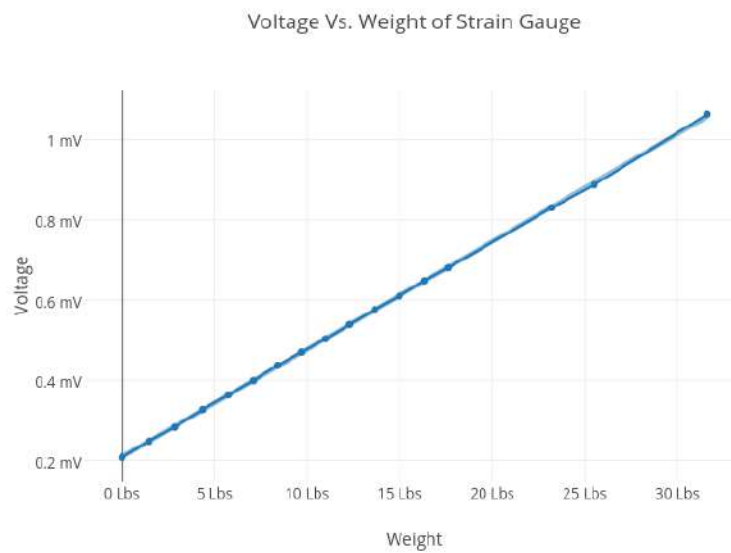
#### LOAD CELL:

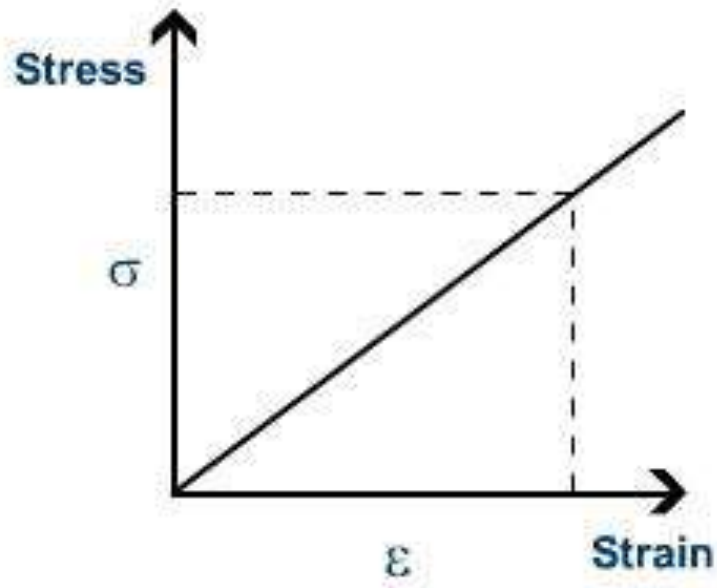
Sl.No.	Loading		Unloading		Average	
	Weight(m gm)	Voltage (mV)	Weight(m gm)	Voltage (mV)	Weight(m gm)	Voltage (mV)

### 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.

Exp No: 04

Date:

## **Level measurement using capacitive transducer.**

### **AIM:**

To measure the level using capacitive transducer.

### **APPARATUS:**

1. Capacitive Transducers
2. Resistors  $1K\Omega$  - 1
3. Op-amp IC 741
4. Non conducting liquid.
5. Power supply

### **THEORY:**

The principle of capacitive level measurement is based on change of capacitance. An insulated electrode acts as one plate of capacitor and the tank wall (or reference electrode in a non-metallic vessel) acts as the other plate. The capacitance depends on the fluid level.

The capacitive transducer contains two parallel metal plates. These plates are separated by the dielectric medium which is either air, material, gas or liquid. In the normal capacitor the distance between the plates are fixed, but in capacitive transducer the distance between them are varied.

The principle of capacitive level measurement is based on change of capacitance. An insulated electrode acts as one plate of capacitor and the tank wall (or reference electrode in a non-metallic vessel) acts as the other plate. The capacitance depends on the fluid level. An empty tank has a lower capacitance while a filled tank has a higher capacitance. A simple capacitor consists of two electrode plate separated by a small thickness of an insulator such as solid, liquid, gas, or vacuum. This insulator is also called as dielectric. Value of C depends on dielectric used, area of the plate and also distance between the plates.

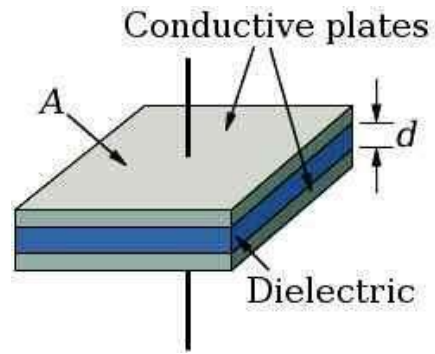


Figure 1. Capacitor

Capacitance,  $C = \epsilon \frac{A}{D}$

Where,  $A$  = Area of the overlap between two plates.

$D$  = Distance between two plates.

$\epsilon$  = Permittivity.

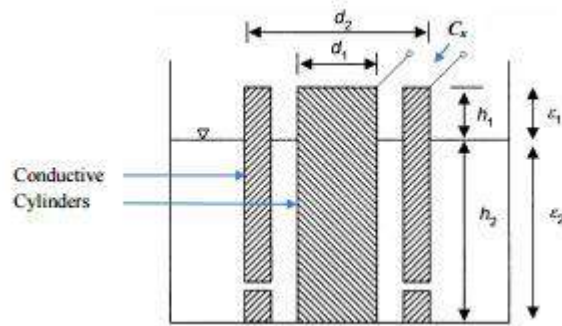


Figure 2. Capacitive level sensor

$$C = \frac{2\pi(\epsilon_1 \epsilon h_1 + \epsilon_2 \epsilon h_2)}{\ln\left(\frac{d_2}{d_1}\right)}$$

### CIRCUIT DIAGRAM:

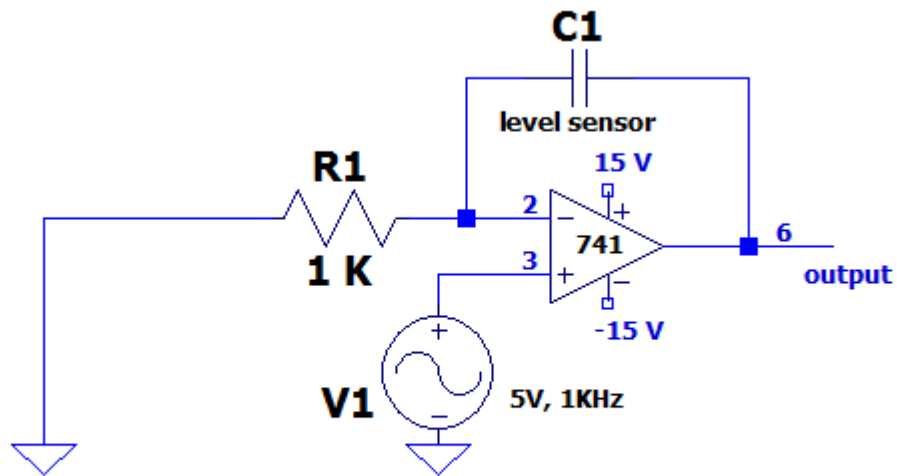


Figure 3. circuit diagram of capacitive level sensor

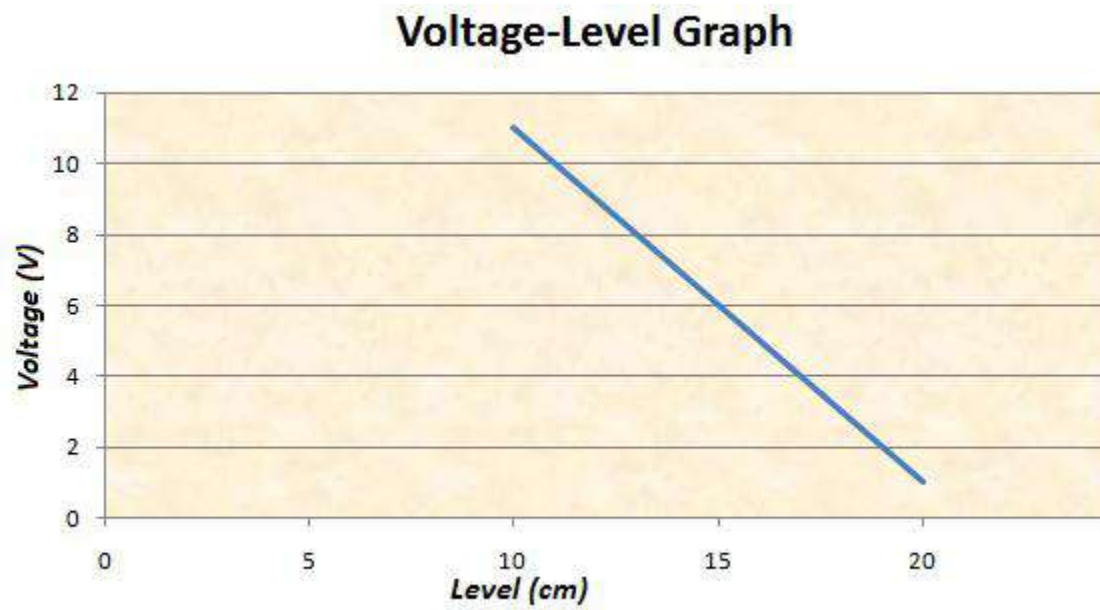
### PROCEDURE:

1. Set up buffer circuit to check the gain of opamp and verify it is equal to one.
2. Set up capacitance trasducer as per circuit diagram.
3. Fill the capacitance level transducer upto about 20 cm.
4. Dram off the water at specific intervals and note down the voltage.
5. Plot the relation between the level and voltage.

### OBSEVATION:

Level (cm)	Voltage (V)
20	
19	
18	
17	
15	
15	
14	
13	
12	
11	
10	

**Model Graph:**



**RESULT:**

The level is measured using capacitance transducer.

Exp No: 05

Date:

## Characteristics of RTD.

### AIM:

To study the characteristics of RTD.

### APPARATUS:

1. RTD
2. Resistors  $1K\Omega$  - 5,  $100\Omega$  - 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  $600^\circ\text{C}$ .

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  $t^\circ\text{C}$  and  $t_0^\circ\text{C}$  respectively;

$\alpha, \beta$  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,  $\alpha = 0.00427/^{\circ}\text{C}$ .

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  $0^{\circ}\text{C}$  Platinum has a linear range of operation upto  $650^{\circ}\text{C}$ , while the useful range for Copper and Nickel are  $120^{\circ}\text{C}$  and  $300^{\circ}\text{C}$  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.

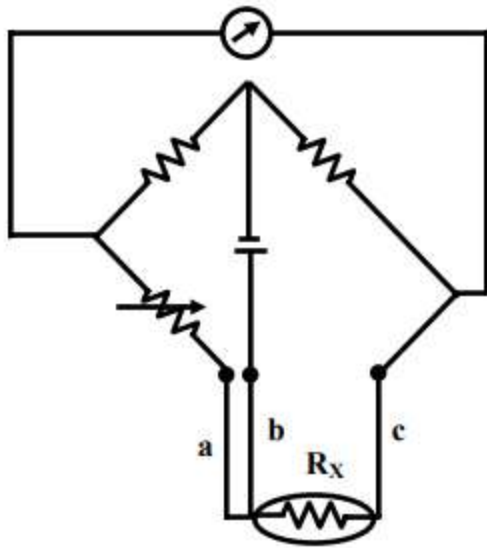


Figure 3.3 wire configuration

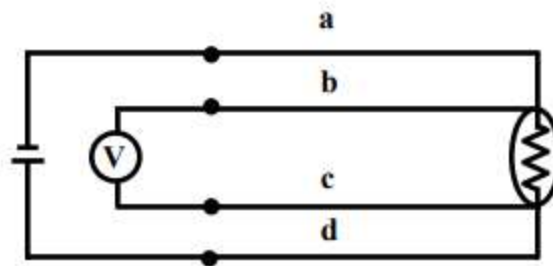


Figure 2.4 wire configuration

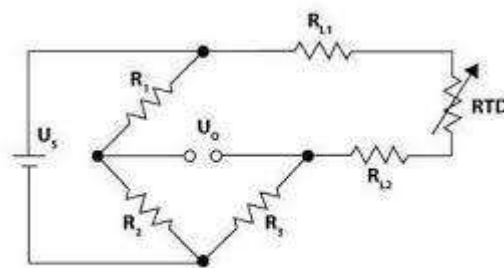
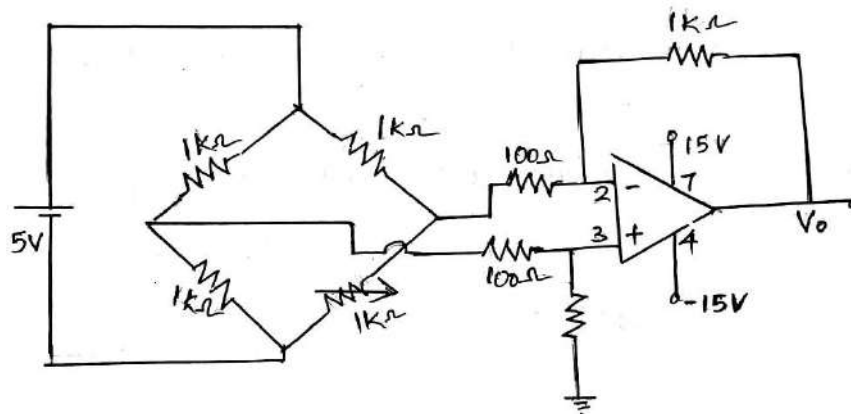


Figure 4.3 wire configuration

### CIRCUIT DIAGRAM:



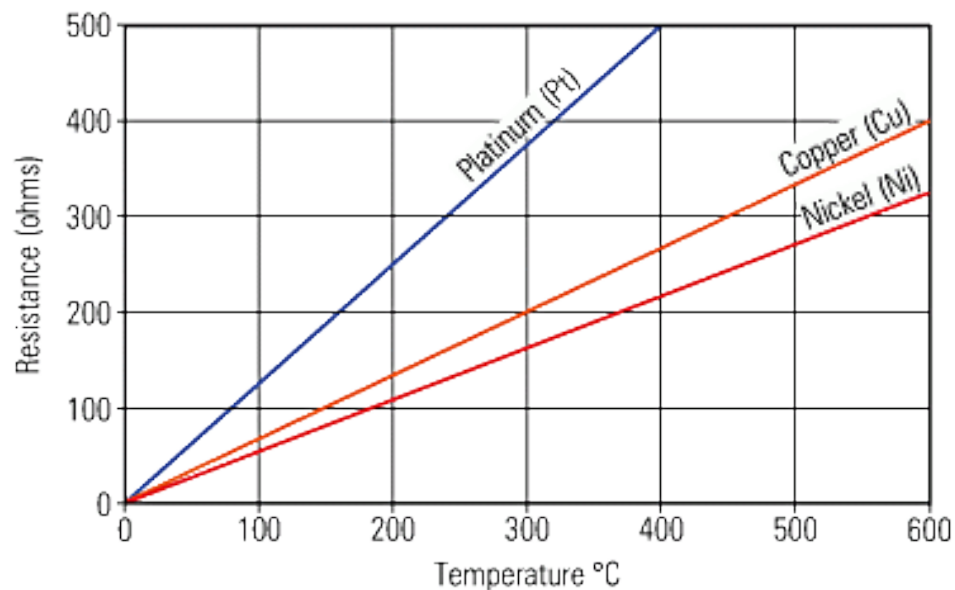
### PROCEDURE:

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  $\frac{3}{4}$  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°C.
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 is studied and is plotted.

Exp No: 06

Date:

## Characteristics of Thermocouple.

### AIM:

To study the characteristics of thermocouple.

### APPARATUS:

1. Thermocouple
2. Resistors  $1K\Omega$  - 1,  $5.6K\Omega$  - 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 as shown in Figure1.

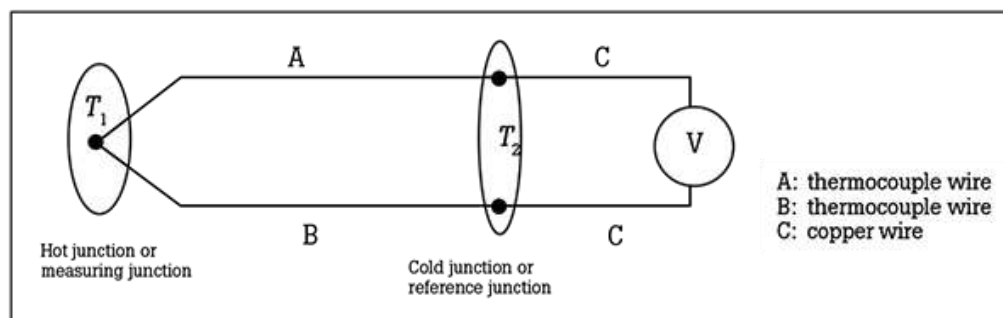


Figure 5. Schematic diagram.

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 seebeck effect. The output voltage is in millivolts. This voltage is suitably signal conditioned to give an output in volts. 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.

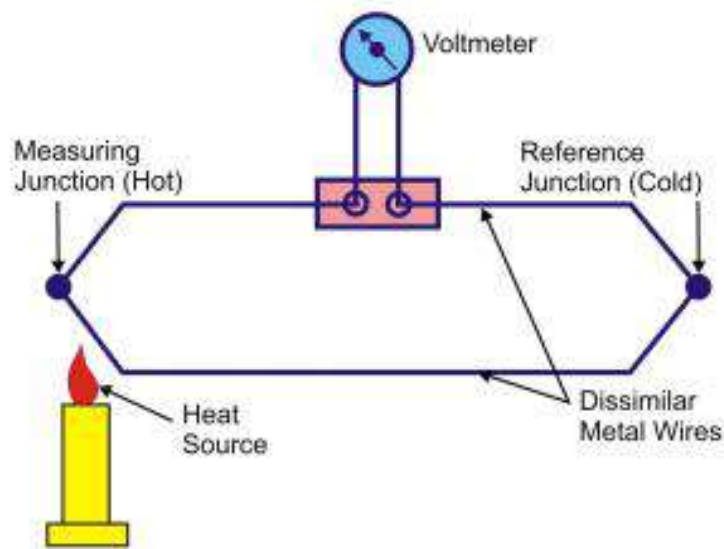
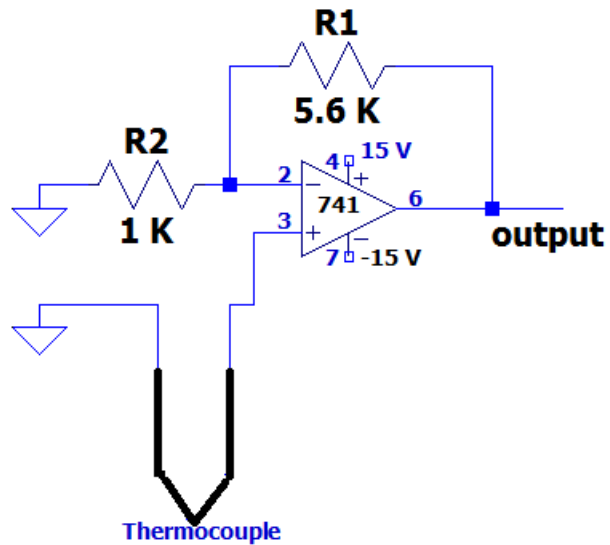


Figure 6. Circuit diagram.

### CIRCUIT DIAGRAM:



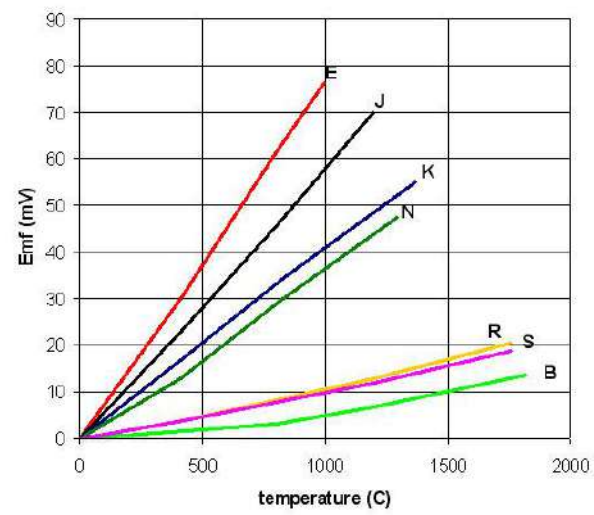
### PROCEDURE:

1. Set up the circuit as per the diagram.
2. Check the op-amp by arranging buffer circuit (Gain = 1).
3. Connect the kettle full with  $\frac{3}{4}$  of the kettle and immerse the thermometer and thermocouple to it.
4. Note output voltage from multimeter for different temperature (up to 100°C).
5. 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.

Exp No: 07

Date:

## Characteristics of Thermistor

### AIM:

To study the characteristics of the given thermistor.

### APPARATUS:

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

### THEORY:

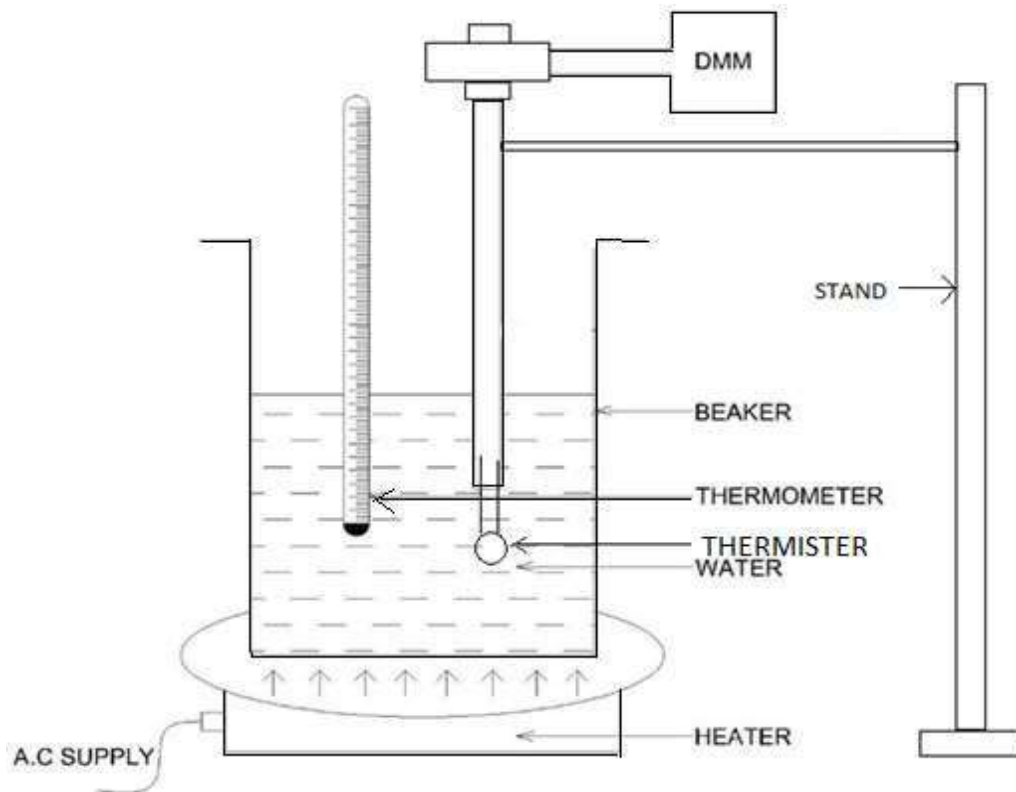
The thermistor is also a temperature sensitive resistor. While the thermocouple is the most versatile temperature transducer and the PRTD is thus sensitive. Of the three major categories of sensors, the thermistor exhibits by far the largest parameter change with temperature. Thermistors are generally 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:

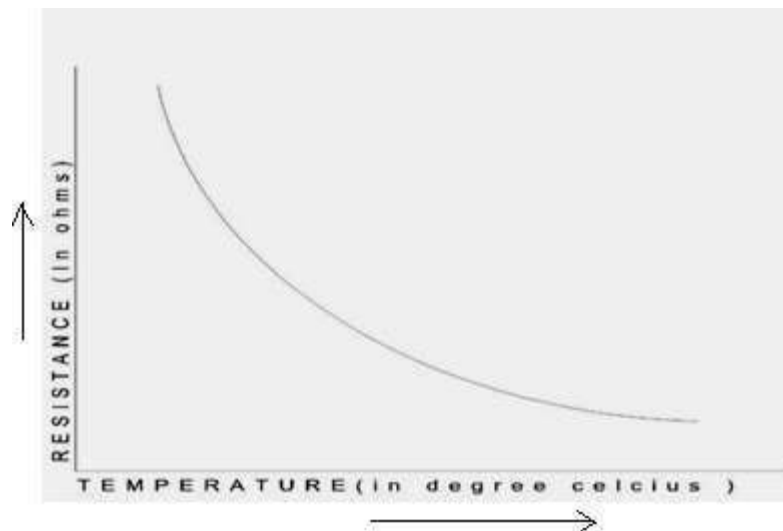
1. Thermistor and thermometer are dipped into a beaker containing water.
2. Water is heated using heater.
3. Thermistor is connected to digital multi-meter and kept in resistance mode.
4. Initially at 30°C temperature resistance.

5. For every  $5^{\circ}\text{C}$  increase, resistance is noted.
6. After taking reading till  $80^{\circ}\text{C}$  water is cooled.

### EXPERIMENTAL SETUP



### MODEL GRAPH



**OBSERVATION:****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.

Exp NO: 08

Date:

## Pressure measurement using Piezoelectric pickup.

### AIM:

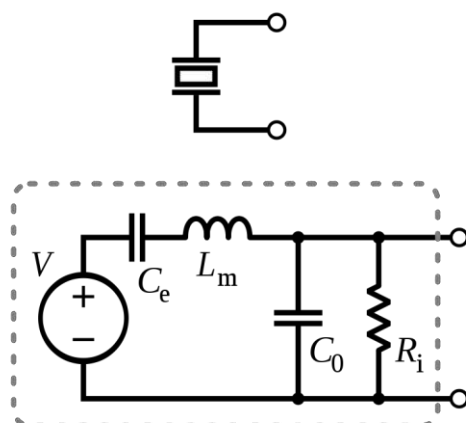
To measure the output voltage corresponding to pressure variation using pressure measurement trainer kit.

### 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'.



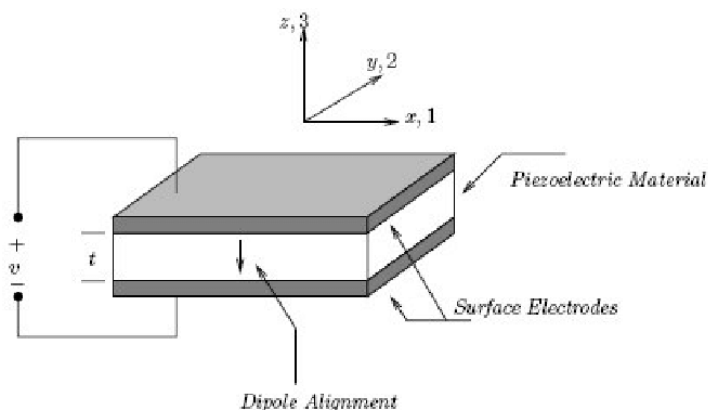
**Figure 4. Schematic symbol and electronic model of a piezoelectric sensor**

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**

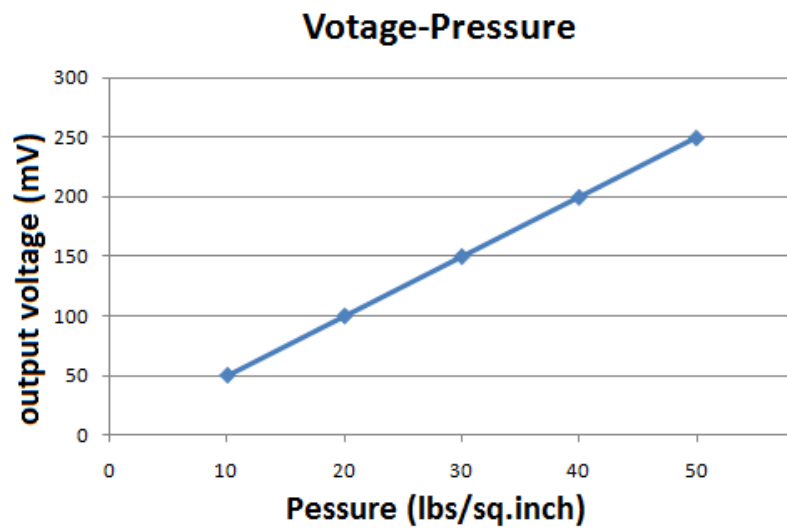
#### PROCEDURE:

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 (inch)	(lbf/square inch)	Output voltage(mv)
	10	
	20	
	30	
	40	

**Model Graph:**



**RESULT:**

The characteristics of piezoelectric pickup is studied.

Exp No: 10

Date:

## Calibration of a Pressure Gauge using Dead-Weight Tester.

### AIM:

To draw a calibration curve of a pressure gauge.

### APPARATUS:

1. Pressure gauge

### THEORY:

A dead-weight tester is a device used for balancing a fluid pressure with a known weight. Typically, it is used for static calibration of pressure gages. As seen in Figure 1, the apparatus is set up for calibration of the pressure gage G. The chamber and cylinder of the tester are filled with clean oil by first moving the plunger to its most forward position and then slowly withdrawing it while the oil is poured in through the opening for the piston. The gage to be tested is installed and piston pressure is now transmitted to the gage when the valve is opened. This pressure may be varied by adding weights to the piston or by using different piston-cylinder combinations of varying areas. The viscous friction between the piston and the cylinder in the axial direction may be substantially reduced by rotating the piston-weight assembly while the measurement is taken. As the pressure is increased, it may be necessary to advance the plunger to account for the compression of the oil and any entrapped gasses in the apertures. The accuracies of dead-weight tester are limited due to: (1) the friction between the cylinder and the piston, (2) the uncertainty in the area of piston, (3) the buoyancy error and (4) gravity error. **The gravity error** due to elevation,  $z$  [m], and latitude,  $\phi$  [°] can be corrected by the dimensionless correction factor as:

$$e_{gravity} = -(2.637 * 10^{-3} \cos(2\phi) + 2.9 * 10^{-8} z + 5 * 10^{-5}) \quad (1)$$

and the **air buoyancy error**,  $e_{\text{buoyancy}}$ , by

$$e_{\text{buoyancy}} = - \frac{\rho_{\text{air}}}{\rho_{\text{masses}}} \quad (2)$$

Then, the indicated pressure of gage,  $p_i$ , can be corrected as:

$$p = p_i(1 + e_{\text{gravity}} + e_{\text{buoyancy}}) \quad (3)$$

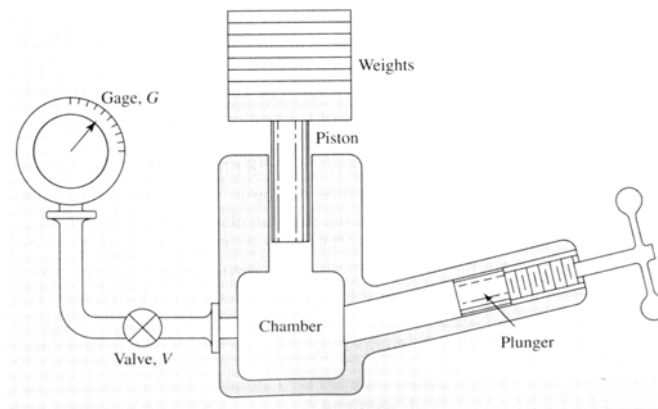


Figure 6. Capacity Deadweight Tester for Bourdon-tube pressure gage

#### PROCEDURE:

1. Mount the pressure gage to be calibrated in its place.
2. Remove the cylinder tap and read the pressure gage for zero value.
3. Place the piston into cylinder and read the pressure gage for the pressure which is written on the piston.
4. Add the first mass block on the cylinder and read the pressure gage. You need to advance the plunger as the weights are increased in order to insure free movement and rotation of the piston inside the cylinder.
5. Repeat step 4 until all mass blocks are added (loading)
6. Tabulate the following data:

- a. Experiment number,
  - b. The pressure gage readout,  $p_{g,l}$ ,
  - c. The total pressure of the dead-weight tester (including the piston pressure),  $p_c$ ,
7. Remove the mass block which is lastly added and read the pressure gage (unloading)
  8. Repeat step 7 until all mass blocks are removed.
  9. Tabulate the following data:
    - a. The pressure gage readout,  $p_{g,u}$ ,
    - b. The total pressure of the dead-weight tester (including the piston pressure),

$p_c$ ,

#### OBSERVATION:

Exp #	Gage Pressure (loading), $p_{g,l}$ , bar	Calibration Pressure, $p_c$ , bar	Gage Pressure (unloading), $p_{g,u}$ , bar	Gage Pressure $p_{avg}$ (bar)	Corrected pressure $p$ (bar)

#### RESULT:

The Calibration curve of the given pressure gauge is drawn.

Exp No: 11

Date:

## Measurement of Speed using Piezoelectric pickup.

### AIM:

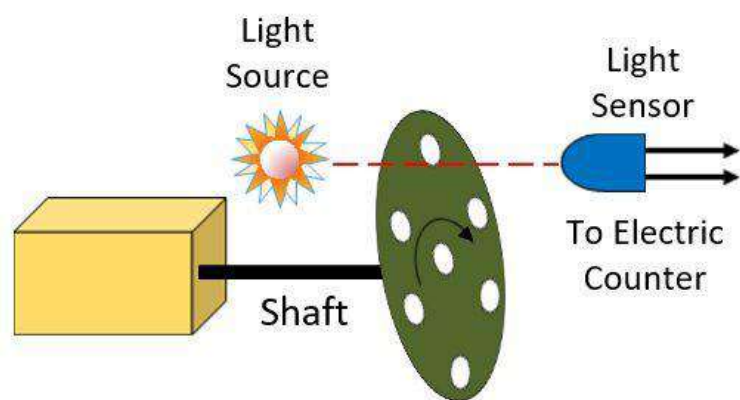
Measurement of speed of D.C motor by photoelectric pick up.

### APPARATUS:

1. DC motor
2. photoelectric pick up
3. Resistors 220  $\Omega$  - 1
4. IR LED
5. Connecting wires.

### THEORY:

In this method, on the shaft of DC motor, a disc with opaque and transparent segments is mounted above the disc. A photoconductor of high sensitivity is placed & a source of light is placed below the disc. When the motor rotates, the disc connected to its shaft rotates. This disrupts the path of light coming below the finite time interval that depends upon rotation speed & photoconductor responds for interruption. On CRO, we get a square wave. Speed of DC motor = (frequency \* diameter of disc)/ No of segments . Where D= mm S=



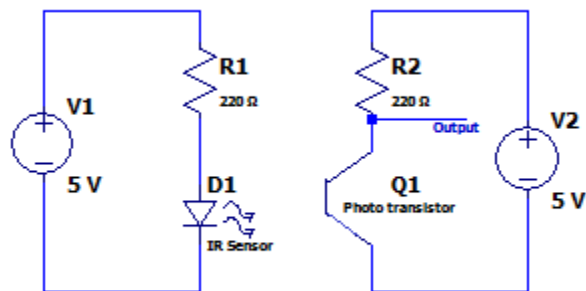
Photoelectric Tachometer

Circuit Globe

### PROCEDURE:

1. Connect the circuit according to the diagram & switch ON the power supply.
2. Adjust the speed of DC motor by the knob & wait until the motor attains maximum speed at Corresponding knob position.
3. Measure the frequency from output wave on CRO.
4. Find the speed of DC motor by the given formula.
5. Varying input and determine frequency and speed for different values.

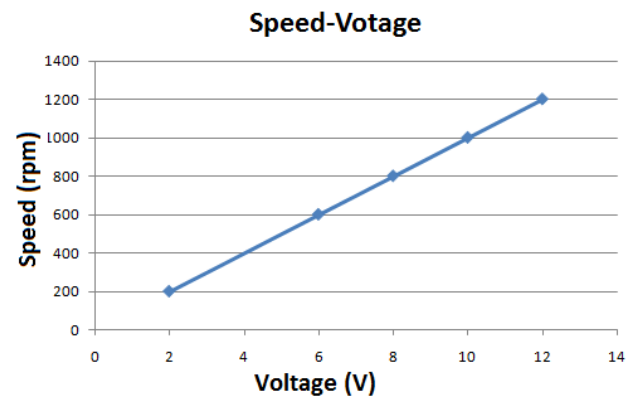
### CIRCUIT DIAGRAM:



### OBSERVATION:

Voltage (V)	Frequency (Hz)	Speed
6		
7		
8		
9		
10		
11		

### Model Graph:



### RESULT:

The speed of DC motor is measured using photoelectric pick up.

Exp No: 13

Date:

## **Characterstics of Hall Effect Transducer.**

### **AIM:**

To plot the characteristics of Hall Effect transducer.

### **APPARATUS:**

1. Hall Effect trainer kit
2. Rheostat
3. Connecting wires

### **THEORY:**

A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall Effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications. In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced. Frequently, a Hall sensor is combined with circuitry that allows the device to act in a digital (on/off) mode, and may be called a switch in this configuration. Commonly seen in industrial applications such as the pneumatic cylinder

### **PROCEDURE:**

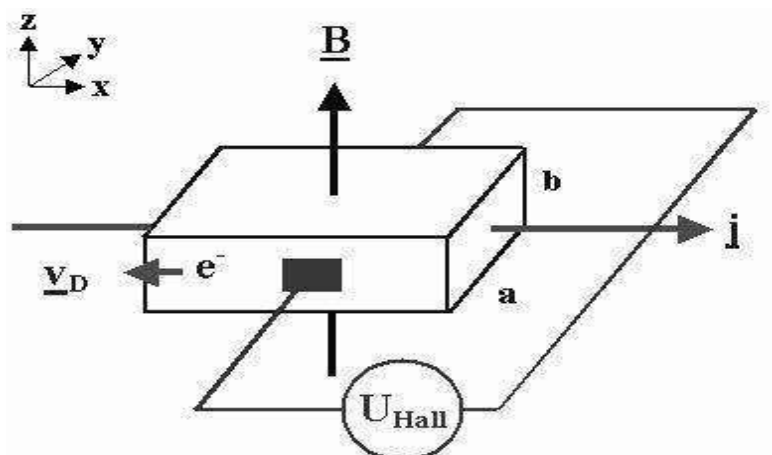
1. Switch on the 230v power supply.
2. Connect the dc input voltage to the sensor input voltage terminal on the trainer.
3. Connect the load to the corresponding terminal provided in the trainer.
4. Give some load in order to get the current in the appropriate meter.
5. Note down the sensor output voltage for the zero input voltage.
6. Now apply the input voltage to the sensor and note down the reading on the ammeter and voltmeter and put it on the tabular column.
7. Plot the graph between current and sensor output voltage

# OBSEVATION:

S.NO	Output current(amps)	Sensor voltage(volts)
1.		
2.		
3.		
4.		

Probe current I(mA)	Mag-netic field( Tesla)	Zero Field Poten-tial(offset voltage) $V_{zero}$	Hall Voltage for one side of the probe with off-set voltage( $V_H^+$ )	Hall voltage for second side without Offset volt-age( $V_H^-$ )	Hall voltage for one side without offset volt-age( $V^+ = V_H^+ - V_{ZERO}$ )	Hall voltage forsecond side without offset voltage( $V^- = V_H^- - V_{ZERO}$ )	Mean Voltage ( $V_H = (V^+ - V^-)/2$ )

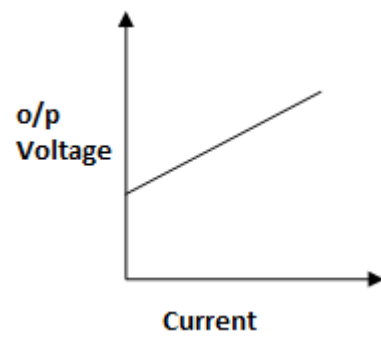
## CIRCUIT DIAGRAM



### EXPERIMENTAL SETUP



### MODEL GRAPH



### RESULT:

The characteristics of Hall effect transducer is studied and plotted.

Exp No: 14

Date:

## Measurement of displacement using inductive transducer.

### AIM:

To measure the displacement using inductive transducer.

### APPARATUS:

1. Inductive transducer.
2. Multimeter

### THEORY:

Inductive transducers work on the principle of inductance change due to any appreciable change in the quantity to be measured i.e. measured. For example, LVDT, a kind of inductive transducers, measures displacement in terms of voltage difference between its two secondary voltages. Secondary voltages are nothing but the result of induction due to the flux change in the secondary coil with the displacement of the iron bar. Anyway, LVDT is discussed here briefly to explain the principle of inductive transducer. LVDT will be explained in another article in more detail. For the time being let's focus on the basic introduction of inductive transducers.

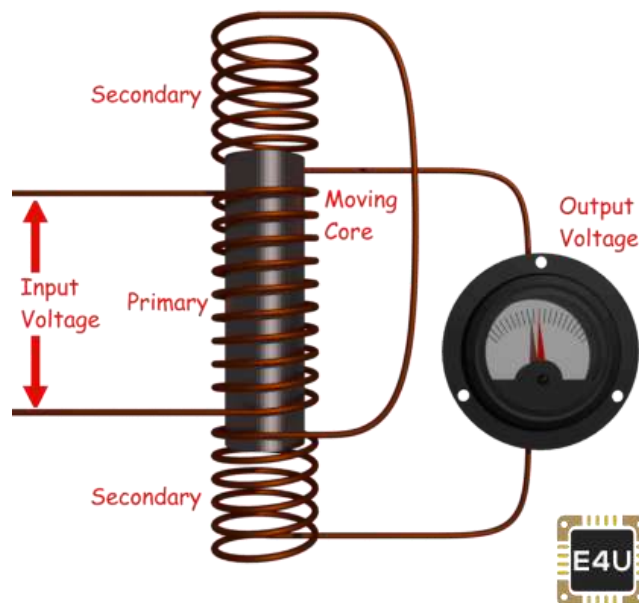


Figure 7. An example of an Inductive Transducer (LVDT)

Now first our motive is to find how the inductive transducers can be made to work. This can be done by changing the flux with the help of measured and this changing flux obviously changes the inductance and this inductance change can be calibrated in terms of measured. Hence inductive transducers use one of the following principles for its working.

1. Change of self inductance
2. Change of mutual inductance
3. Production of eddy current

### **Change of Self Inductance of Inductive Transducer**

$$L = \frac{N^2}{R}$$

We know very well that self inductance of a coil is given by

Where,

N = number of turns.

R = reluctance of the magnetic circuit.

Also we know that reluctance R is given by

$$R = \frac{l}{\mu A}$$

$$L = \frac{N^2 \mu A}{l}$$

Where,  $\mu$  = effective permeability of the medium in and around the coil.

So, we can vary self inductance by

- Change in number of turns, N,
- Changing geometric configuration, G,
- Changing permeability

For the sake of understanding we can say that if the displacement is to be measured by the inductive transducers, it should change any of the above parameter for causing the change in self inductance.

### Change of Mutual Inductance of Inductive Transducer

Here transducers, which work on change of mutual inductance principle, use multiple coils. We use here two coils for the sake of understanding. Both coils have their self-inductance as well. So let's denote their self-inductance by  $L_1$  and  $L_2$ . Mutual inductance between these two coils is given by

$$M = K\sqrt{L_1 L_2}$$

Thus mutual inductance can be changed by varying self inductance or by varying coefficient of coupling,  $K$ . The methods of changing self inductance we already discussed. Now coefficient of coupling depends on the distance and orientation between two coils. Thus for the measurement of displacement we can fix one coil and make other movable which moves with the source whose displacement is to be measured. With the change in distance in displacement coefficient of coupling changes and it causes the change in mutual inductance. This change in mutual inductance can be calibrated with the displacement and measurement can be done.

### Production of Eddy Current of Inductive Transducer

We know that when a conducting plate is placed near a coil carrying alternating current, a circulating current is induced in the plate called "EDDY CURRENT". This principle is used in such type of inductive transducer. When a coil is placed near to coil carrying alternating current, a circulating current is induced in it which in turn produces its own flux which try to reduce the flux of the coil carrying the current and hence inductance of the coil changes. Nearer the plate is to the coil, higher will be eddy current and higher is the reduction in inductance and vice versa. Thus inductance of coil varied with the variation of distance between coil and plate. Thus the movement of the plate can be calibrated in terms of inductance change to measure the quantity like displacement.

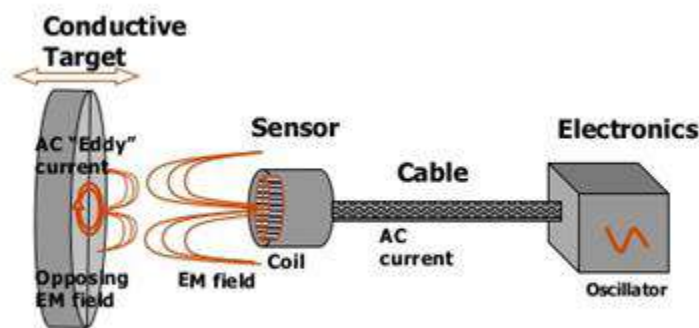
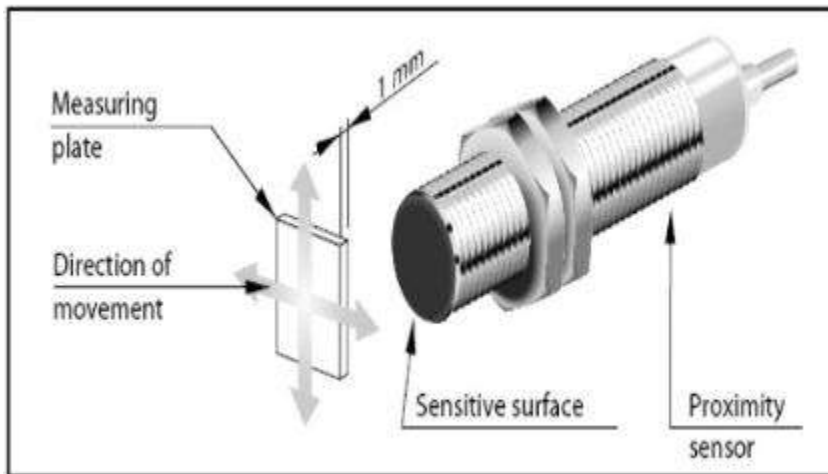


Figure 8. Inductive displacement transducer.

**DIAGRAM:**



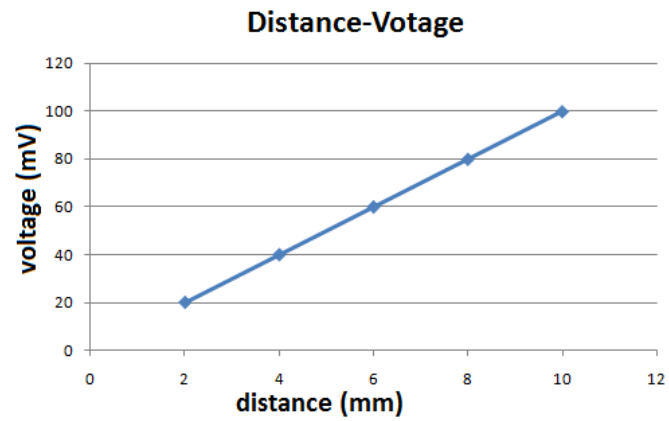
**PROCEDURE:**

1. Set up the circuit diagram.
2. Then change the displacement of inductive transducer gradually by 1 cm.
3. For various displacement there will be different voltage, which can be noted from multimeter.
4. Plot a voltage displacement graph which as linear.

**OBSEVATION:**

Distance (mm)	Output voltage (mV)
-5	
-4	
-3	
-2	
-1	
0	
1	
2	
3	
4	
5	

**MODEL GRAPH:**



**RESULT:**

Studied the characteristics of inductive displacement transducer.

Exp No: 15

Date:

## **Determination of the characteristics of Capacitive displacement Transducer.**

### **AIM:**

To study the characteristics of Capacitive displacement Transducer

### **APPARATUS:**

1. Capacitive Transducers
2. Resistors 1K $\Omega$  - 1
3. Op-amp IC 741
4. Power supply

### **THEORY:**

The capacitive transducer or sensor is nothing but the capacitor with variable capacitance. The capacitive transducer comprises of two parallel metal plates that are separated by the material such as air, which is called as the dielectric material. In the typical capacitor the distance between the two plates is fixed, but in variable capacitance transducers the distance between the two plates is variable.

In the instruments using capacitance transducers the value of the capacitance changes due to change in the value of the input quantity that is to be measured. This change in capacitance can be measured easily and it is calibrated against the input quantity, thus the value if the input quantity can be measured directly.

The capacitance  $C$  between the two plates of capacitive transducers is given by:

$$C = \epsilon_0 \epsilon_r \frac{A}{D}$$

Where,  $A$  = Area of the overlap between two plates.

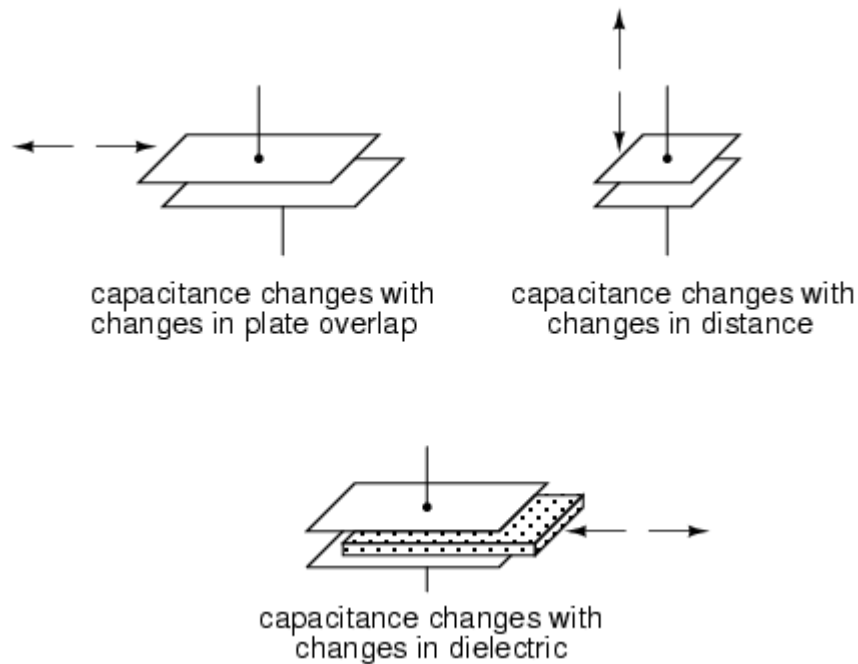
$D$  = Distance between two plates.

$\epsilon_0$  = Absolute Permittivity.

$\epsilon_r$  = Relative Permittivity

It is clear from the above formula that capacitance of the capacitive transducer depends on the area of the plates and the distance between the plates. The capacitance of the capacitive transducer also changes with the dielectric constant of the dielectric material used in it.

Thus the capacitance of the variable capacitance transducer can change with the change of the dielectric material, change in the area of the plates and the distance between the plates. Depending on the parameter that changes for the capacitive transducers, they are of three types as mentioned below.



**Figure 9. Type of Capacitive Transducers.**

### **1) Changing Dielectric Constant type of Capacitive Transducers**

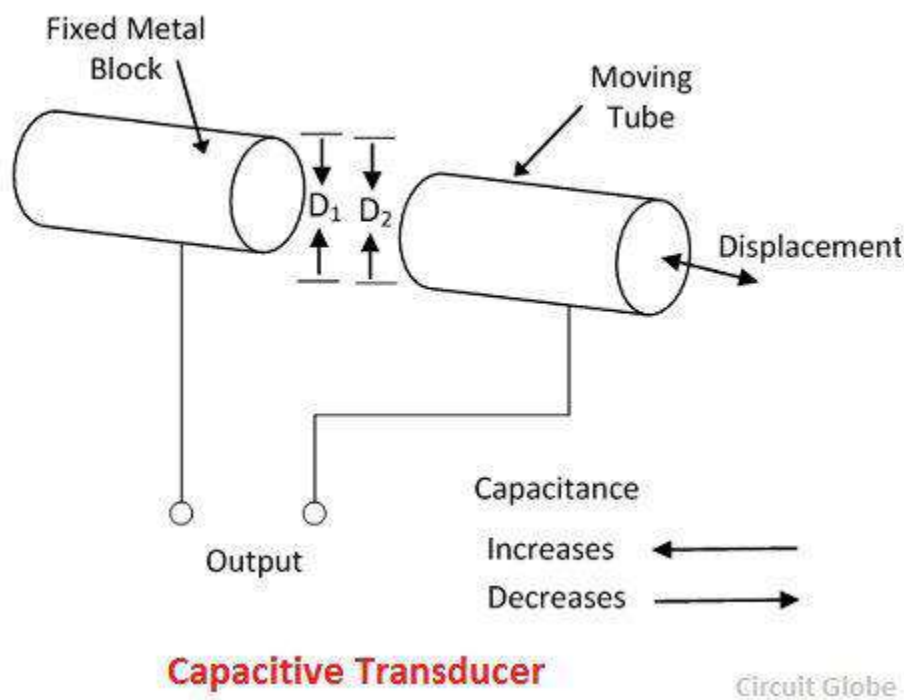
In these capacitive transducer the dielectric material between the two plates changes, due to which the capacitance of the transducer also changes. When the input quantity to be measured changes the value of the dielectric constant also changes so the capacitance of the instrument changes. This capacitance, calibrated against the input quantity, directly gives the value of the quantity to be measured. This principle is used for measurement of level in the hydrogen container, where the change in level of hydrogen between the two plates results in change of the dielectric constant of the capacitance transducer. Apart from level, this principle can also be used for measurement of humidity and moisture content of the air.

### **2) Changing Area of the Plates of Capacitive Transducers**

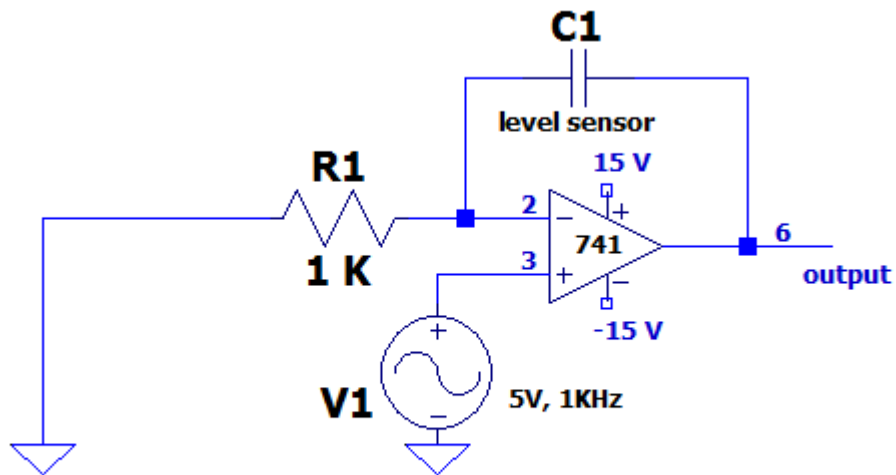
The capacitance of the variable capacitance transducer also changes with the area of the two plates. This principle is used in the torque meter, used for measurement of the torque on the shaft. This comprises of the sleeve that has teeth cut axially and the matching shaft that has similar teeth at its periphery.

### 3) Changing Distance between the Plates of Capacitive Transducers

In these capacitive transducers the distance between the plates is variable, while the area of the plates and the dielectric constant remain constant. This is the most commonly used type of variable capacitance transducer. For measurement of the displacement of the object, one plate of the capacitance transducer is kept fixed, while the other is connected to the object. When the object moves, the plate of the capacitance transducer also moves, this results in change in distance between the two plates and the change in the capacitance. The changed capacitance is measured easily and it calibrated against the input quantity, which is displacement. This principle can also be used to measure pressure, velocity, acceleration etc.



**CIRCUIT DIAGRAM:**



**PROCEDURE:**

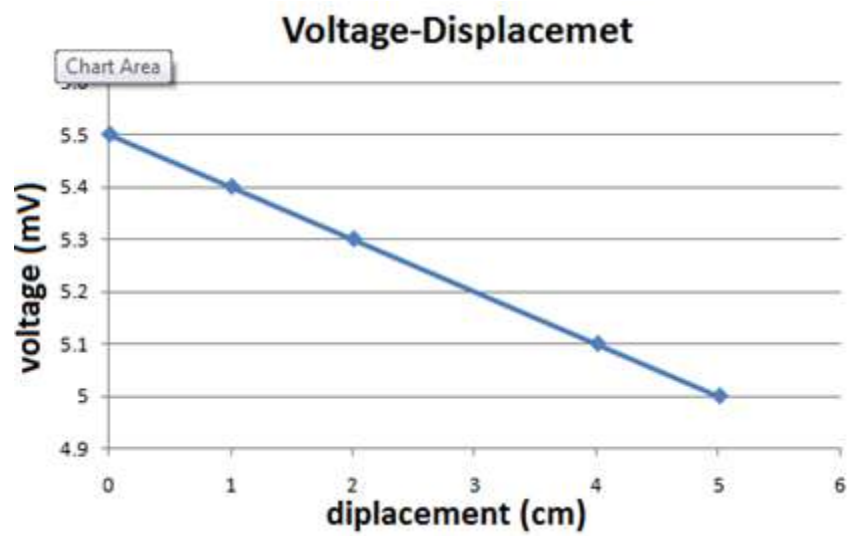
1. Set up the circuit diagram.
2. Then change the displacement of capacitance transducer gradually by 1 cm upto 6 cm.
3. For various displacement there will be different voltage , which can be noted from multimeter.
4. Plot a voltage displacement graph which as linear.

**OBSEVATION:**

Distance (cm)	Output voltage (mV)
-5	
-4	
-3	
-2	
-1	
0	

1	
2	
3	
4	
5	

**MODEL GRAPH:**



**RESULT:**

Studied the characteristics of capacitance displacement transducer.

Exp No: 17

Date:

## Loading Effect of Potentiometer.

### AIM:

To verify the loading effect of the given Potentiometer.

### APPARATUS:

1. Potentiometer.
2. RPS
3. Voltmeter.
4. Connecting wires.

### THEORY:

A potentiometer is a device which converts change in resistance into electrical output. It contains variable resistor which is controlled by a moving part called wiper. One can alter the output by changing the number of turns of wire or by changing the length. The output voltage depends on the input voltage and the ratio of the input and output voltage. The potentiometer also acts as a voltage divider.

### PROCEDURE:

1. Connections are given as per the circuit diagram.
2. RPS is switched ON and 10 V is supplied to the potentiometer.
3. The wiper position of potentiometer is varied in steps of 2 cm and corresponding voltmeter readings are noted down.
4. The load rheostat is connected across the potentiometer.

### FORMULA

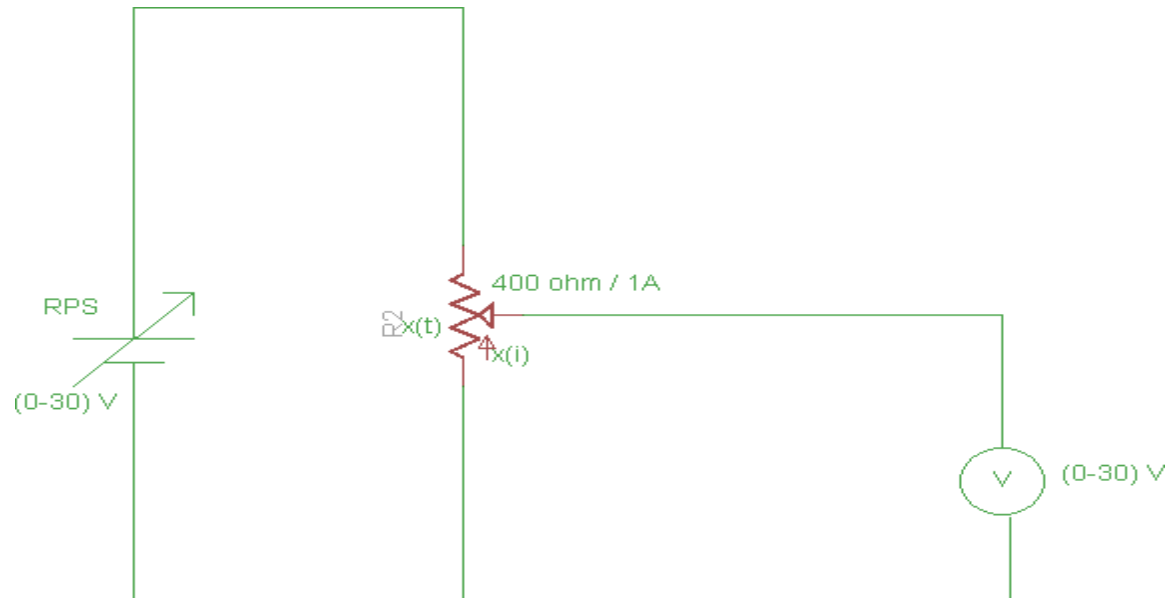
$$\% \text{Error} = \frac{K^2(1-K)}{K(1-K)R_p/R_m + 1} * 100$$

$$\% \text{Error} = \frac{E(\text{no load}) - E(\text{load})}{E(\text{no load})} * 100$$

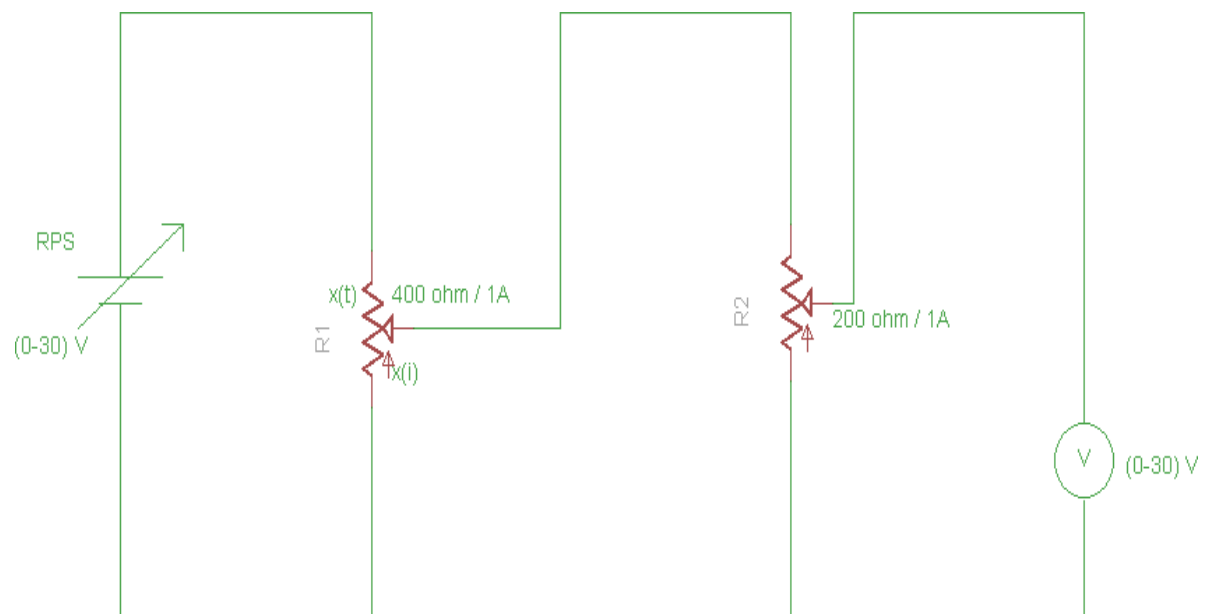
Where  $K = x(i)/x(t)$

## CIRCUIT DIAGRAM

Without load

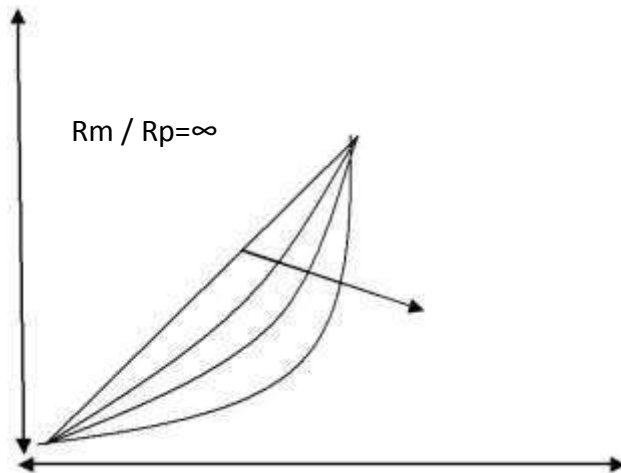


With load

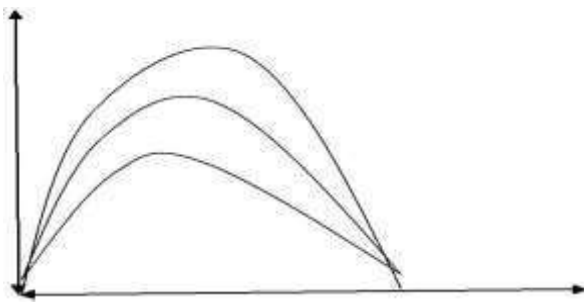


## MODEL GRAPH

Without load



With load



**OBSERVATION:**

(a) **Without load:**  $E_i = 15V$ ,  $X_o = 33\text{cm}$ ,  $R_m = \infty$ ,  $R_p = 400\Omega$

S.NO	$E_i$ (VOLTS)	$E_o$ (VOLTS)	$X_i$ (CMS)	$K = X_i/X_o$	$E_o/E_i$

(b) **With Load:**  $E_i = 15V$ ,  $X_o = 33\text{ cm}$ ,  $R_m = 400\Omega$ ,  $R_p = \infty$

S.NO	$E_i$ (VOLT S)	$E_o$ (VOLT S)	$X_i$ (CMS)	$K = X_i/X_o$	$E_o/E_i$	%error

**RESULT:**

Loading effect of the given potentiometer is verified.

Exp No: 18

Date:

## Lissajous Pattern .

### AIM:

To perform amplitude, frequency, and phase measurements using a calibrated cathode ray oscilloscope and to make use of Lissajous figures for phase and frequency measurements.

### APPARATUS:

1. Cathode ray tube.

### THEORY:

- **Instrument Measurement of Voltage Using CRO**

A voltage can be measured by noting the Y deflection produced by the voltage; using this deflection in conjunction with the Y-gain setting, the voltage can be calculated as follows:

$$V = (\text{no. of boxes in cm.}) \times (\text{selected Volts/cm scale})$$

- **Measurement of Current and Resistance Using a CRO:**

Using the general method, a correctly calibrated CRO can be used in conjunction with a known value of resistance R to determine the current I flowing through the resistor.

- **Measurement of Frequency Using a CRO:**

A simple method of determining the frequency of a signal is to estimate its periodic time from the trace on the screen of a CRT. However, this method has limited accuracy, and should only be used where other methods are not available. To calculate the frequency of the observed signal, one has to measure the period,

i.e. the time taken for 1 complete cycle, using the calibrated sweep scale. The period could be calculated by

$$T = (\text{no. of squares in cm}) \times (\text{selected Time/cm scale})$$

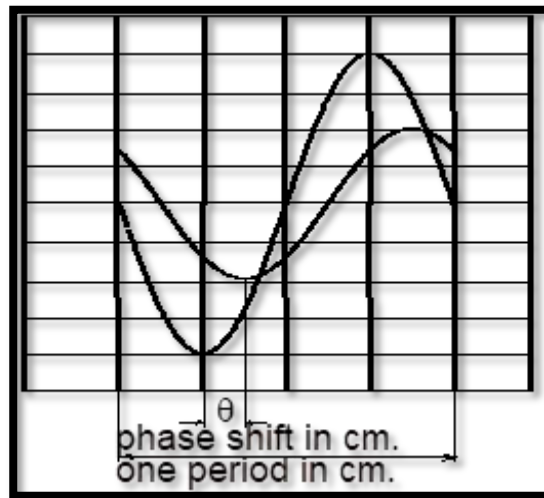
Once the period T is known, the frequency is given by

$$f(\text{Hz}) = 1/T(\text{sec})$$

- **Measurement of Phase:**

The calibrated time scales can be used to calculate the phase shift between two sinusoidal signals of the same frequency. If a dual trace or beam CRO is available to display the two signals simultaneously (one of the signals is used for synchronization), both of the signals will appear in proper time perspective and the amount of time difference between the waveforms can be measured.

This, in turn can be utilized to calculate the phase angle  $\theta$ , between the two signals.



**Figure 10. Phase shift between two signals**

Referring to figure1, the phase shift can be calculated by the formula;

$$\theta = \frac{\text{Phase shift in cm}}{\text{One period in cm}} * 360^\circ$$

Note that the calculation does not involve the actual calibrated Timebase setting. In fact, the observed waveforms can be varied using the horizontal amplifier venire adjustment to obtain as many boxes for one full scale as desired. Another

method for fast calculation is to multiply the scale factor by the phase difference (in cm) where the scale factor is degrees per box or degrees per cm.

- **Use of Lissajous Patterns to Calculate Phase Shift:**

Lissajous patterns are obtained on the scope simultaneously by applying the two sinusoidal inputs to be compared at the vertical and horizontal channels. The phase shift is then determined using measured values taken from resulting Lissajous pattern. This pattern on

the CRT screen may be either a straight line or a circle or an ellipse depending on the amount of phase shift.

Figure.2 shows the resulting closed curve if the phase shift is between and. This pattern is an ellipse (inclined at if the two amplitudes are the same). The angle of inclination at which the ellipse is generated is of no importance in the phase angle calculation. Noting that the vertical signal amplitude at instant 1 is

$N = A \sin(\theta)$ ,  $\theta$  can be computed by

$$\theta = 180^\circ - \sin^{-1}(N/M)$$

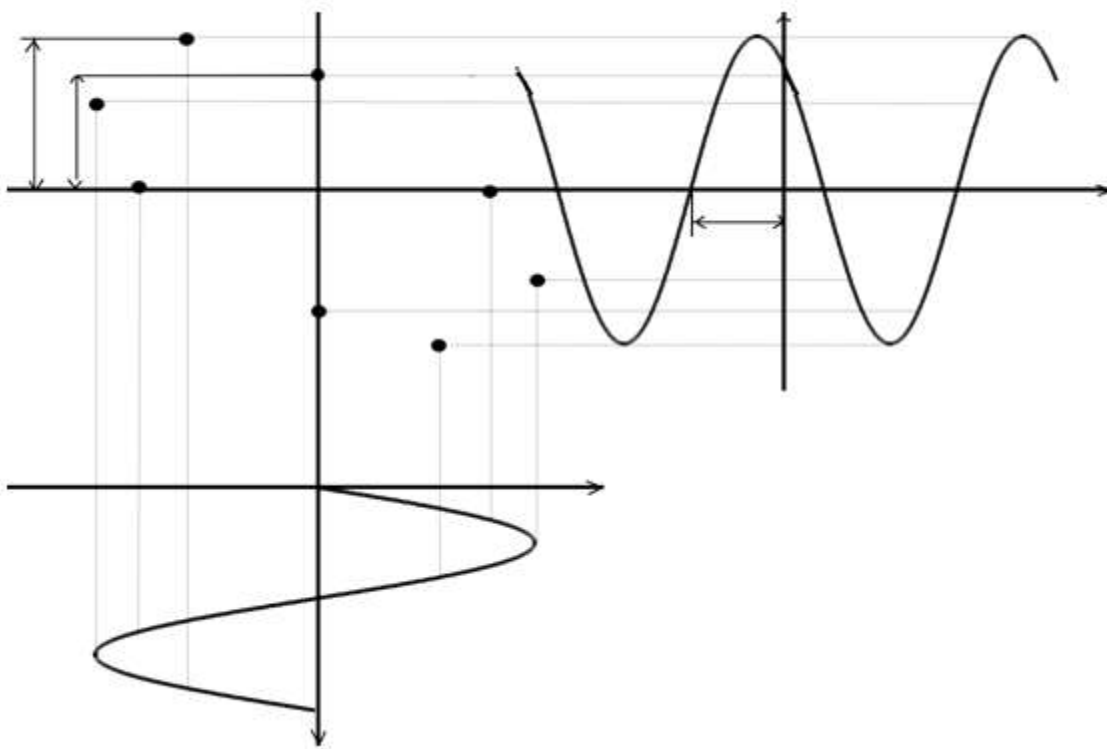


Figure 2. Lissajous Pattern

Phase angles between  $0^\circ$  to  $90^\circ$ , the ellipse has a positive slope and angle calculated by the following formula:

$$\theta = \sin^{-1}(N/M)$$

The actual scale settings do not change the ratio (N/M). Hence try to get an ellipse of maximum possible size on the CRO for increased accuracy. For phase angles of  $90^\circ$  to  $180^\circ$ , the ellipse has a negative slope and the angle calculated by the above method must be

subtracted from 180° to obtain the phase shift. Phase angles between 180° and 270° result in Lissajous patterns similar to those for  $\theta : 90^\circ\text{--}180^\circ$ , and cannot be directly distinguished. One technique for determining, if the phase shift is less or more than 180°, is to add an extra slight phase shift to the signal  $V_v$ . If the phase angle measured increases, then the angle is less than 180°. If it decreases, the angle is greater than 180°. Figure 3 shows how to compute the required phase angle.

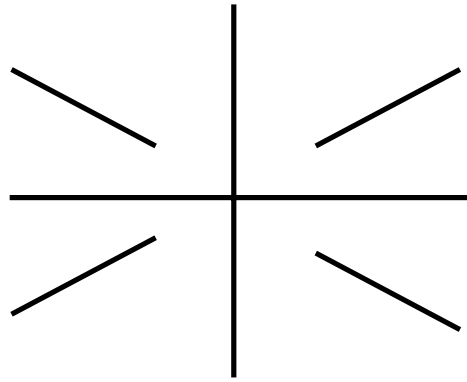


Figure 3. Phase angle calculation in 3 quadrants

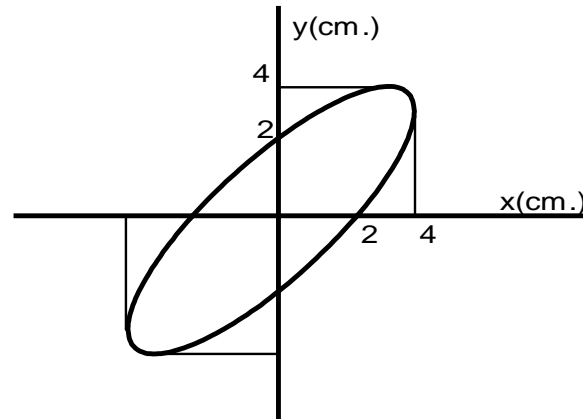
- **Use of Lissajous Patterns for Frequency Measurements:**

If a well calibrated CRO Timebase is not available, a signal generator can be used to measure the frequency of an unknown sinusoidal signal. It is connected to the vertical channel (or horizontal) and the calibrated signal source is fed to the horizontal channel (or vertical). The frequency of the signal generator is adjusted so that a steady Lissajous pattern is obtained. The Lissajous pattern can be very involved to analyze. However, for the frequency measurement, all that is needed is the number of tangencies (points at the edge of arcs) along the vertical and horizontal lines. The frequency relationship between the horizontal and vertical inputs is given by;

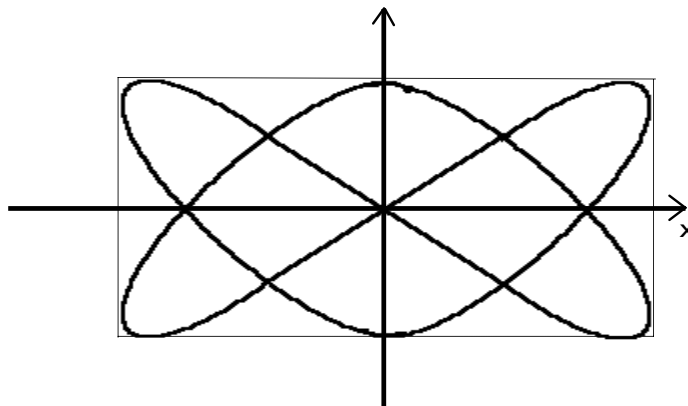
$$\frac{f_h}{f_v} = \frac{\text{No. of tangencies (vertical)}}{\text{No. of tangencies (horizontal)}}$$

### PROCEDURE:

1. The Lissajous pattern shown in figure is observed on the CRT screen. Find the phase shift between the signals applied to the X and Y inputs of the scope.



2. Figure shows a Lissajous pattern observed on the CRT screen. Determine the frequency relationship between the signals applied to the X and Y inputs of the scope.



3. Two sinusoidal inputs having the same amplitudes but different period, are applied to the X and Y inputs of the CRO. Draw the Lissajous pattern which will be observed on the CRT, for  $T_y = 4T_x$ .

4. The signals given  $V_1$  and  $V_2$  are applied to the X and Y inputs of the scope. Sketch the Lissajous pattern and calculate the phase difference between the two signals.

$$V_1 = 10\cos(\omega t)$$

$$V_2 = 15\sin(\omega t - 180)$$

### RESULT:

Lissajous patterns for phase and frequency measurements are plotted.

## **EXPERIMENTS USING LabVIEW/Arduino/Python**

Exp No: 1

Date:

## **Introduction to LabVIEW.**

### **AIM:**

To familiarise LabVIEW.

### **THEORY:**

LabVIEW stands for Laboratory Virtual Instrumentation Engineering Workbench. LabVIEW is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G" Originally released for the Apple Macintosh in 1986 the latest version of LabVIEW is version 8.6, released in August of 2008. LabVIEW is a graphical programming environment developed by National Instruments (NI) which allows high-level or system-level designs. It uses a graphical programming language to create so-called Virtual Instruments (VI) blocks in an intuitive flowchart-like manner. A design is achieved by integrating different components or subsystems within a graphical framework. LabVIEW provides data acquisition, analysis, and visualisation features well suited for DSP system-level design. LabVIEW constitutes a graphical programming language that allows one to design and analyze a DSP system in a shorter time as compared to text-based programming environments.

#### **1. Virtual Instruments**

LabVIEW graphical programs are called Virtual Instruments (VIs). VIs run based on the concept of data flow programming. This means that execution of a block or a graphical component is dependent on the flow of data, or more specifically a block executes when data is made available at all of its inputs. They are analogous to functions from conventional language programs. VIs have both an interactive user interface and a source code equivalent, and accept parameters from higher-level VIs. The following are descriptions of these three VI features.

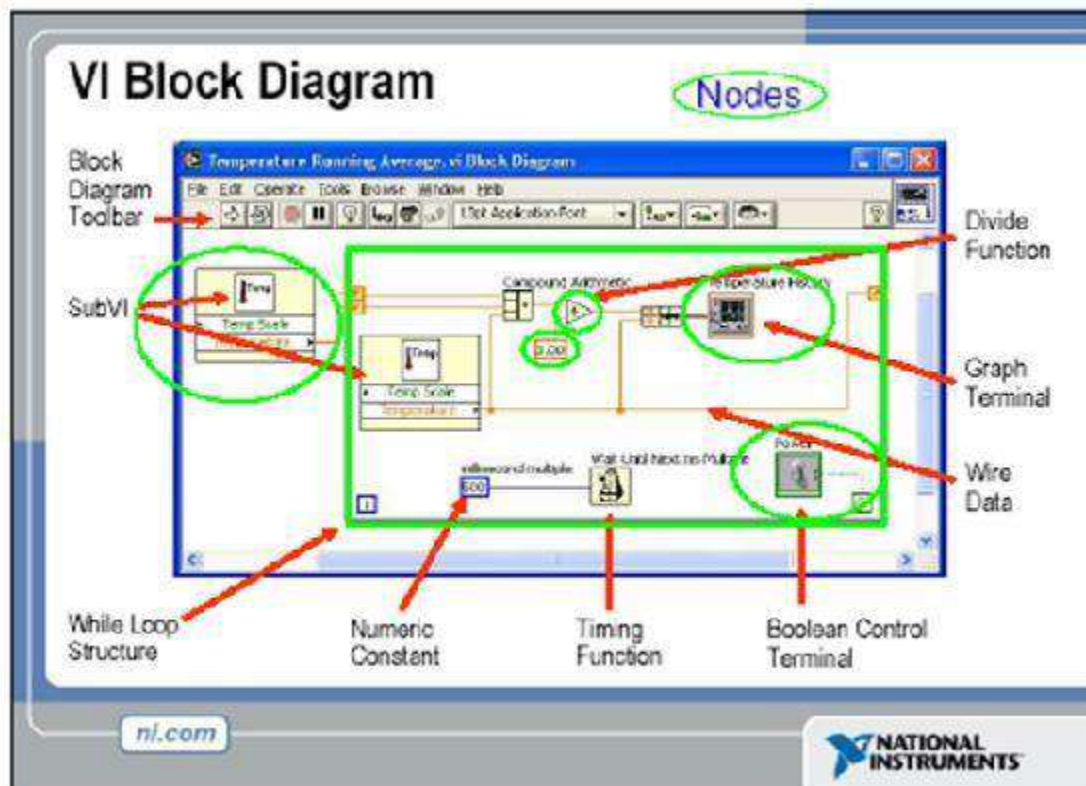
VIs contain an interactive user interface, which is called the front panel, because it simulates the panel of a physical instrument. The front panel can contain knobs, push buttons, graphs, and other controls and indicators. You input data using a keyboard and mouse, and then view the results on the computer screen.

1. VIs receive instructions from a block diagram, which you construct in G. The

block diagram supplies a pictorial solution to a programming problem. The block diagram contains the source code for the VI.

2. VIs use a hierarchical and modular structure. We can use them as top-level programs, or as subprograms within other programs or subprograms. A VI within another VI is called a subVI. The icon and connector pane of a VI work like a graphical parameter list so that other VIs can pass data to it as a subVI.

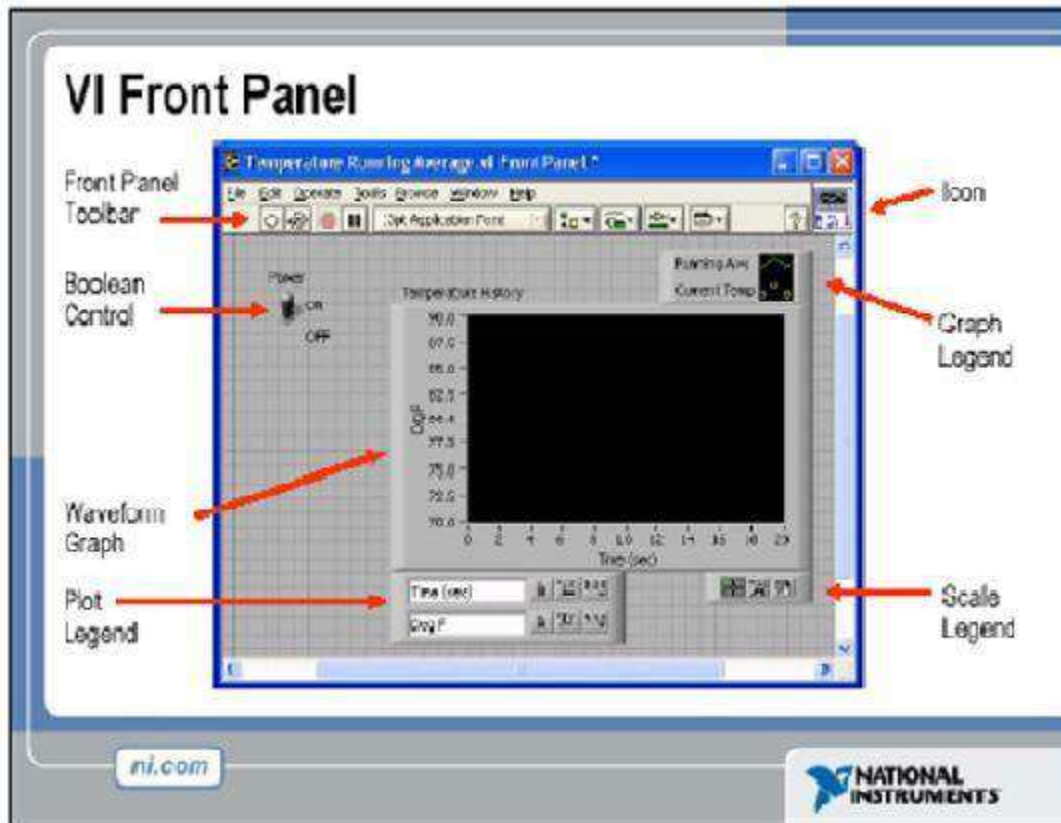
### BLOCK DIAGRAM:



The block diagram represents a complete LabVIEW application, and is an example of how intricate LabVIEW programming can be. A BD contains terminal icons, nodes, wires, and structures. Terminal icons are interfaces through which data are exchanged between an FP and a BD. Terminal icons correspond to controls or indicators that appear on an FP. Whenever a control or indicator is placed on an FP, a terminal icon gets added to the corresponding BD. A node represents an object

which has input and/or output connectors and performs a certain function. SubVIs and functions are examples of nodes. Wires establish the flow of data in a BD. Structures such as repetitions or conditional executions are used to control the flow of a program.

#### FRONT PANEL:



An FP contains the user interfaces of a VI shown in a BD. Inputs to a VI are represented by so-called controls. Knobs, pushbuttons and dials are a few examples of controls. Outputs from a VI are represented by so-called indicators. Graphs, LEDs (light indicators) and meters are a few examples of indicators. As a VI runs, its FP provides a display or user interface of controls (inputs) and indicators (outputs).

## Tools Palette:



LabVIEW uses a floating Tools palette, which can be used to edit and debug VIs.

## Function Palette



The Functions palette consists of a graphical, floating palette that automatically opens when switch to the block diagram. Use this palette to place nodes (constants, indicators, VIs, and so on) on the block diagram of a VI. Each top-level icon contains sub-palettes.

## Control Palette

The Controls palette consists of a graphical, floating palette that automatically opens when we launch LabVIEW. Use this palette to place controls and indicators on the front panel of a VI. Each top-level icon contains sub-palette.

## Icon and Connector

A VI icon is a graphical representation of a VI. It appears in the top right corner of a BD or an FP window. When a VI is inserted in a BD as a subVI, its icon gets displayed. A connector pane defines inputs (controls) and outputs (indicators) of a VI. The number of inputs and outputs can be changed by using different connector pane patterns. A VI icon is shown at the top right corner of the BD and its

corresponding connector pane having two inputs and one output is shown at the top right corner of the FP.

**DAQ Assistant:**

—a graphical way to configure channels and measurement tasks for your device for use in LabVIEW, LabWindows/CVI, and Measurement Studio. You also can use the DAQ Assistant to generate NI-DAQmx code based on your channels and tasks for use in NI application software programs.

- Increased performance, including faster single-point analog I/O and multithreading.
- Simpler, more intuitive APIs for creating DAQ applications using fewer functions and VIs than earlier versions of NI-DAQ.
- Expanded functionality in the NI-DAQmx API for LabVIEW, including property nodes for data acquisition and improved waveform data type support for analog I/O.
- Similar APIs and functionality for ANSI C, LabWindows/CVI, and Measurement Studio, including native .NET and C++ interfaces.

**RESULT:**

Familiarised the concepts of LabVIEW.

Exp No: 02

Date:

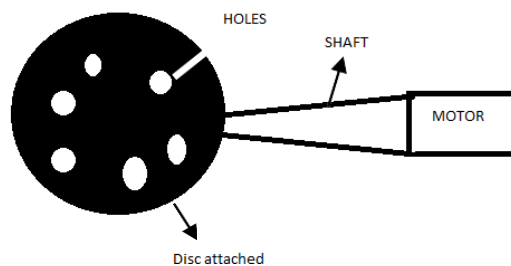
## Speed Monitoring system for a DC Motor.

### AIM:

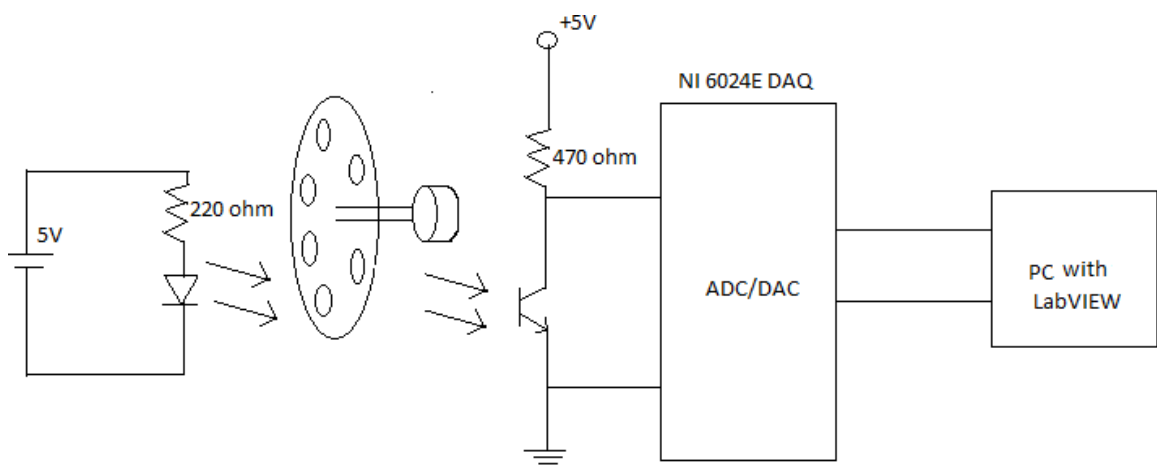
To set up hardware and to develop a LabVIEW VI for monitoring the speed of a DC motor.

### THEORY:

For sensing the speed of the motor, a disc with perforations has to be attached to the shaft.



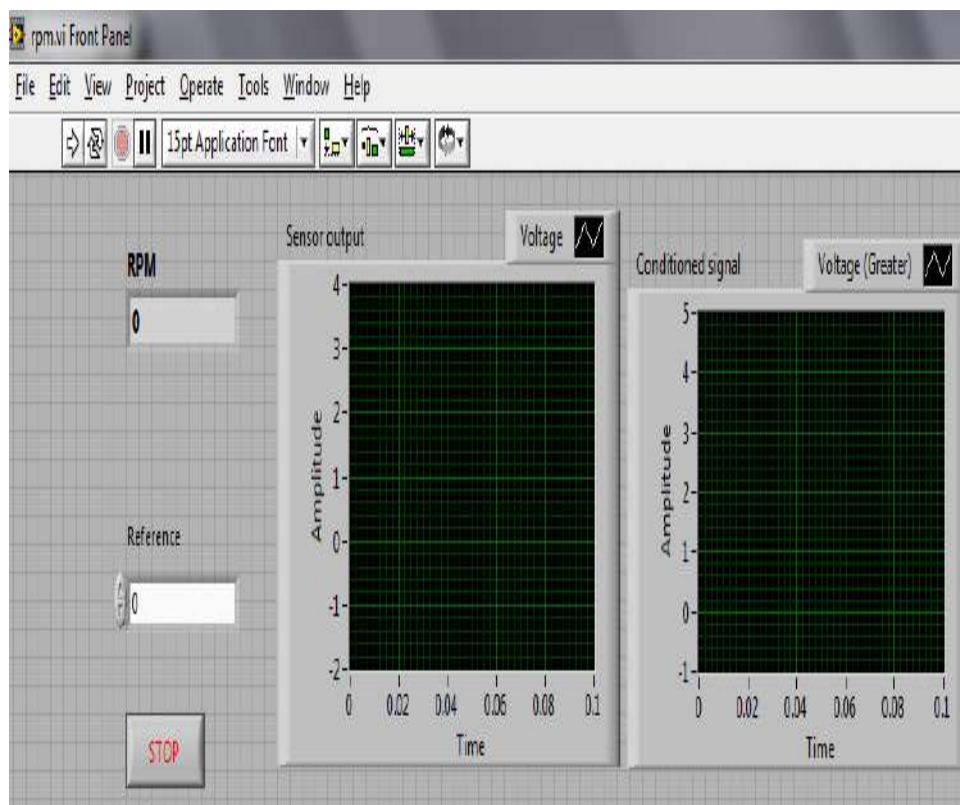
At one side of the disc an IR LED is kept ON and at the other side a phototransistor is shown. Fig:



As the motor rotates a train of pulses will be produced at the collector of the photo transistor. It can be connected to any one analog input channels of the DAQ

card (NI 6024E). Develop a VI in Lab VIEW for data acquisition. There is an express VI called DAQ assistant for data acquisition. Just set the channel number, type of the data etc...and we can acquire data very easily. A Lab VIEW program (VI) has two parts. A front panel and a block diagram. Front panel is the GUI (Graphical User Interface) where we will place buttons, indicators, control switches, charts, XY plots etc...for handling data. In the block diagram we will be specifying the things to be done using a graphical program. For speed monitoring first we have to acquire the train of pulses from the collector of the phototransistor. Process the data using the tools available and convert the data into rpm. The rpm data can be displayed numerically in a text indicator or in a meter indicator display.

### FRONT PANEL FOR SPEED MONITORING



### RESULT:

Developed the hardware and a LabVIEW VI for monitoring the speed of a DC motor.

Exp No: 03

Date:

## Light Intensity Meter.

### AIM:

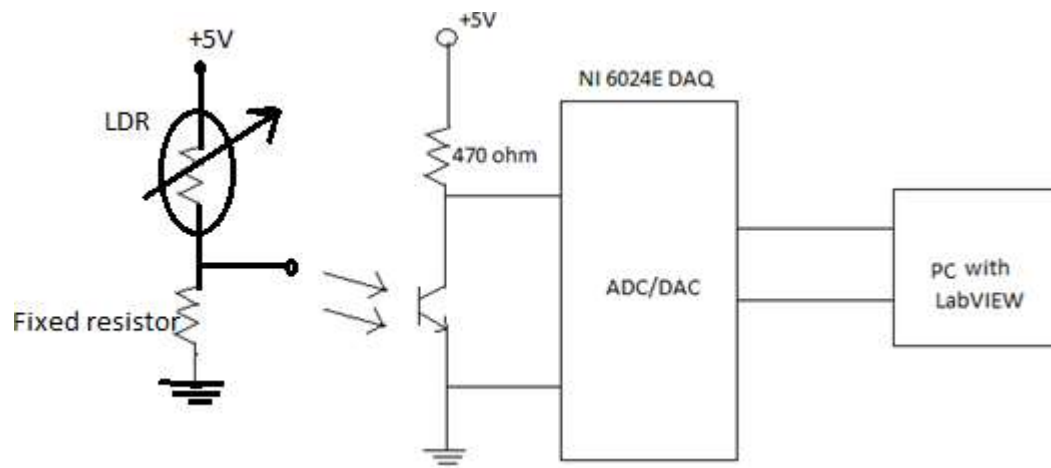
To setup the hardware and a LabVIEW VI for light intensity meter.

### THEORY:

#### LDR:

LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.

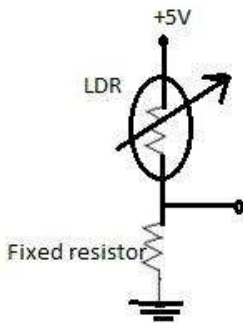
#### WORKING OF LDR:



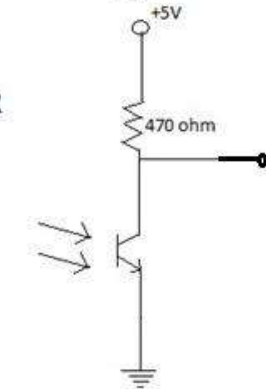
When light falls on the LDR its resistance varies and accordingly an output voltage is generated which is given to the DAQ card.

## Light Sensing Circuits

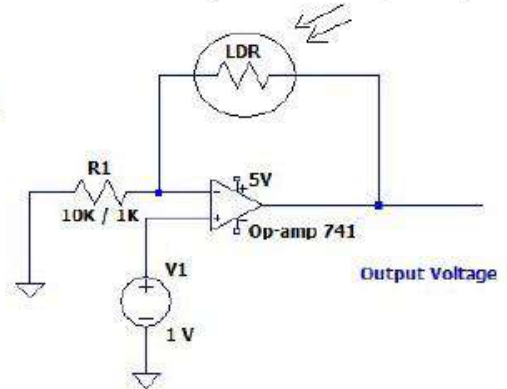
### 1. Using LDR



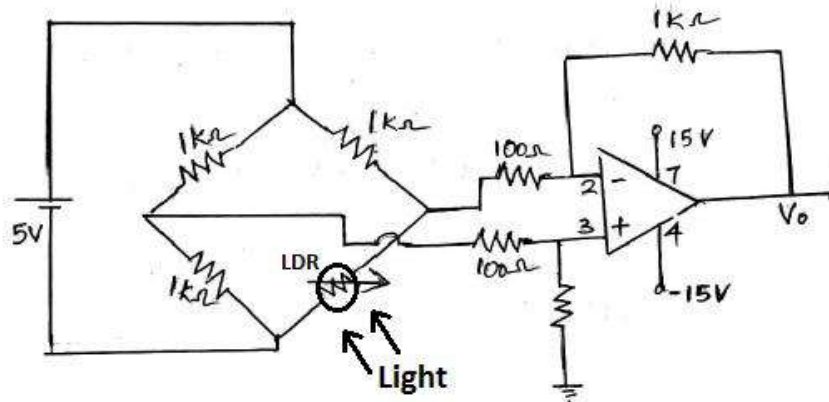
OR



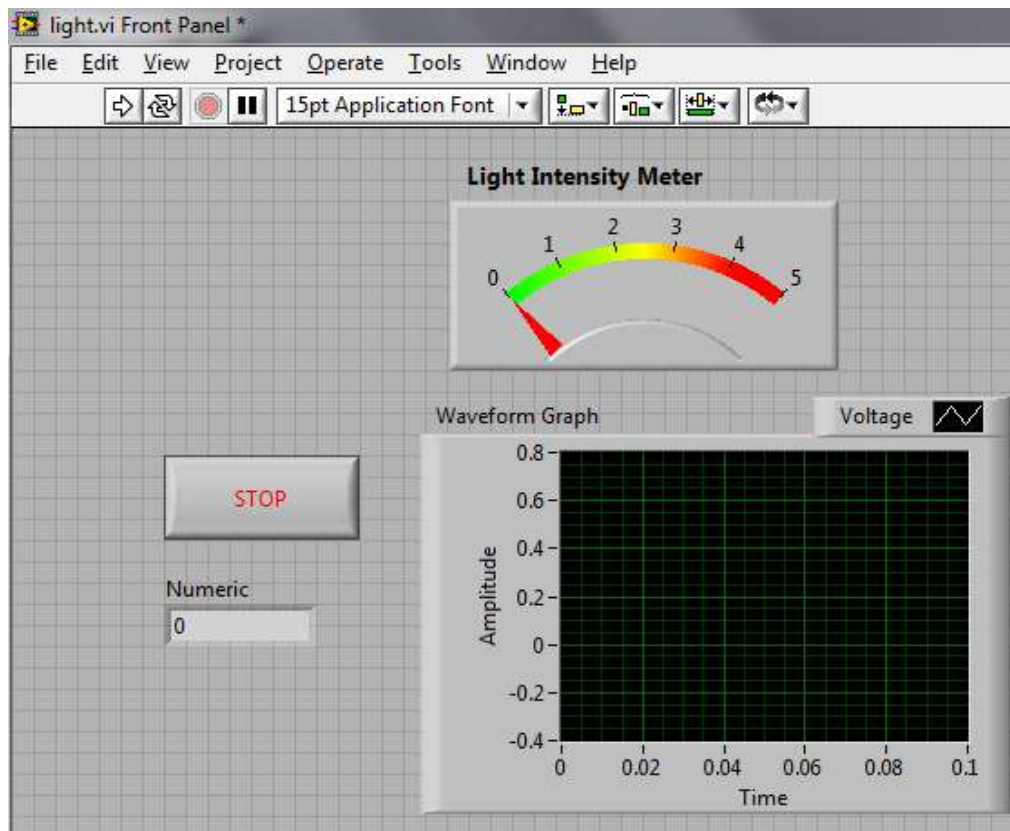
OR



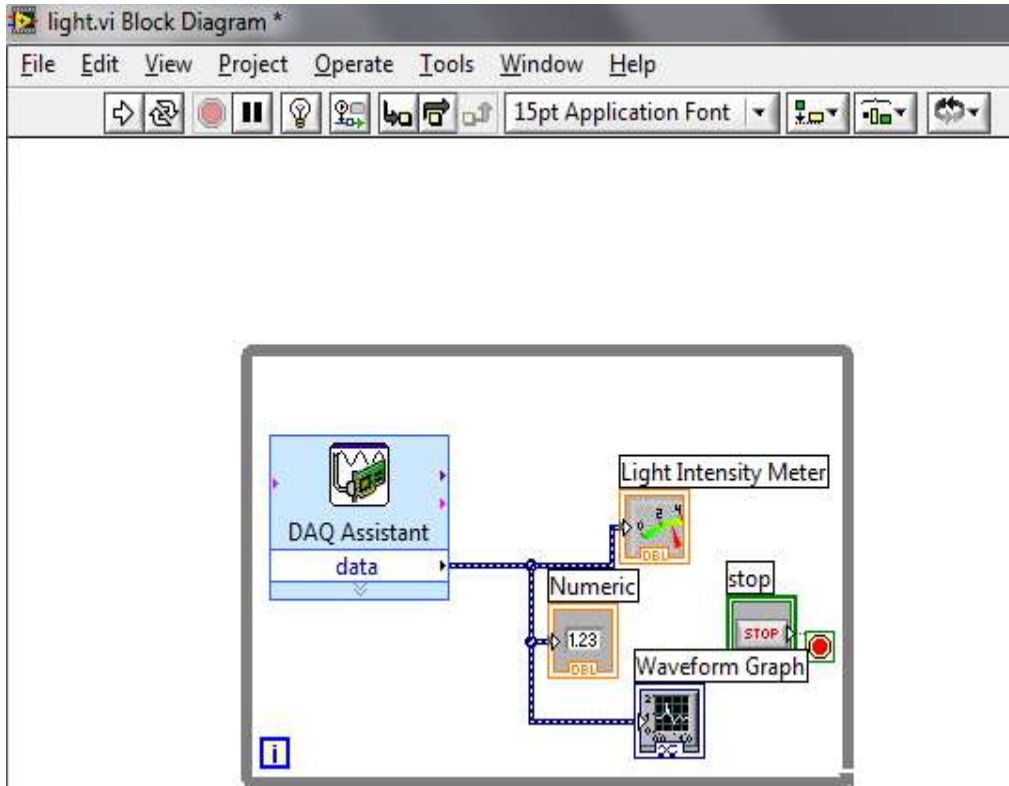
### 4. Using bridge and difference amplifier



## FRONT PANEL FOR LIGHT INTENSITY METER



## BLOCK DIAGRAM



## RESULT:

Developed the hardware setup and LabVIEW VI for light intensity meter.

Exp No: 04

Date:

## Realization of Maxwell's Inductance Bridge.

### AIM:

Realize Maxwell's Inductance bridge using LabVIEW.

### THEORY:

AC Bridges are used to measure the values of unknown resistance, inductance, and capacitance. AC bridges are believed to be very convenient and provide accurate result of the measurement. The construction of the bridges is very simple. The bridge has four arms, one AC supply source and the balance detector. It works on the principle that the balance ratio of the impedances will give the balance condition to the circuit which is determined by the null detector. The bridges have four arms, two have non-inductive resistance and the other two have inductances with negligible resistance.

A Maxwell bridge is a modification to a Wheatstone bridge used to measure an unknown inductance in terms of calibrated resistance and inductance or resistance and capacitance.

Let us consider  $\omega = 314$ ,

Let us consider  $E$  to be a constant (let it be 100V).

When the circuit is balanced then, current passing through the galvanometer ( $D$ ) = 0.

If the circuit is balanced, then from the circuit the line "abc" is parallel to line "adc".

By Voltage division rule:

Voltage across "ab" i.e.,

$$V_{ab} = \frac{E \cdot (R_1 + XL_1)}{(R_1 + R_3 + XL_1)}.$$

$$V_{ab} = \frac{E \cdot (\sqrt{R_1 \cdot R_1 + \omega L_1 \cdot \omega L_1})}{\sqrt{(R_1 + R_3) \cdot (R_1 + R_3) + \omega L_1 \cdot \omega L_1}}$$

$$V_b = E - V_{ab};$$

Voltage across “ad” i.e.,  $V_{ad} = (E * \text{Sqrt}((R2+r2)*(R2+r2)+wL2*wL2))/$

$$\text{Sqrt}((r2+R2+R4)*(r2+R2+R4)+ wL2*wL2)$$

$$V_d = V - V_{ad};$$

Since the circuit is balanced,

If for the value of L1 and R1 given for the circuit doesn't satisfy  $V_b - V_d = 0$ , then the circuit is not balanced.

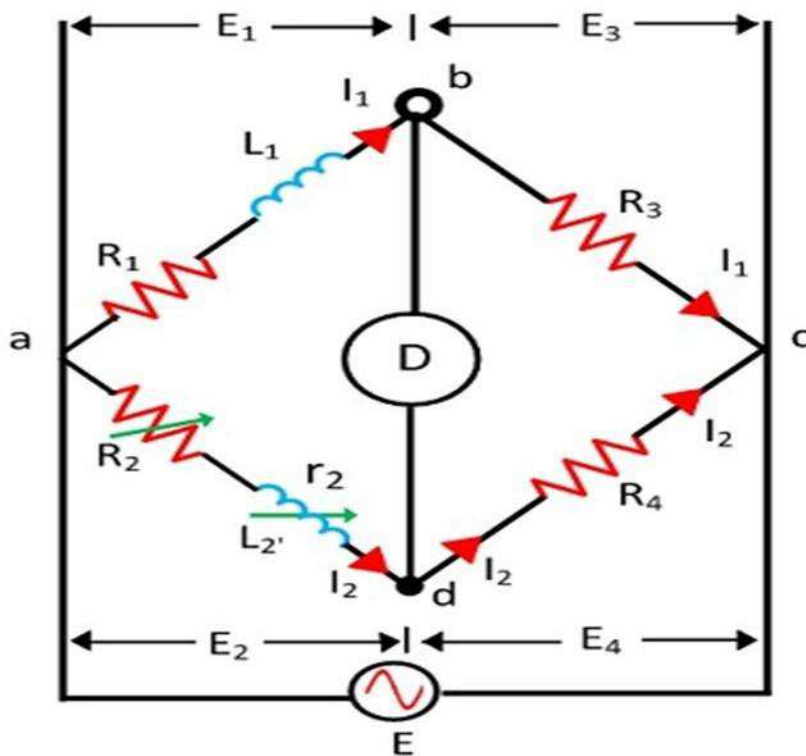
Theoretical Values of L1 And R1: At balanced condition:  $L1 = (R3 * L1) / R4; R1 = (R3 * (R2 + r2)) / R4$

#### PROCEDURE:

1. For the supply, we have considered, a sine wave input, we get this from input function of the LabView software. We considered frequency of the input to be 50Hz.
2. We have considered the 5 numeric controls for the resistors, 2 numeric knobs for the inductors, and numeric constant for angular frequency from the numeric functions of the LabView.
3. Indicate above meters according to its equivalent names from given circuit diagram.
4. Now, by using numeric controls such as addition, subtraction, etc, to form the equations  $V_{ab} = E * (\text{Sqrt}(R1 * R1 + wL1 * wL1)) / \text{Sqrt}((R1 + R3) * (R1 + R3) + wL1 * wL1)$  and then make an equation  $V_b = E - V_{ab}$
5. Now, similar to the above point, form an equation  $V_{ad} = (E * \text{Sqrt}((R2 + r2) * (R2 + r2) + wL2 * wL2)) / \text{Sqrt}((r2 + R2 + R4) * (r2 + R2 + R4) + wL2 * wL2)$  and then form an equation  $V_d = E - V_{ad}$
6. Now, using subtraction numeric control, subtract  $V_b - V_d$  and give this connection to numeric meter and name it as deflection.
7. If the deflection value is zero then, for the given values of the resistors and inductors the bridge is balanced. Or else we would be getting deflection

either positive or negative depending on given values of inductors and resistors in it.

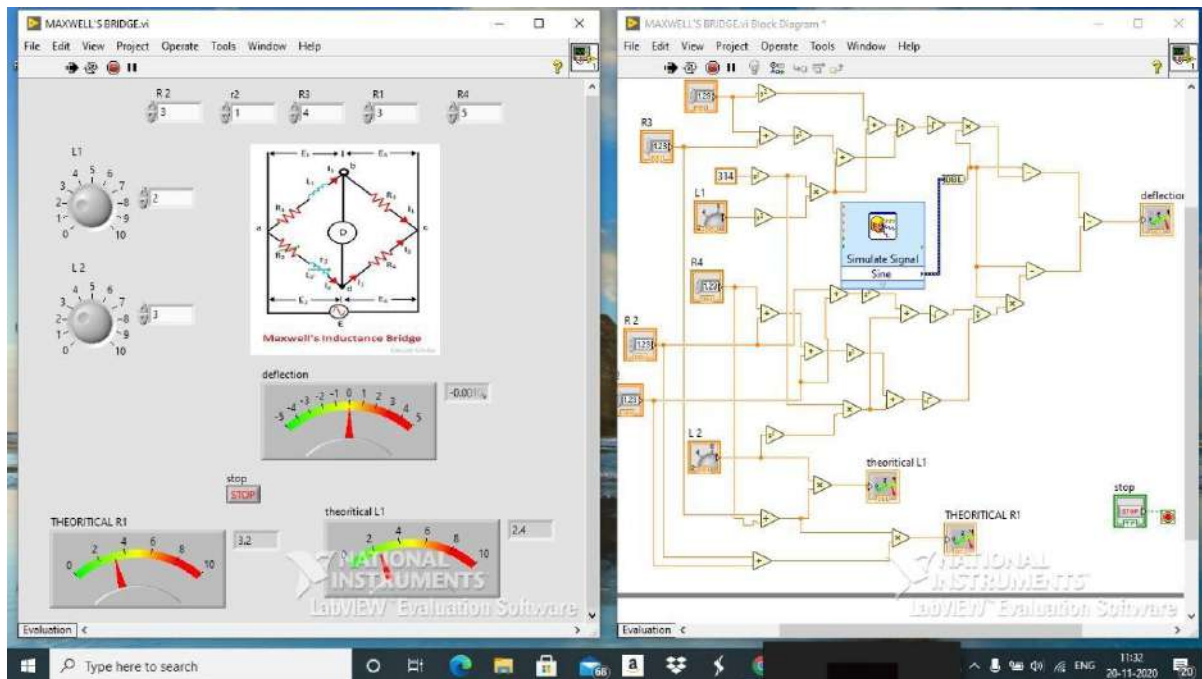
8. We even form an equation " $L_1 = (R_3 \cdot L_2) / R_4$ " using the numeric control functions.
9. The above equation is the condition in which the circuit gets balanced and deflection will be zero for the above values of resistors and inductors.



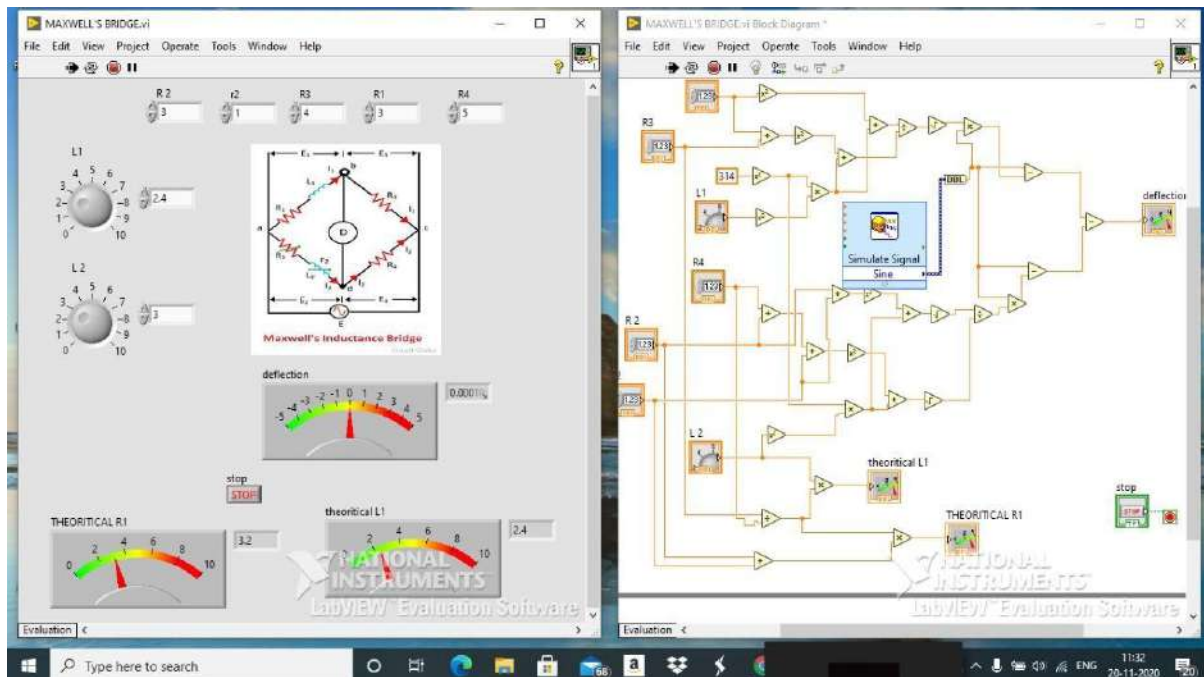
**Maxwell's Inductance Bridge**

Circuit Globe

## MAXWELL'S BRIDGE BEFORE BALANCING



## MAXWELL'S BRIDGE AFTER BALANCING



## RESULT:

Realized Maxwell's Inductance bridge using LabVIEW.

Exp No: 05

Date:

## Realisation of Wheatstone's Bridge.

### AIM:

Realisation of Wheatstone's resistance bridge using LabVIEW.

### THEORY:

A Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. The primary benefit of the circuit is its ability to provide extremely accurate measurements.

Let us consider E to be a constant (let it be 100V).

When the circuit is balanced then, current passing through the galvanometer(D)= 0.

If the circuit is balanced, then from the circuit the line "abc" is parallel to line "adc".

By Voltage division rule:

Voltage across "AC" i.e.,  $V_{ac} = (E \cdot R_1) / (R_1 + R_3)$

$V_c = E - V_{ac};$

Voltage across "AD" i.e.,  $V_{ad} = (E \cdot R_2) / (R_2 + R_4)$

$V_d = E - V_{ad};$

Since the circuit is balanced,

$V_c - V_d = 0$

If for the value of R1 given for the circuit doesn't satisfy  $V_c - V_d = 0$ , then the circuit isn't balanced.

Theoretical Value of R1: At

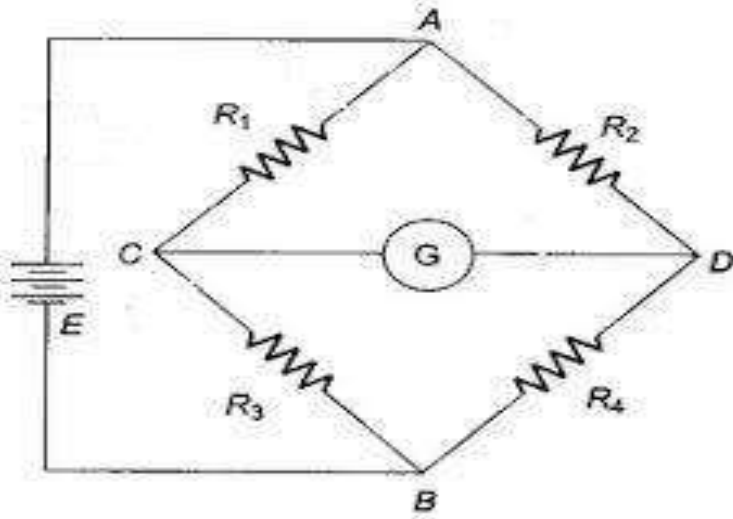
balanced condition:

$$R_1 = R_2 \cdot R_3 / R_4$$

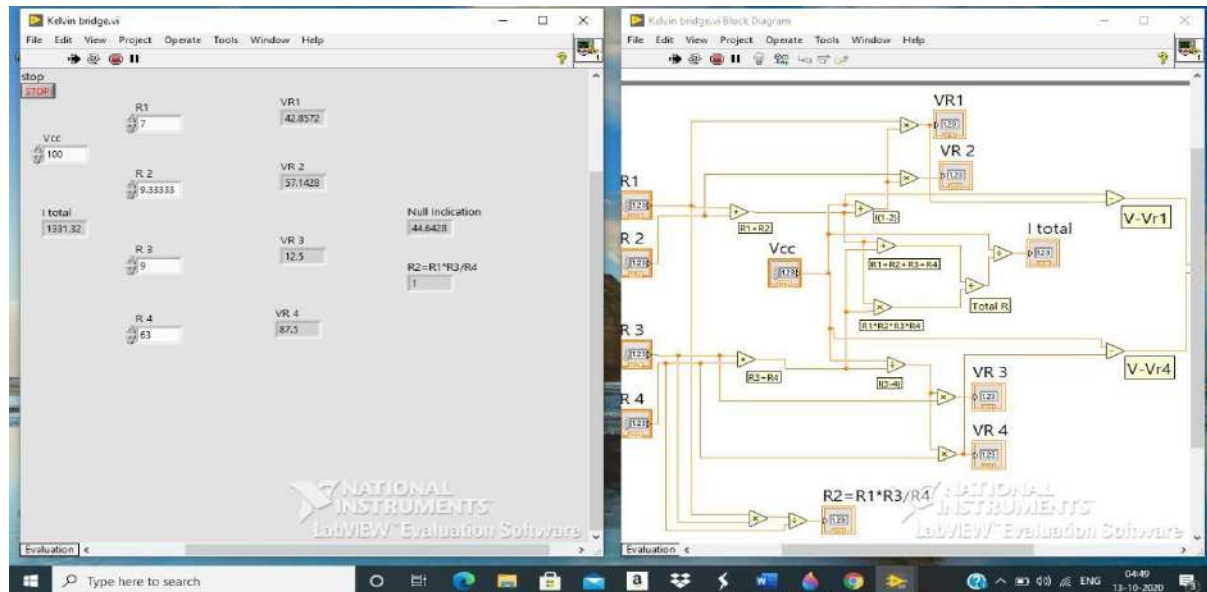
**PROCEDURE:**

1. For the supply, we have considered, a numeric constant input, we get this from input function of the LabView software.
2. We have considered the 4 numeric controls for the resistors and capacitors, and numeric constant for angular frequency from the numeric functions of the LabView.
3. Indicate above meters according to its equivalent names from given circuit diagram.
4. Now, by using numeric controls such as addition, subtraction, etc, to form the equations " $V_{ab} = E \cdot R_1 / (R_1 + R_3)$ " and then make an equation " $V_b = E - V_{ab}$ "
5. Now, similar to the above point, form an equation " $V_{ad} = (E \cdot R_2) / (R_2 + R_4)$ " and then form an equation " $V_d = E - V_{ad}$ "
6. Now, using subtraction numeric control, subtract " $V_b - V_d$ " and give this connection to numeric meter and name it as deflection.
7. If the deflection value is zero then, for the given values of the resistors and capacitors the bridge is balanced. Or else we would be getting deflection either positive or negative depending on given values of resistors in it.
8. We, even form an equation " $R_1 = (R_2 \cdot R_3) / R_4$ " using the numeric control functions.
9. The above equation is the condition in which the circuit gets balanced and deflection will be zero for the above values of resistors.

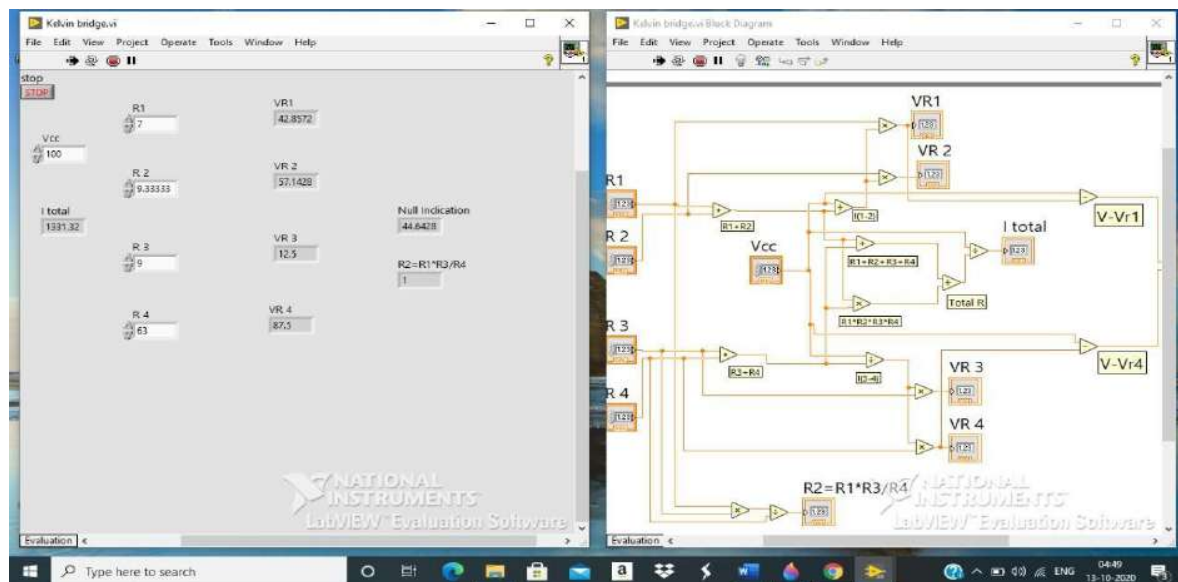
## WHEATSTONE'S BRIDGE



## WHEATSTONE'S BRIDGE BEFORE BALANCING



## WHEATSTONE'S BRIDGE AFTER BALANCING



## RESULT:

Wheatstone's bridge is realized using LabVIEW

Exp No: 06

Date:

## **Measurement of temperature and humidity using Arduino.**

### **AIM:**

To setup a measurement system for monitoring surrounding temperature and humidity.

### **THEORY:**

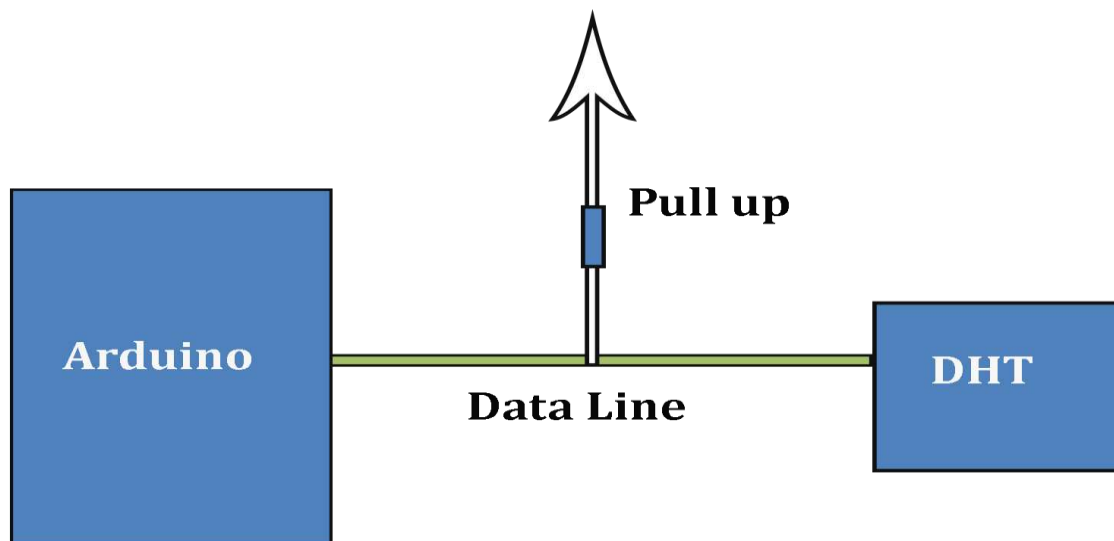
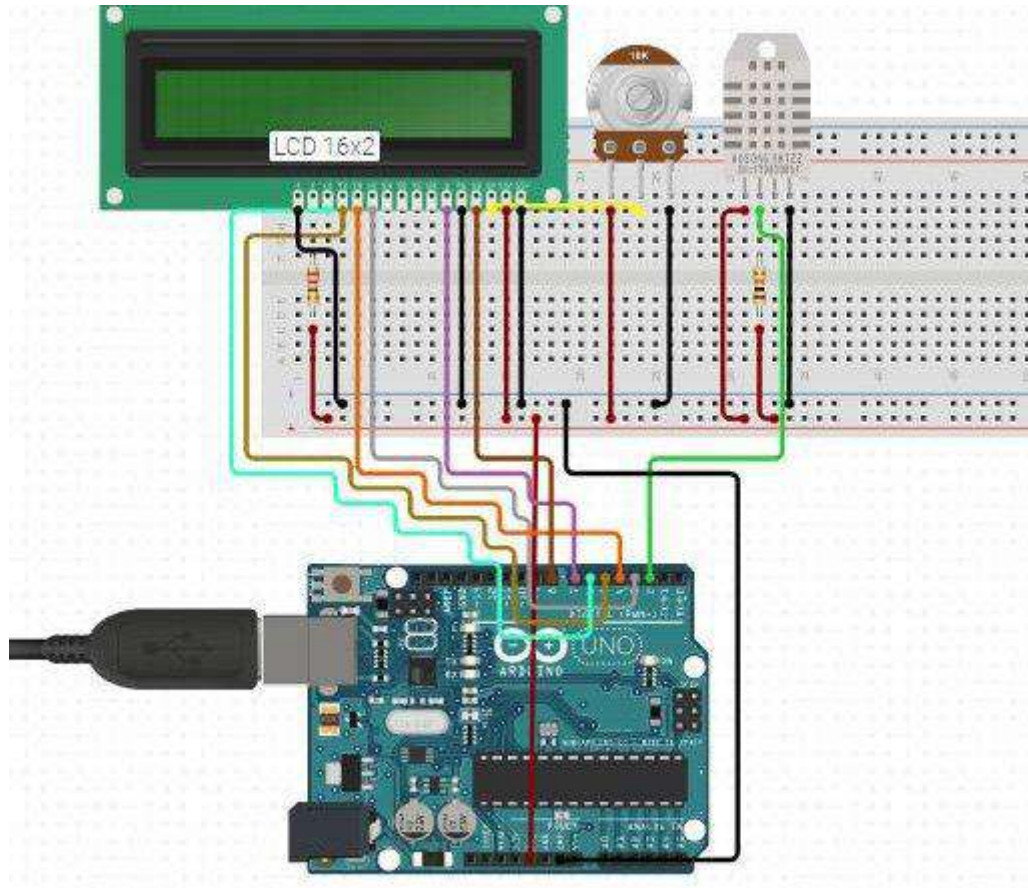
A mixed temperature and humidity sensor DHT11 is utilized with Arduino-uno to develop this project. Working of this project depends on single-wire serial communication. The first Arduino transmits a start signal to the DHT module and then DHT presents a response signal including temperature and humidity data. Arduino gathers and removes in two parts one is humidity and the second one is temperature and then sends them to 16x2 LCD. In this project, we have utilized a sensor module DHT11. The DHT11 sensor module is a linked module for sensing humidity and temperature which presents a calibrated digital output signal. DHT11 delivers us a specific value of humidity and temperature and assures high security and long term immobility. DHT11 module operates on serial communication. This module transfers data in the form of the pulse train of a specific time period. Before sending data to Arduino it requires some initialize command with a time delay. And the whole process time is about 4ms. Entire data transmission is of 40-bit and data format of this process is given below:

Firstly, Arduino sends a high to low start signal to DHT11 with  $18\mu\text{s}$  delay. And then Arduino pull-up the data line and waits for  $20\text{--}40\mu\text{s}$  for DHT's response (as shown below). Once DHT recognizes starts signal, it will send a low voltage level response signal to Arduino of time delay about  $80\mu\text{s}$ . After that DHT controller pulls up the data line and holds it for  $80\mu\text{s}$  for DHT's arranging of transmitting data.

When a data bus is at a low voltage level which means that DHT11 is transmitting a response signal. Once it is done, DHT again presents a data line pull-up for  $80\mu\text{s}$  for preparing data transmission.

The data format that is transmitting by DHT to Arduino for every bit starts with  $50\mu\text{s}$  low voltage level and length of high voltage level signal defines whether a data bit is "0" or "1".

## SET-UP



**PROGRAM:**

```
#include<dht.h>          // Including library for dht
#include<LiquidCrystal.h>
LiquidCrystallcd(2, 3, 4, 5, 6, 7);

#define dht_dpin 12

dht DHT;

byte degree[8] =
{
    0b00011,
    0b00011,
    0b00000,
    0b00000,
    0b00000,
    0b00000,
    0b00000,
    0b00000
};

void setup()
{
    lcd.begin(16, 2);
    lcd.createChar(1, degree);
    lcd.clear();
    lcd.print("  Humidity  ");
    lcd.setCursor(0,1);
    lcd.print(" Measurement ");
    delay(2000);
    lcd.clear();
    lcd.print("Circuit Digest ");
    delay(2000);
}

void loop()
{
    DHT.read11(dht_dpin);
    lcd.setCursor(0,0);
    lcd.print("Humidity: ");
    lcd.print(DHT.humidity);    // printing Humidity on LCD
    lcd.print(" %");
    lcd.setCursor(0,1);
    lcd.print("Temperature:");
    lcd.print(DHT.temperature); // Printing temperature on LCD
    lcd.write(1);
    lcd.print("C");
    delay(500);
}
```

**RESULT:**

A measurement system is developed for monitoring surrounding temperature and humidity.

Exp No: 07

Date:

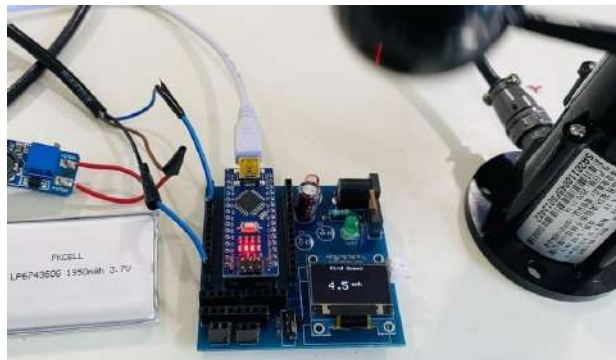
## Measurement of wind speed using Anemometer and Arduino.

### AIM:

To measure Wind Speed using Adafruit Anemometer Sensor & Arduino.

### THEORY:

An anemometer is a device used for measuring wind speed and direction. It is also a common Weather Station instrument. In all studies that involve wind speed

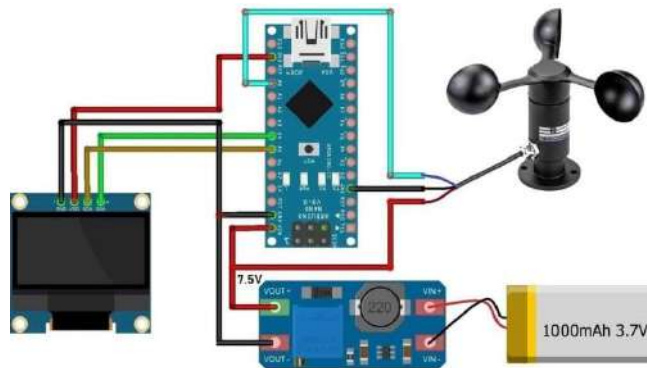


measurement such as meteorology wind turbines & agriculture, we need accurate wind speed information for decision making. There are several types of anemometers with medium and high costs such as cups hot wire & pitot tubes. The anemometer used here is the cup-type anemometer. The anemometer sensor we are using here is the Adafruit anemometer. The Adafruit anemometer is capable of measuring wind speeds up to 70 m/s or 156 mph which should be adequate for our location. We can interface the Adafruit Anemometer Sensor with Arduino and OLED Display. The sensor will measure the wind speed in m/s and displays the value on OLED Screen. You can convert the wind speed from m/s to miles per hour or kilometer per hour.

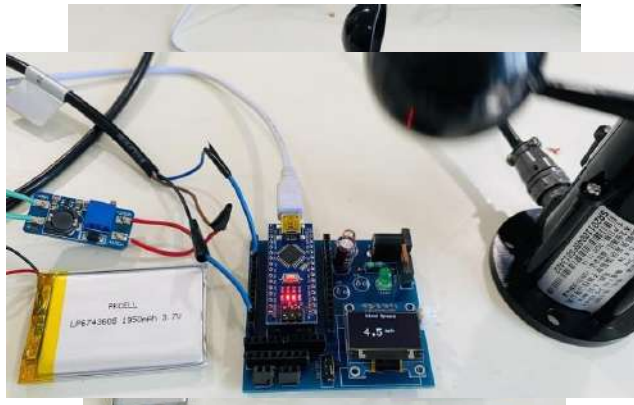
### COMPONENTS

1	Arduino Board	Arduino Nano	1
2	Anemometer Sensor	Adafruit Anemometer Cup Type	1
3	OLED Display	0.96" I2C OLED Display	1
4	MT3608	Boost Converter Module	1
5	Battery	3.7V Lithium-Ion Battery	1

Now let us interface the Adafruit Anemometer Sensor with Arduino & measure the wind speed. Check the schematic or circuit below.

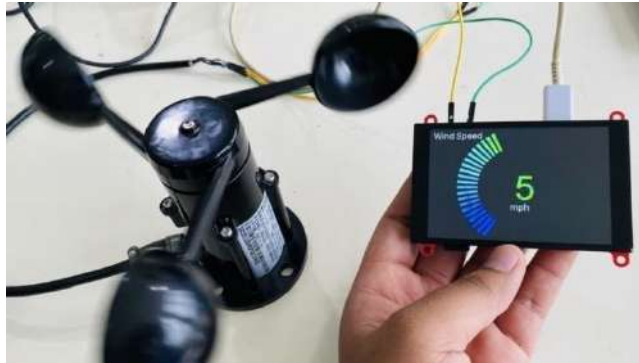


The Adafruit Anemometer works between 7-24V DC. So the voltage from the Arduino is not enough to power on the sensor. Hence I have to use [MT3608](#) DC-to-DC Boost Converter Module to boost the 3.7V from Lithium-Ion Battery to 7.5V. To adjust the output voltage, connect the battery first to the input of the MT3608 Module and then rotate the potentiometer until the output voltage shows 7.5V on multimeter. The Sensor VCC wire and the Arduino Vin pin are supplied with 7.5V from the output of the Boost Converter Module. The blue wire that is the analog output pin of the anemometer sensor is connected to the A0 of Arduino. Similarly the I2C Pin of OLED Display, i.e SDA & SCL is connected to A4 & A5 of Arduino. The OLED Display is supplied with 3.3V from Arduino 3.3V Pin.



Once you upload the Arduino Anemometer code to the Arduino Board, the OLED Display will start displaying the wind speed. When the anemometer cup is stable the OLED will show speed around 0.1m/s to 0.3m/s. The speed will vary or increase when the sensor is taken in a windy region. I used my home roof to check the wind speed. Initially tried measuring the speed in m/s and got the result as shown in the image below. The speed variation is increases or decreases depending upon the blade rotation. Then used the industrial standard measurement and converted the m/s to miles per hour (mph). You can also use the mathematical calculation to convert the speed to a kilometer per hour (kph). This is how you can make DIY Arduino Anemometer Project for measuring wind speed for Weather Station.

## SET-UP



## Program

```
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels
#define OLED_RESET 4 // Reset pin # (or -1 if sharing reset pin)
Adafruit_SSD1306 display(SCREEN_WIDTH , SCREEN_HEIGHT , &Wire, OLED_RESET);
void setup()
{
  Serial.begin(9600);
  if (!display.begin(SSD1306_SWITCHCAPVCC , 0x3C))
  {
    Serial.println(F("SSD1306 allocation failed" ));
    for (;;) // Don't proceed, loop forever
    {
      display.display();
      delay(100);
      display.clearDisplay ();
      display.clearDisplay ();
      display.setTextColor (WHITE);
      display.setTextSize (2);
      display.setCursor (0, 20);
      display.print("Anemometer" );
      display.display();
      delay(3000);
    }
  }
  void loop()
  {
    float sensorValue = analogRead (A0);
    Serial.print("Analog Value = " );
    Serial.println(sensorValue );
    float voltage = (sensorValue / 1023) * 5;
    Serial.print("Voltage = " );
    Serial.print(voltage);
    Serial.println(" V");
    float wind_speed = mapfloat (voltage, 0.4, 2, 0, 32.4);
    float speed_mph = ((wind_speed * 3600)/1609.344 );
    Serial.print("Wind Speed = " );
```

```

Serial.print(wind_speed );
Serial.println("m/s");
Serial.print(speed_mph );
Serial.println("mph");
display.clearDisplay ();
display.setTextSize (1);
display.setCursor (30, 0);
display.println("Wind Speed" );
// display.setTextSize(2);
// display.setCursor(25, 30);
// display.print(" m/s");
display.setTextSize (2);
display.setCursor (25, 30);
display.print(speed_mph , 1);
display.setTextSize (1);
display.print(" mph");
display.display();
Serial.println(" ");
delay(300);
}
float mapfloat (float x, float in_min, float in_max, float out_min, float out_max)
{
return (x - in_min) * (out_max - out_min) / (in_max - in_min) + out_min;
}

```

### **RESULT:**

Developed a measurement system for measuring wind speed using Arduino.

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Exp No: 08

Date:

## **Water level Measurement using Arduino.**

### **AIM:**

In this project, How Water Level Sensor Works and Interface it with Arduino.

### **COMPONENTS**

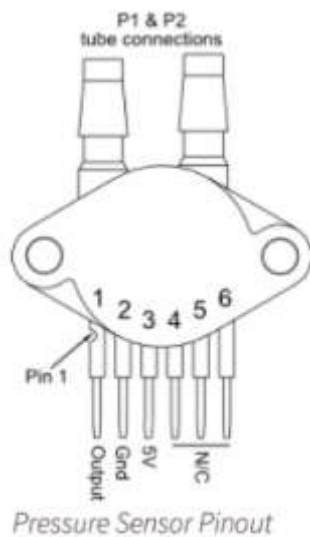
1. Arduino Uno or any internal ADC microcontroller
2. MPX5010DP Pressure sensor
3. LCD Display 16×2
4. Water purifier pipe 1 mtr

### **THEORY:**

The sensor has a series of ten exposed copper traces, five of which are power traces and five are sense traces. These traces are interlaced so that there is one sense trace between every two power traces. Usually these traces are not connected but are bridged by water when submerged. sensor. Most of the traditional measuring systems were designed and implemented by complicated hardware circuitry. It made the product expensive, with low functionality and with limited precision. With virtual measurement technology, more of the instrument can be substituted by software. Using this approach the cheaper and more versatile measurement system can be developed. The method for obtaining liquid level with one differential pressure sensors MPX5010DP is suggested and considered. Some basic considerations about the modern integrated pressure sensors and some aspects concerning their capability for liquid level measurement are done. Finally, a prototype of a liquid level monitoring system based on integrated differential pressure sensors, arduino board is developed for measuring liquid level accurately at distances up to 10 metres. There are three types of pressure measurement. Absolute pressure does include atmospheric pressure, and is measured

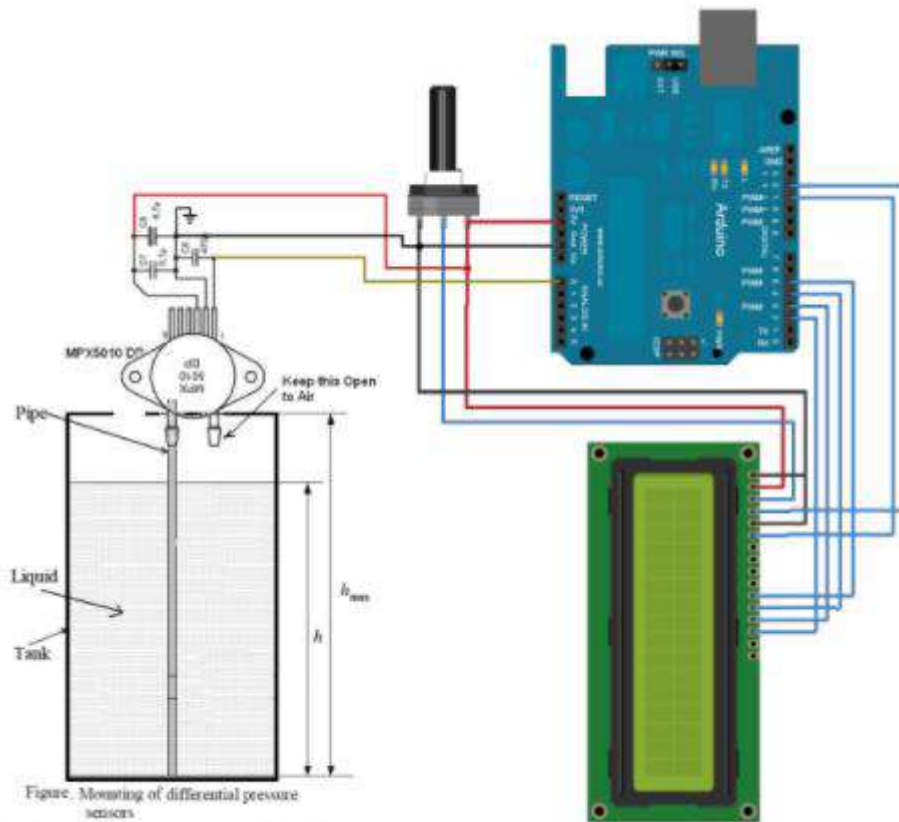
relative to vacuum. Differential pressure is the difference between two pressures. Gage pressure is a form of differential pressure measurement in which atmospheric pressure is used as the reference. A pressure transmitter can be used to determine the liquid level in a tank, well, river or other body of liquid. If a pipe is placed vertically, with one end dipped into a liquid and the upper end of the pipe is closed and some air volume is trapped.

### Pin Diagram of MPX5010DP



### Circuit Diagram of Water level measurement

This time we used LCD to display the liquid level as we progressed in skills. Connect Sensor one end to water filter pipe, take care that air will not leak through the sensor and pipe joint as we want to measure pressure of air trapped in pipe. Keep one end of sensor open to air. Capacitors near to sensor are provided for noise reduction. You can use fixed 1K resistor in between ground and LCD contrast setting pin instead of pot.



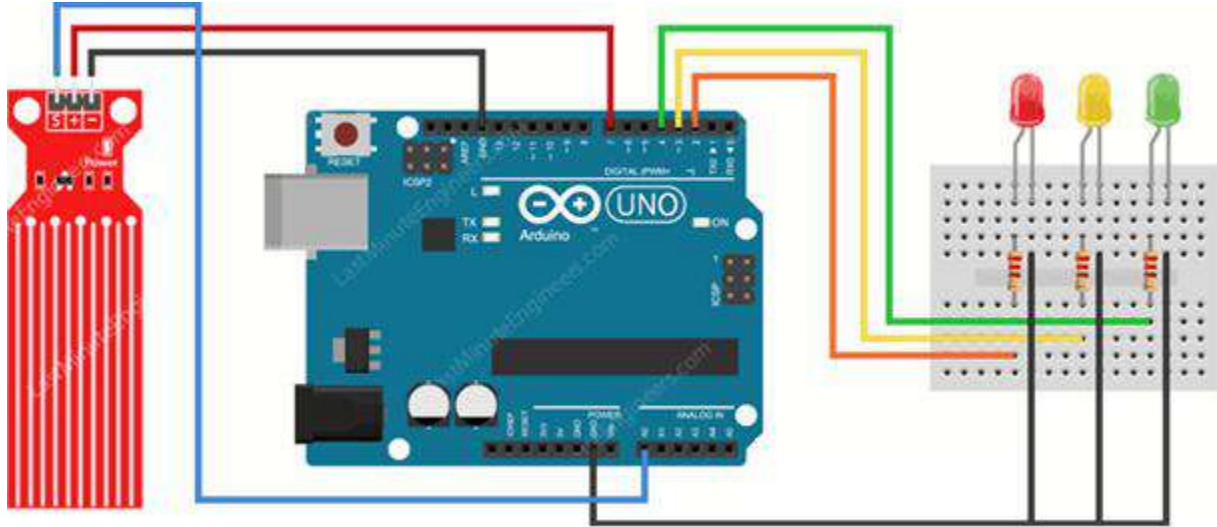
*Water Level Measurement Circuit*

## Program

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(12, 11, 10, 5, 4, 3, 2);
int Level;
void setup()
{
  lcd.begin(16,1);
  Serial.begin(9600);
}
void loop()
{
  Level = analogRead(A0)-45; //Sensor is having some offset so do
  some
  //calibration here
  lcd.setCursor(0 , 0);
  lcd.print("Liquid Level:");
  lcd.print(Level);
  lcd.print(" Ltr");
  Serial.print("Liquid Level:");
  Serial.print(Level);
  Serial.println(" Ltr");
  delay(1000);
}
```

## Alternative solution

Aim: To make a portable water level monitoring system that will light up LEDs according to water level.



Anything below the lower threshold will trigger the red LED to turn on. Anything above the upper threshold will turn on the green LED. Anything between these will turn on the yellow LED.

```
/* Change these values based on your calibration values */
int lowerThreshold = 420;
int upperThreshold = 520;

// Sensor pins
#define sensorPower 7
#define sensorPin A0

// Value for storing water level
int val = 0;

// Declare pins to which LEDs are connected
int redLED = 2;
int yellowLED = 3;
int greenLED = 4;

void setup() {
  Serial.begin(9600);
  pinMode(sensorPower, OUTPUT);
  digitalWrite(sensorPower, LOW);

  // Set LED pins as an OUTPUT
  pinMode(redLED, OUTPUT);
  pinMode(yellowLED, OUTPUT);
  pinMode(greenLED, OUTPUT);
  // Initially turn off all LEDs
  digitalWrite(redLED, LOW);
```

```

        digitalWrite(yellowLED, LOW);
        digitalWrite(greenLED, LOW);
    }

    void loop() {
        int level = readSensor();

        if (level == 0) {
            Serial.println("Water Level: Empty");
            digitalWrite(redLED, LOW);
            digitalWrite(yellowLED, LOW);
            digitalWrite(greenLED, LOW);
        }
        else if (level > 0 && level <= lowerThreshold) {
            Serial.println("Water Level: Low");
            digitalWrite(redLED, HIGH);
            digitalWrite(yellowLED, LOW);
            digitalWrite(greenLED, LOW);
        }
        else if (level > lowerThreshold && level <= upperThreshold) {
            Serial.println("Water Level: Medium");
            digitalWrite(redLED, LOW);
            digitalWrite(yellowLED, HIGH);
            digitalWrite(greenLED, LOW);
        }
        else if (level > upperThreshold) {
            Serial.println("Water Level: High");
            digitalWrite(redLED, LOW);
            digitalWrite(yellowLED, LOW);
            digitalWrite(greenLED, HIGH);
        }
        delay(1000);
    }

    //This is a function used to get the reading
    int readSensor() {
        digitalWrite(sensorPower, HIGH);
        delay(10);
        val = analogRead(sensorPin);
        digitalWrite(sensorPower, LOW);
        return val;
    }
}

```

## RESULT:

Developed a measurement system for measuring liquid level using Arduino.