Indian Institute of Space Science and Technology

LVDT, RTD and Optical Sensor

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1 Aim of the Experiment

To analyse the working and implementation of a LVDT, RTD and optical sensor.

2 LVDT - Linear Variable Differential Transformer

LVDT is a displacement sensor which can measure translational as well as rotational displacement. It is an inductive sensor which is based on the principle of mutual inductance. The sensor gives a voltage output. The advantage of LVDT over potentiometric displacement sensor is that it makes non-contact measurement,i.e., there is no physical contact between the core and winding. It has very high resolution and does not suffer from wear and tear. It finds application is areas such as machine tools, robotics, avionics and computerized manufacturing.

2.1 Equipments Required

- TK294G Linear Variable Differential Transformer (LVDT) sub-unit
- Micrometer
- DSO(Digital Storage Oscilloscope)
- Function Generator
- Capacitor(100mF)
- Diode(2)
- Resistor(two 10kΩ)
- Breadboard
- Connecting Wires
- Multimeter

2.2 Theory

Differential transformers on a variable inductance principle, are also used to measure displacement. The most popular variable inductance transducer for linear displacement measurement is the Linear Variable Differential Transformer (LVDT).

The LVDT has a magnetic core with relatively high permeability. The LVDT consists of three symmetrically spaced coils wound onto an insulated former. The magnetic core moves through the former without contact, providing a path for magnetic flux linkage between coils. The position of the magnetic core controls the mutual between the primary coil and the two outside of secondary coils. Both the secondary windings are placed equidistant from primary and are identical in all respects. When the primary winding of LVDT is supplied with AC supply, it produces an alternating magnetic flux in the core which in turn links with the secondary winding S1 and S2 to produce emf due to transformer action.

Let us assume that the emf produced in secondary winding S1 is Es1 and that in S2 is Es2. Due to this connection, the net output voltage E0 of the LVDT is given as below.

$$E_0 = E_{s1} – E_{s2}$$

i) **Case-1: Core is in the NULL Position**
Since the secondary windings of LVDT are identical and symmetrical on either side of core, therefore the mutual inductance is equal in both the secondary windings, S_1 and S_2. This means $\mathbf{E_{s1} = E_{s2}}$ and hence net output voltage $\mathbf{E_0 = 0}$. This position of soft iron core is called NULL position. Thus NULL position of Linear Variable Differential Transformer is the normal position of movable core where the net output voltage is zero.
Now, the core can either be moved toward right or left to the null position.

ii) **Case-2: Core is moved right to the NULL position**
When core of LVDT is moved to the right of the NULL position, the mutual inductance of secondary winding S_1 will become more than that of winding S_2. This means the emf induced in winding S_1 will be more than S_2. Hence $\mathbf{E_{s1}>E_{s2}}$ and net output voltage $\mathbf{E_0 = E_{s1} - E_{s2} =}$ **positive**. This means that the output voltage E_0 will be in phase with the primary voltage.

iii) **Case-3: Core is moved left of the NULL position**
When the core of LVDT is moved toward left of NULL position, the mutual inductance of secondary winding S_1 will become less than that of winding S_2. Hence,the emf induced in secondary winding S_2 will be more than that of S_1. This means $\mathbf{E_{s2} > E_{s1}}$ and hence net output voltage $\mathbf{E_0 = E_{s1} - E_{s2} =}$ **negative**. This means that the output voltage of LVDT will be 180 degree out of phase with the primary voltage.

When the core fully moves out of the secondary winding, E0 becomes constant.

2.2.1 Equivalent Electrical Circuit of LVDT

Here,

M_1: mutual inductance of S_1

M_2: mutual inductance of S_2

R_p: winding resistance at primary side

R_s: winding resistance at secondary side

e_{s1}: induced voltage of S_1

e_{s2}: induced voltage of S_2

Applying KVL and Faradays law,

$$Es_1(s) = \frac{sM_1}{R_p + sL_p} E_p(s)$$

$$Es_2(s) = \frac{sM_2}{R_p + sL_p} E_p(s)$$

Input signal: $e_p = A\sin(\omega t)$

Taking modulus:

$$e_{s1} = \frac{A\omega M_1}{\sqrt{R_p^2 + \omega^2 L_p^2}} \sin(\omega t + \phi)$$

$$e_{s2} = \frac{A\omega M_2}{\sqrt{R_p^2 + \omega^2 L_p^2}} \sin(\omega t + \phi)$$

$$e_0 = \frac{A\omega (M_1 - M_2)}{\sqrt{R_p^2 + \omega^2 L_p^2}} \sin(\omega t + \phi)$$

where, $\phi = 90^\circ - \tan^{-1}(\frac{\omega L_p}{R_p})$

Voltmeter can only measure the amplitude or the rms value, but not the phase. Hence, we need to use a two- channel oscilloscope. Mutual inductance is directly proportional to the number of turns linked with the primary winding.

$$M_1 \propto L_1 - x$$

$$M_2 \propto L_1 + x$$

Since, $e_0 \propto (M_1 - M_2)$, $e_0 \propto x$.

The signal conditioning of the circuit is done using the half wave rectifier and LPF. The modulus of the e_0 is obtained using a half wave rectifier and the average value of e_0 is obtained using a LPF.

The value of capacitor should be chosen such that the cut-off frequency of the LPF is much less than the input frequency. The thevinin resistance of the circuit as seen by the capacitor is 2R = 20KΩ. Let the input frequency be f. The value of capacitor C is chosen such that,

$$\frac{1}{4\pi RC} << f$$

The output voltage is given as:

$$e_0 = |e_{s1}| - |e_{s2}| = (E_{s1} - E_{s2})|\sin(\omega t + \phi)|$$

$$e_{LPF} = \frac{2}{\pi}[E_{s1} - E_{s2}]$$

$$e_{LPF} = \frac{2}{\pi} kx$$

Hence, the output voltage e_{LPF} is obtained to be proportional to x.

2.3 Procedure

i) Give a sinusoidal wave input to the LVDT with a peak to peak amplitude of 4V and frequency of 20KHz from a function generator.

ii) Connect the output from the positive terminal of the secondary windings and the input to the DSO.

iii) Short the negative terminals of the secondary winding

iv) Apply a force on the LVDT arm using the micrometer to push the core present inside.

v) Lock the micrometer at the required positions and note the readings.

vi) Now, make the signal conditioning circuit of the LVDT on the breadboard.Connect two diodes to form a half wave rectifier and connect a capacitor so as to form a LPF.

vii) Connect a multimeter to the secondary windings.

viii) Agin, move the micrometer as stated previously to change the position of core and note the readings from the multimeter.

2.4 Inferences

i) When the force is applied on the micrometer, initially the output increases. Here, the output is out of phase with the input. This implies that the emf is greater in the secondary winding, S_2.

ii) When the core is further moved, the output decreases and reaches zero. This implies that the core has reached the middle point at which the emf across both the secondary windings is equal.

iii) When the core is further moved inside, the output voltage increases. Here, the output is in phase with the input. This implies that the emf is greater in the secondary winding S_1.

When the half wave rectifier is and lpf are connected,

iv) When the core is moved inside, the voltmeter reading first increases negatively. The negative sign implies that the emf is greater in the secondary winding, S_2.

v) When the core is further moved, the voltmeter reading decreases in the negative direction and reaches zero. This implies that the core has reached the middle point at which the emf across both the secondary windings is equal.

vi) When the core is further moved, the voltmeter reading increases positively. The positive sign implies that the emf is greater in the secondary winding, S_1.

2.5 Simulation

2.5.1 Spice Model

Circuit Diagram of LVDT:

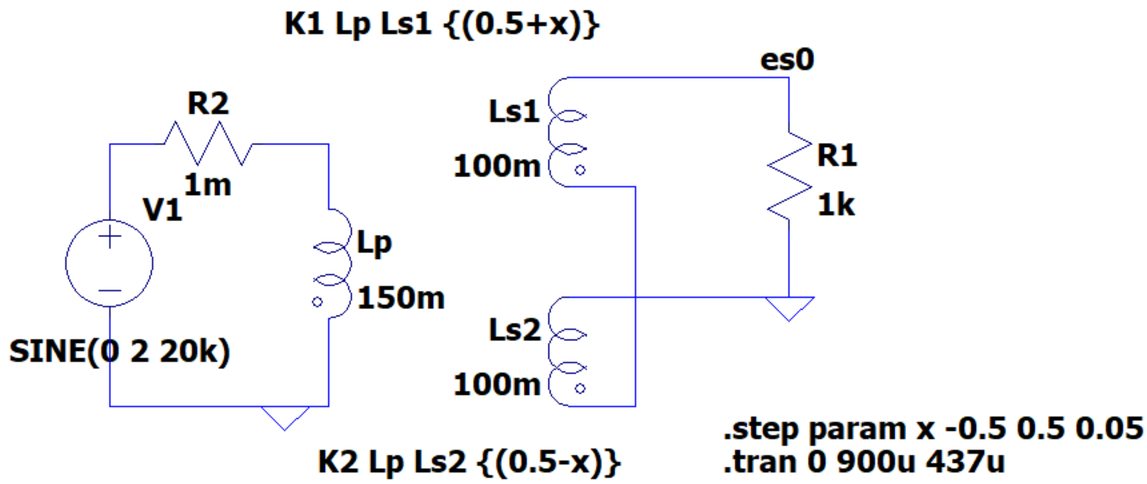

Figure 1: LVDT

Circuit Diagram including Signal Conditioning:

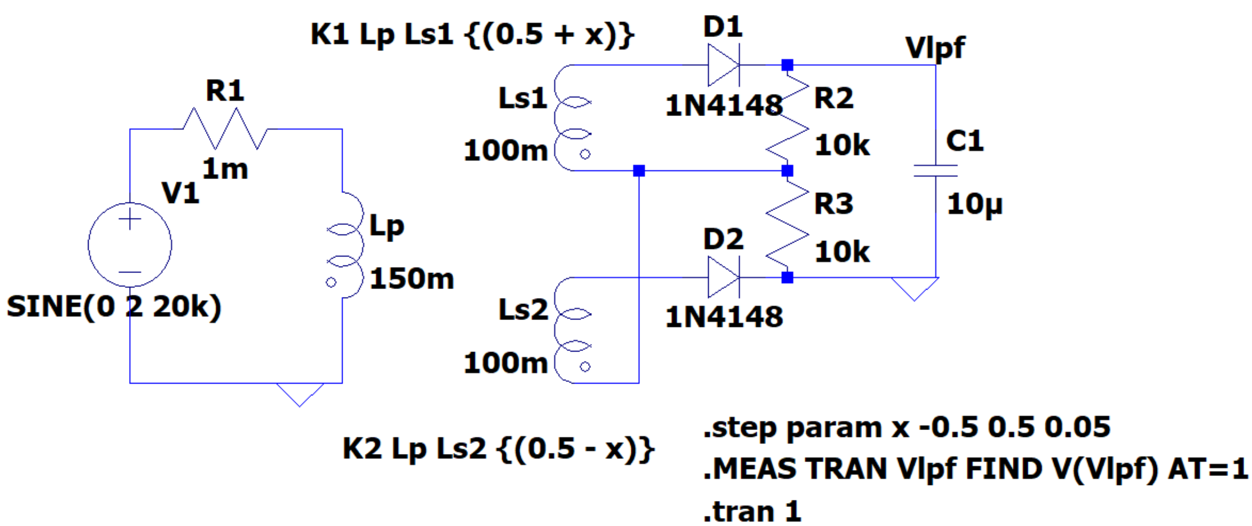

Figure 2: LVDT with Signal Conditioning

2.5.2 Design Conditions

We need to simulate an LVDT on $\mathrm{L_T}$Spice. We need to mimic a transformer with a primary winding and two secondary windings. This is done using the inductances and the **K statement** $\mathrm{L_T}$Spice. K statement denoted the mutual coupling coefficient. Now, we need to mimic the core such that the output voltage is proportional to the displacement **x**. When the core is moved, we are changing the mutual inductance linked with the secondary winding, which in turn is proportional to x. The relation between mutual inductance, M and mutual coupling coefficient, K is given by:

$$M = \frac{K}{\sqrt{L_p L_s}}$$

Hence, to mimic the core, we set the K statement in $\mathrm{L_T}$Spice to be proportional x. The value of x is varied in $\mathrm{L_T}$Spice using the **.step param** command in $\mathrm{L_T}$Spice. The diode used for the half-wave rectifier is 1N4148. The voltage across the capacitor at time = 1s is measured using the **.meas** command.

2.5.3 Simulation Results

Output Waveform for Different values of x:

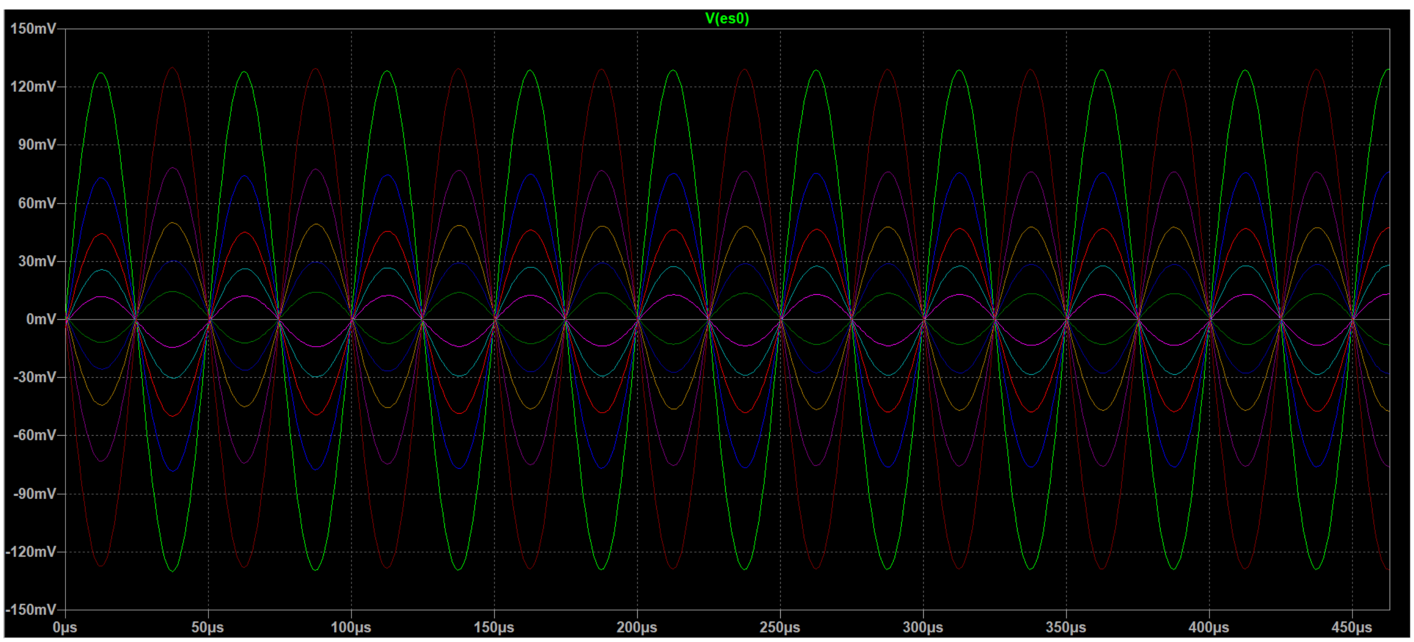

Figure 3: Output Waveform for Different values of x

DC Voltage Obtained Across the capacitor for Different values of x:

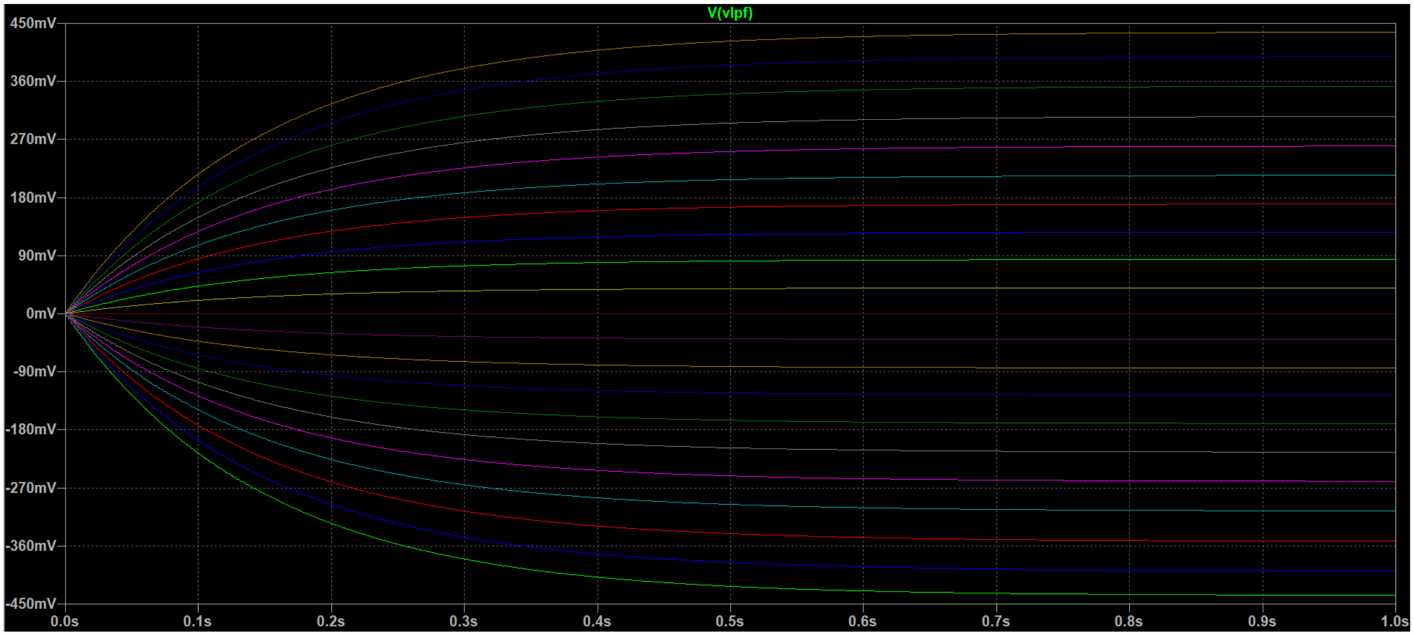

Figure 4: DC Voltage Obtained Across the capacitor for Different values of x

Graph of modulus of e_{LPF} vs x:

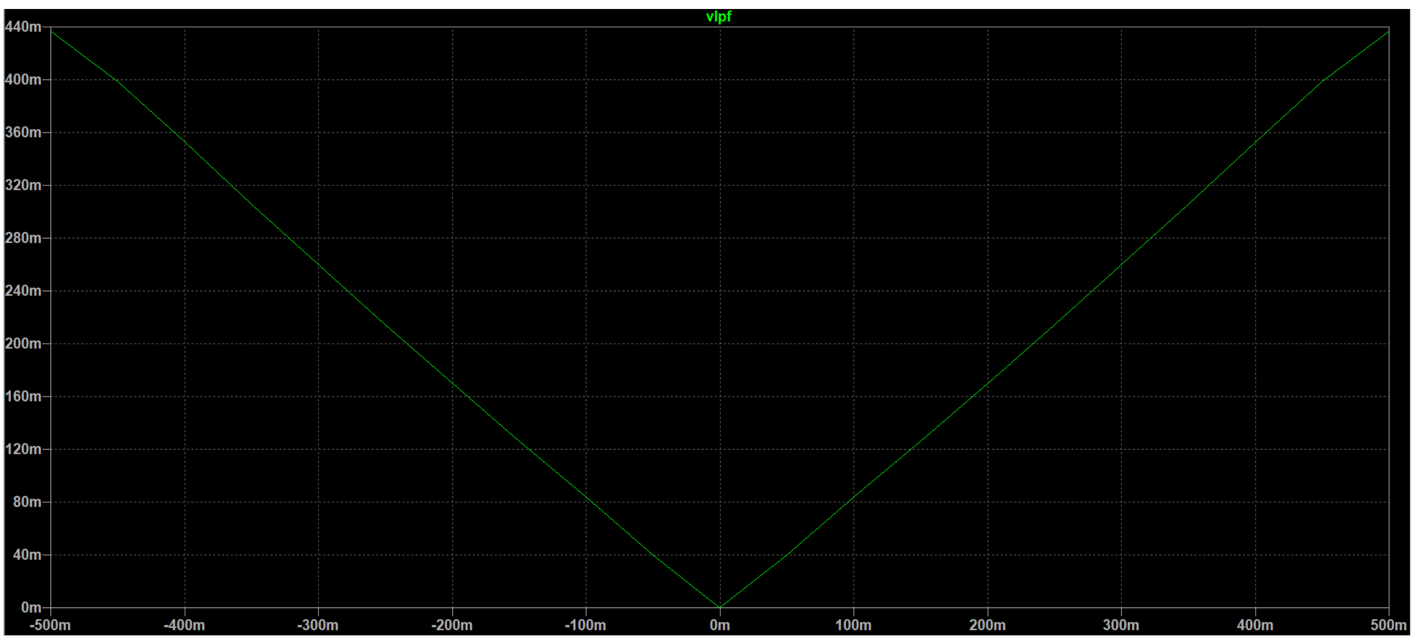

Figure 5: Graph of modulus of e_{LPF} vs x

Graph of e_{LPF} vs x:

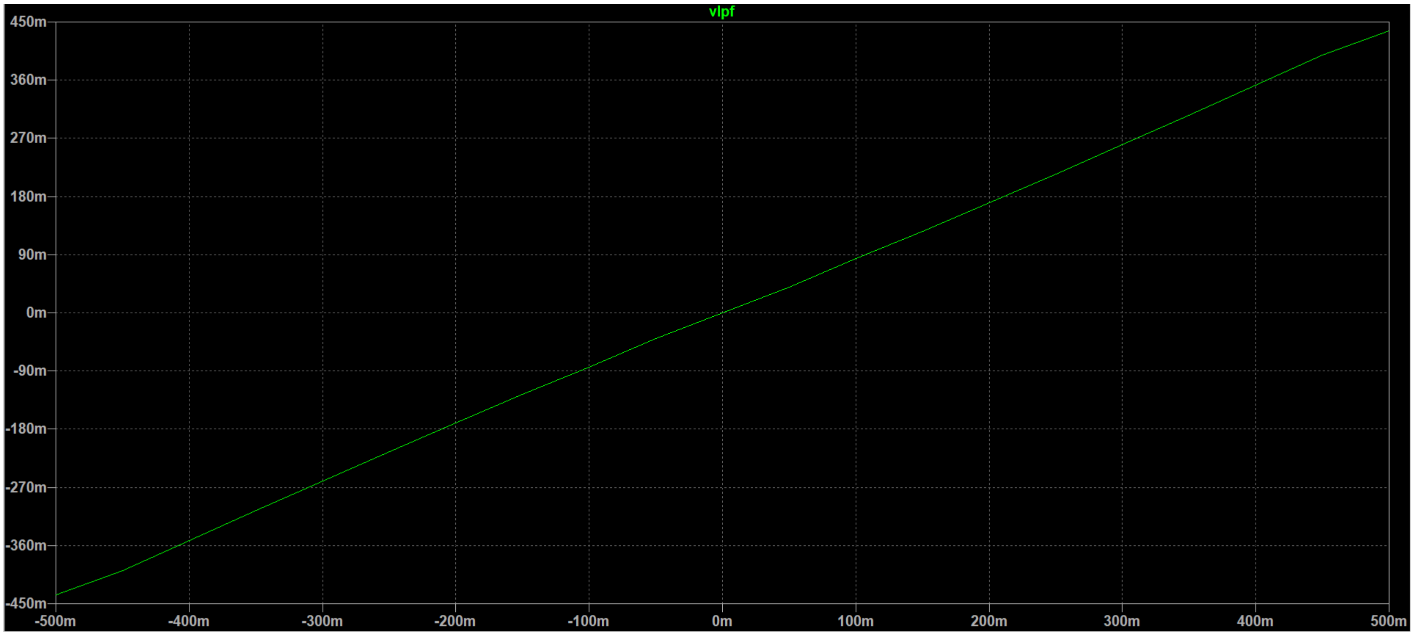

Figure 6: Graph of e_{LPF} vs x

2.5.4 % Non-Linearity

Figure 7: Best Fit Line

x	e_{LPF}	*Predicted Y*	*Residuals*	*% Non-Linearity*
-0.5	-0.43648	-0.436725485	0.000245485	0.028120733
-0.45	-0.3987	-0.393052466	-0.005647534	-0.646934106
-0.4	-0.35275	-0.349379446	-0.003370554	-0.386102333
-0.35	-0.305686	-0.305706427	2.04268E-05	0.002339927
-0.3	-0.259809	-0.262033407	0.002224407	0.254809433
-0.25	-0.214565	-0.218360388	0.003795388	0.434767773
-0.2	-0.170217	-0.174687368	0.004470368	0.512087875
-0.15	-0.126127	-0.131014349	0.004887349	0.559853662
-0.1	-0.084022	-0.087341329	0.003319329	0.380234514
-0.05	-0.0400043	-0.04366831	0.00366401	0.419718221
-6.93889E-17	4.71402E-15	4.70952E-06	-4.70952E-06	-0.000539484
0.05	0.0399847	0.043677729	-0.003693029	-0.423042399
0.1	0.0840635	0.087350748	-0.003287248	-0.37655959
0.15	0.126151	0.131023768	-0.004872768	-0.558183391
0.2	0.170258	0.174696787	-0.004438787	-0.508470226
0.25	0.214542	0.218369807	-0.003827807	-0.438481427
0.3	0.259807	0.262042826	-0.002235826	-0.256117503
0.35	0.305707	0.305715846	-8.84589E-06	-0.001013311
0.4	0.352754	0.349388865	0.003365135	0.385481573
0.45	0.398703	0.393061885	0.005641115	0.646198794
0.5	0.436489	0.436734904	-0.000245904	-0.028168736

Table 1: LVDT: % Non-Linearity

% Sensor Non-Linearity = **0.646198794%**

2.5.5 Inference

1. The emf across L_{s2} is greater when the output is 180°out of phase with the input.
2. The emf across L_{s1} is greater when the output is in phase with the input.
3. When the voltage e_{lpf} is negative, the emf across L_{s2} is greater.
4. When the voltage e_{lpf} is positive, the emf across L_{s1} is greater.
5. The values of inductances of the primary and secondary windings should be chosen carefully such that the sensor is linear
6. The non-linearity of the sensor can be due to the knee voltage of the diode.

2.5.6 Result

We designed an LVDT with signal conditioning circuit and simulated it using L_TSpice. The % Sensor Non-Linearity obtained is 0.646198794%.

2.6 Commercial Model - AML/IEU Industrial Series LVDT Displacement Transducer

2.6.1 Specifications

- **Signal Output**:0-5volt
- **Supply Voltage (unregulated)**:10-24Vdc
- **Supply Current**: 35mA @ 15V
- **Non-Linearity**: <0.50(<0.25 optional)
- **Output Bandwidth (flat)**: 100Hz
- **Zero Temperature Coefficient**: <±0.010%Stroke Range/°C
- **Span Temperature Coefficient**: <±0.030%Stroke Range/ °C
- **Stroke Measurement Range**: ±0.5, ±2.5, ±5, ±10, ±12.5, ±15, ±25, ±50, ±75, ±100, ±125, ±150, ±175, ±200, ±250, ±300, ±400, ±500, ±550 (maximum stroke is ±125 Sprung Loaded Core & Extension)

2.6.2 Applications

AML/IEU Industrial Series LVDT Displacement Transducer can be AC or DC powered and are sealed to IP65 as standard with the option of IP68 making them ideally suited for harsh and demanding applications where conditions are humid, wet, dusty or dirty. Typical applications include process plants, paper mills, and industrial test rigs. The AML/IE industrial displacement transducers are constructed from stainless steel and fitted with a tough cable and can be supplied in a variety of mechanical configurations including captive guided core & extension rod, which is standard, plus spring-loaded core & extension rod with ball-end or guided core & extension with spherical rod-end bearings.The AML/IE is supplied in a variety of packaging formats, enabling engineers to select quickly and precisely, the product required for a particular application.

2.6.3 Signal Conditioner

The signal conditioner chosen is AD598.
Features of AD598:

- Single Chip Solution, Contains Internal Oscillator and Voltage Reference
- No Adjustments Required
- Insensitive to Transducer Null Voltage
- Insensitive to Primary to Secondary Phase Shifts
- DC Output Proportional to Position
- 20 Hz to 20 kHz Frequency Range
- Single or Dual Supply Operation

- Unipolar or Bipolar Output
- Will Operate a Remote LVDT at Up to 300 Feet
- Position Output Can Drive Up to 1000 Feet of Cable
- Will Also Interface to an RVDT
- Outstanding Performance
- Linearity: 0.05% of FS max
- Output Voltage: 611 V min
- Gain Drift: 50 ppm/8 °C of FS max
- Offset Drift: 50 ppm/8 °C of FS max

3 RTD - Resistance Temperature Detector

RTD stands for Resistance Temperature Detector. An RTD is a temperature sensor which measures temperature using the principle that the resistance of a metal changes with temperature. In practice, an electrical current is transmitted through a piece of metal (the RTD element or resistor) located in proximity to the area where temperature is to be measured. The resistance value of the RTD element is then measured by an instrument. This resistance value is then correlated to temperature based upon the known resistance characteristics of the RTD element.

3.1 Equipments Required

1. PT100
2. Instrumentation Module transducer kit TK2941A
3. Decade Resistance Box
4. Heat Bar Control Box/Temperature source
5. Heat Sink
6. Notch scale
7. Calibration tank
8. Voltmeter
9. Thermometer
10. Voltage source
11. Connecting wires

3.2 Theory

RTDs works on the basis of the relationship between metals and temperature. As the temperature of a metal increases, the resistance of the metal to the flow of electricity increases. Similarly, as the temperature of the RTD resistance element increases, the electrical resistance, measured in ohms increases.
The relationship between resistance of the metal and temperature is given as:

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

α , β and γ are constants; t is the temperature to be measured; t_0 is the reference temperature that depends on the metal.

The RTD used in the lab is **PT-100**. It is a platinum rod whose resistance at 0°C = 100 Ω. The resistance of PT-100 is given as:

$$R_{rtd} = R_0(1 + \alpha(t - t_0) + \beta(t - t_0)^2)$$

where, $\alpha = 3.9083 \times 10^{-3}(°C)^{-1}$; $\beta = -5.775 \times 10^{-7}(°C)^{-2}$

We are using the Wheatstone bridge present in the Instrumentation module.The wheatstone bridge has two fixed arms, R_1 and R_2, whose values are fixed as 1 KΩ using the switches. The variable arm of the wheatsone bridge, R_3, is connected to the decade resistance box. The RTD is connected to the unknown arm of the wheatstone bridge, R_4. A 5V power supply is provided and a multimeter is connected across the wheatstone bridge. The RTD and the thermometer are placed in a calibration tank which is placed on a Notch scale. The temperature can be varied along the Notch Scale. It takes some 10 to 15 minutes for the tank temperature to reach the stable state. As, the temperature increases, the RTD resistance also increases. The variable resistance is then adjusted such that multimeter reads zero.

The **0 deflection state** of the wheatstone bridge is given by:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

In our experiment, R_1 is chosen to be equal to R_2. Therefore, at 0 deflection, $R_3 = R_4$.
Here, $R_{rtd} = R_4 = R_3$. Therefore, using the relation between R_{rtd} and temperature, the temperature can be determined.

3.3 Procedure

i) Set the value of R_1 and R_2 as 1 KΩ.

ii) Connect the variable arm to the decade resistance box and the unknown arm to the RTD.

iii) Provide 5V power supply to the Instrumentation module and connect the multimeter.

iv) Note the room temperature from the thermometer.

v) Place the RTD and the thermometer in the calibration tank and wait till it reaches a steady state.

vi) Balance the wheatstone bridge by varying the resistance of the unknown arm using the decade resistance box till the multimeter reads 0.

vii) Note the resistance value and the temperature value.

viii) Repeat the process by increasing the temperature and then plot the graph between R_{RTD} and temperature.

3.4 Simulation

3.4.1 Spice Model

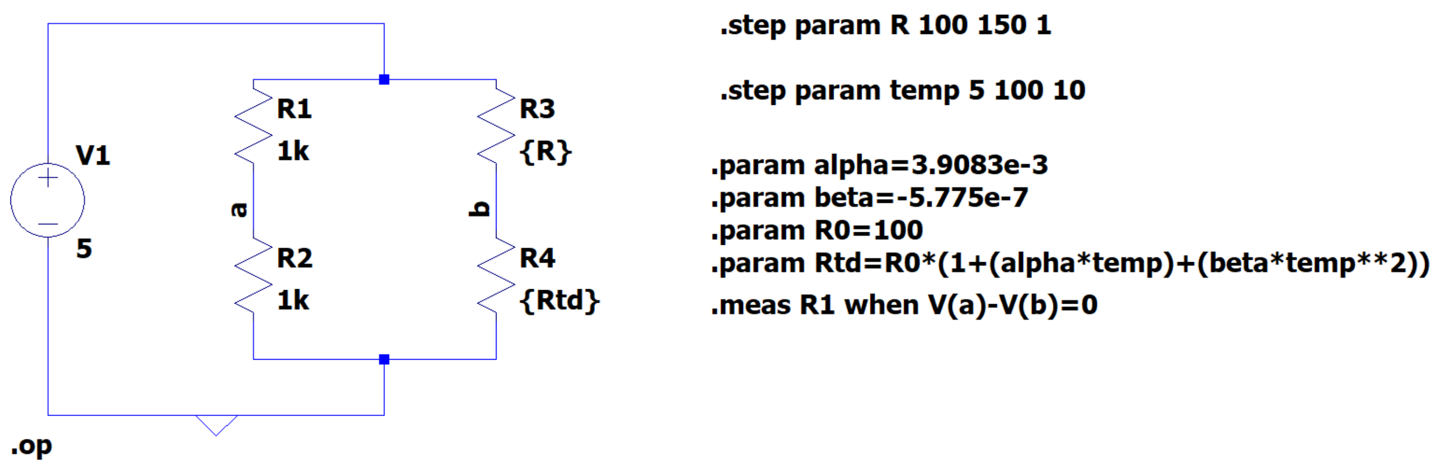

Figure 8: RTD

3.4.2 Design Conditions

We need to simulate a RTD on LTSpice. A wheatstone bridge is constructed using four resistances. R_1 and R_2 are set to be equal to 1 kΩ. The value of resistance R_3 is varied using the **.step param** command in L_TSpice. The resistance at which the voltage across the wheatstone bridge becomes 0 is measured using the **.meas** command.

3.4.3 Simulation Results

Graph of Voltage across wheatstone bridge vs R_3:

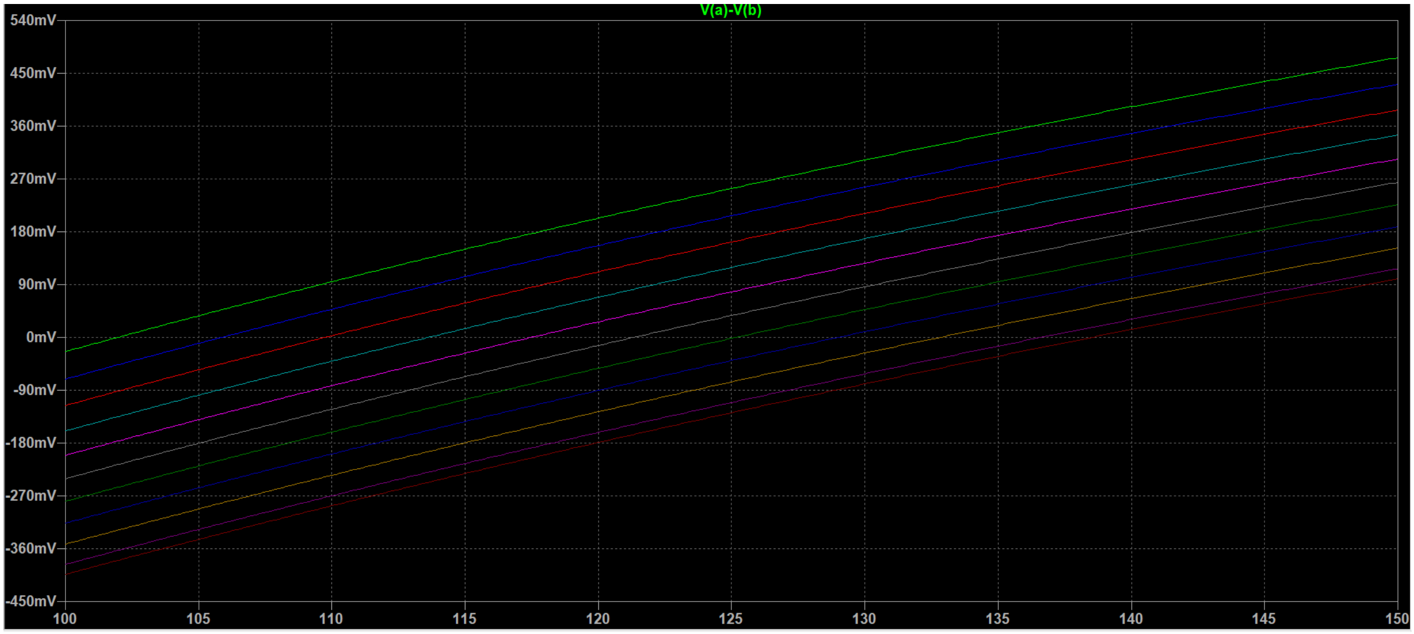

Figure 9: Graph of Voltage across wheatstone bridge vs R_3

Graph of R_3 vs Temperature:

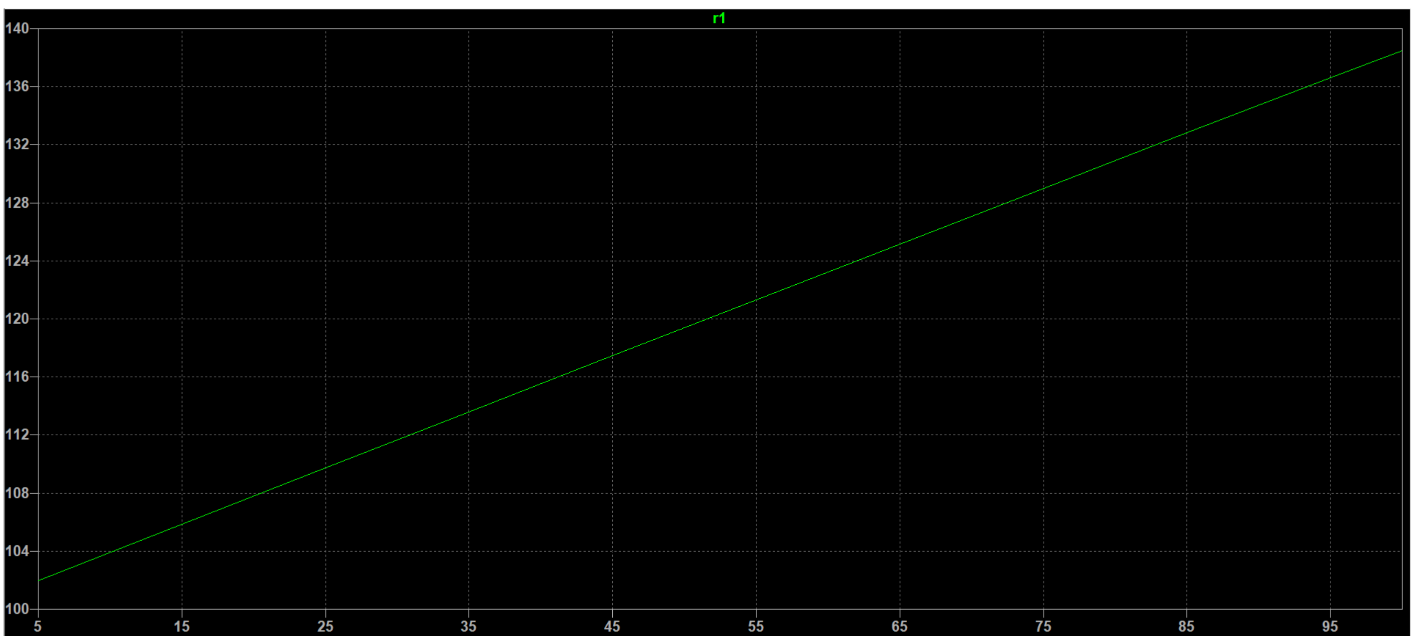

Figure 10: Graph of R_3 vs Temperature

3.4.4 % Non-Linearity

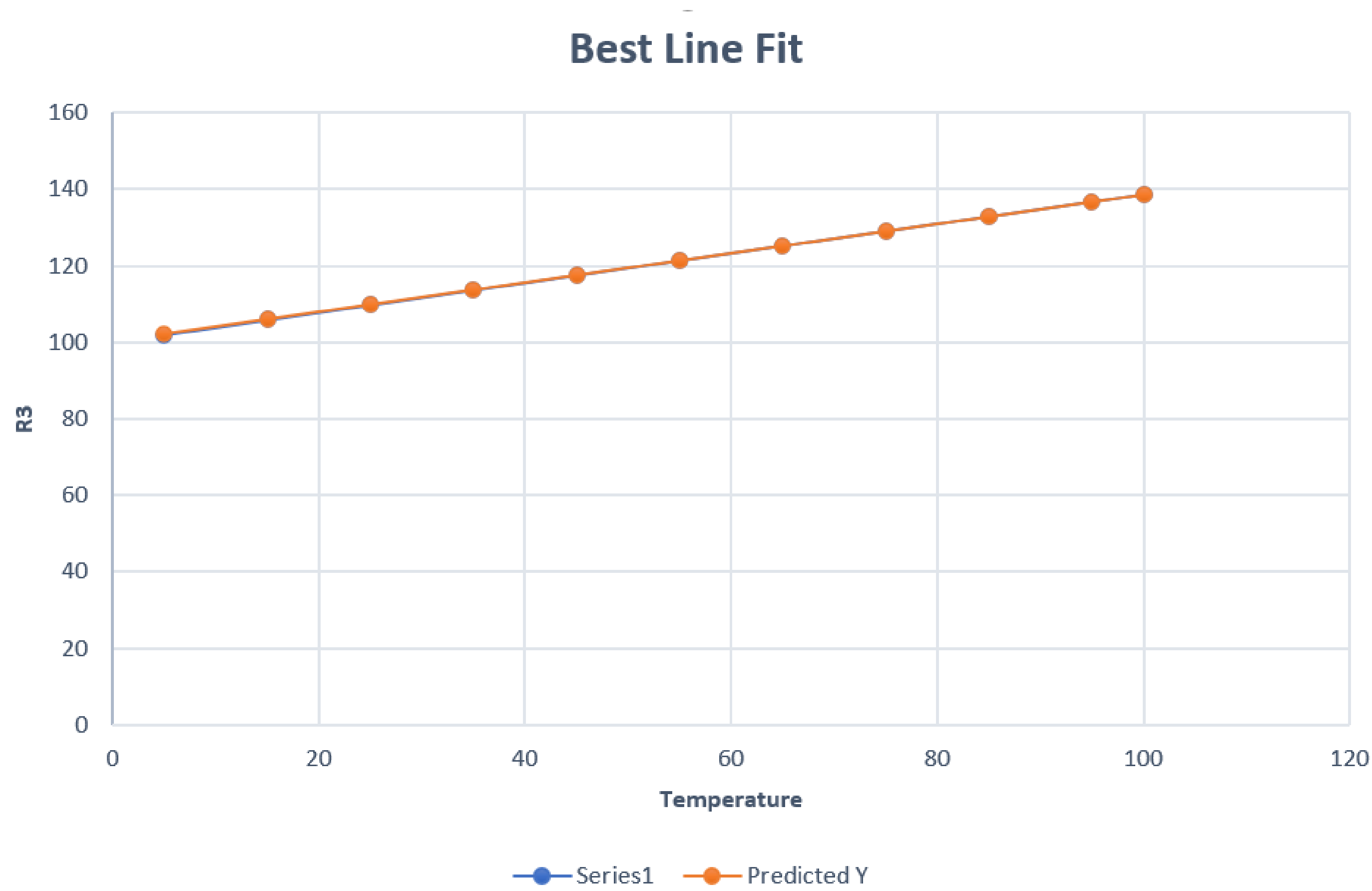

Figure 11: Graph of R_3 vs Temperature

Temperature	*R3*	*Predicted Y*	*Residuals*	*% Non-Linearity*
5	101.953	102.0345423	-0.081542333	-0.223079727
15	105.85	105.8809099	-0.030909935	-0.084561965
25	109.736	109.7272775	0.008722462	0.023862507
35	113.609	113.5736451	0.03535486	0.096722183
45	117.471	117.4200127	0.050987257	0.13948857
55	121.322	121.2663803	0.055619654	0.152161668
65	125.16	125.1127479	0.047252052	0.129269969
75	128.987	128.9591156	0.027884449	0.076284981
85	132.804	132.8054832	-0.001483153	-0.004057542
95	136.609	136.6518508	-0.042850756	-0.117229108
100	138.506	138.5750346	-0.069034557	-0.188861536

Table 2: RTD: % Non-Linearity

% Sensor Non-Linearity = **0.223079727%**

3.4.5 Inference

i) The graph of R_3 vs temperature is a straight line which implies that the RTD is a linear sensor.

ii) The small non-linearity obtained is due to the presence of β.

3.4.6 Result

We designed an RTD with signal conditioning circuit and simulated it using L_TSpice.
The % Sensor Non-Linearity obtained is 0.223079727%

3.5 Commercial Model - PT100

The PT100 is a commonly used industrial temperature sensor. It is known for its capability to measure high range temperature (200°C) with an accuracy of 0.1°C. The constriction of the sensor is also simple and hence it can be used in rugged environments.

3.5.1 Specifications

- **Material Body**: Stainless steel AISI 316L (1.4404)
- **Sensing Elements**: PT100 Platinum Elements per IEC751 (alpha = 0.00385 Ω/Ω/ °C)
- **Accuracy**: ±0.03 °C to ±0.3 °C depending upon class selection
- **Operating Temperature**: from -200 to + 650 °C selection dependant
- **Cable Type**: Selection – PFA-Silicone-PVC-Fibreglass
- **Protection**: IP65
- **Resistance Range**: 1.849K to 39.026K

3.5.2 Applications

- Measure high range Temperatures
- Rugged in construction hence can be used in harsh environments
- Measure duct temperatures
- Can measure a wide range of temperature with decent accuracy

3.5.3 Signal Conditioner

The signal conditioner chosen is DRF-RTD.
The DRF series DIN rail signal conditioners are designed to accept a broad range of input signals, such as ac and dc voltage and current, frequency, temperature (thermocouple and RTD), and process transducers, and provide standard process outputs of either 4 to 20 mA, or 0 to 10 Vdc. The DRF series feature a modern housing design, that is easily mounted on standard 35 mm DIN rails. Connections are safely and securely made through pluggable screw terminal connectors, with

input and output connections on the opposite sides of the module.
Features:

- RTD: 2 or 3 wire 100Ω platinum
- RTD: α=0.00385
- Accuracy: <0.2% full scale
- Linearity: <0.1% full scale
- Thermal Drift: 250 ppm/ °C typical
- Response Time: <250 ms (90% of signal)
- RTD Excitation: 1 Vdc
- Input Impedance: Measured with a "Wheatstone" bridge. Bridge to positive through a 100Ω resistance, Bridge to negative through a 10 KΩ resistance
- Power: 24 Vdc ±10%, 230 Vac ±10% 50/60 Hz, 115 Vac ±10% 50/60 Hz
- Power Consumption: <3.8 VA
- Output: 4 to 20 mA and 0 to 10 Vdc

4 Optical Sensor

4.1 Equipments Required

- Light Transducer Box
- Light Source
- Power Supply
- Instrumentation Module transducer kit TK2941A
- Multimeter
- Colour Filters

4.2 Theory

4.2.1 LDR - Light Dependent Resistor

LDR/photoconductive cell works on the principle of photoconductivity. When light is absorbed by a semiconductor, the number of free electrons and holes increases and hence, the conductivity increases. To cause excitation, the energy of the light striking the semiconductor should be sufficient enough for the electrons to cross the bandgap, i.e., to move from the valence band to conduction band. The LDR has a light sensitive material that is placed on an insulating substrate in a zig-zag shape in order to obtain the required power rating and resistance. Even in the absence of light, there will be a small amount of current due to the thermally generated electron and hole pairs. When the light intensity increases, the resistance decreases.

4.2.2 Phototransistor

A phototransistor converts the incident light into photocurrent. IInstead of providing base current to trigger the transistor, the light rays are used to illuminate the base region. The area of the base and collector region, in case of a phototransistor is quite large, as compared to a normal diode. This is because, greater the amount of light incident on the phototransistor, more the current, it will generate. The output of the phototransistor is taken from the emitter terminal and the light rays are allowed to be incident on the base region.The magnitude og current generated by the phototransistor depend on the light intensity.

4.2.3 Photodiode

The photodiode, under forward bias conditions, will work as an ordinary diode. Under reverse bias conditions, it will behave as a photodiode. When a photon of sufficient energy strikes the diode, it makes electron-hole pairs. If the absorption arises in the depletion region junction, the carriers are removed from the junction by the inbuilt electric field of the depletion region. Therefore, the holes move towards the anode and the electrons move towards the cathode. Hence, a photocurrent is generated. The photocurrent generated is in the order of microampere range.

4.3 Procedure

4.3.1 Intensity Variation Test

i) Use the voltage divider portion of the Instrumentation Module to reduce the supply voltage

ii) Give voltage supply to the LDR.

iii) Connect a voltmeter across the sensor an ammeter in series.

iv) Set the voltage such that the maximum current through the LDR is 8mA.

v) Set the angle of incidence to 0°so that the light falls perpendicular to the sensor.

vi) Now, slowly move the light source from the maximum distance to the minimum distance.

vii) Note the value of current for different values of distance of the light source from the sensor.

4.3.2 Polar Response

i) Change the angle of incidence of light by rotating the mount on the the sensor for a fixed distance of the light source.

ii) Note the current values for different values of angle of incidence.

iii) Plot a graph of current vs angle of incidence.

4.3.3 Spectral Response

i) Place a colour filter in the front of the sensor.

ii) Note the current reading in the ammeter for colour filter of different wavelength.

Repeat the same procedure for phototransistor and photodiode by adjusting the bias voltage. For phototransistors, we need to perform the experiment at different values of bias voltages

4.4 Inference

i) When the light source is moved away from the sensor, the light intensity decreases and hence the current reading in the ammeter decreases and hence the resistance increases.

ii) When the angle of LDR is changed, the light allowed to enter the hole, i.e., the amount of light incident the sensor decreases and hence, the current passing through the sensor decreases.

iii) While using different colour filters, as the wavelength of the colour increases, the current reading in the ammeter also increases.

4.5 Commercial Model - 20mm GL20528 Light Sensitive Photoresistor LDR

The resistance of 20mm GL20528 Light Sensitive Photoresistor LDR changes with the change in the ambient light exposed on the surface of the sensor. As the light on the sensor increases then the resistance across the two leads decreases. Light Dependent Resistor is a type of photocell which finds excellent use in light sensing device application, whether it is automatic outdoor light ON/OFF switch or indoor automatic light switch; moreover, the 12mm LDR or photoresistor sensor works best in both light and dark regions. The photo-resistor is a staple of electronics. If you need a way to sense the level of ambient light, then there is no easier way to do it without an LDR/photo-resistor.

4.5.1 Specifications

- **Diameter (mm)**: 20
- **Spectral Peak**: 560 nm
- **No. of Pins**: 2
- **Dark resistance**: max. 2 kΩ
- **Light Resistance**: 10 – 20 kΩ
- **Maximum Voltage(V)**: 500 VDC
- **Maximum Power(W)**: 0.5
- **Response Time(μs)**: 30
- **Shipment Weight**: 0.085 kg
- **Shipment Dimensions**: $4 \times 3 \times 2$ cm

4.5.2 Applications

Analog Applications:

- Camera exposure control

- Auto slide focus – dual cell
- Photocopy machines – the density of the toner
- Colorimetric test equipment
- Densitometer
- Electronics scales – dual cell
- Automatic gain control – modulated light source
- Automated rear view mirror

Digital Applications:

- Automatic headlight dimmer
- Nightlight control
- Oil burner flame out
- Streetlight control
- Absence/presence (beam breaker)
- Position sensor

4.5.3 Signal Conditioner

LM393 Photosensitive Light-Dependent Control Sensor LDR Module is using a high-quality LM393 voltage comparator. Easy to install using the sensitive type photosensitive resistance sensor the comparator output signal gives a clean and good waveform.

Driving ability is 15mA with the adjustable potentiometer, it can adjust the brightness of the light. Working voltage is 3. 3V to 5V. Where output is a digital switch output. Since this module is sensitive to the light, usually used for detecting the ambient brightness and light intensity.

You can use this board digital output DO port drive relay module directly(our store on sale these relay modules), and can also use as a photoelectric switch. The analog output ao connects with ad module and it can get more precise light intensity value through the ad-converter