Indian Institute of Space Science and Technology

LVDT RTD and Optical Sensors

By:
Nirbhay Tyagi
SC19B091

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1 Aim of the experiment

To analyze, simulate and understand the working of various sensors like LVDT, RTD and optical sensors.

2 LVDT - Linear Variable Differentiable Transformer

The LVDT is a displacement sensor which is used for the measurement of translational and rotational displacement. It is a non-contact measurement device and based on the mutual inductance of inductors. LVDT gives voltage as output and has very high resolution as compared to conventional potentiometer devices which have low life span due to wear and tear. It is mainly used in robotics, machine tools, computerized manufacturing etc.

2.1 Equipments Required

1. LVDT TK294G
2. Function Generator
3. DSO
4. Linear Transducer Test Rig TK294
5. Micrometer
6. Capacitor, 2 resistors(10K Ω) and 2 diodes
7. Bread Board
8. Connecting Wires
9. Multimeter

2.2 Theory

LVDT consists of 3 Windings:

1. Primary
2. Secondary

The two secondary windings are placed equidistant from each other and are identical in every aspect. The windings are fixed and the core moves inside an LVDT.
We excite the primary coil with primary voltage and generate magnetic flux. The flux from the primary gets coupled with secondary winding this induces EMF across secondary winding. When core moves the mutual inductance changes and hence, the flux also changes therefore, the EMF induced also varies.
Let the EMF induced in secondary windings be es_1 and es_2. We connect the negative terminals together and take the output across the positive terminals.

$$e_o = es_1 - es_2$$

LVDT is a linear sensor withing certain limits after which it saturates.

x	M	e	Phase
0	M1 = M2	es1 = es2	NULL Position
>0	M1 >M2	es1 >es2	Eo will be in phase
<0	M1 <M2	es1 <es2	Eo will be out of phase by 180

Table 1: Sign variation of x and eo

The Electrical voltage varies with respect to x.
After applying KVL and Faradays law on the Electrical Equivalent of LVDT, we get:

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

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

Generally, we take sinusoidal signal as input $ep = Asin(\omega t)$ and taking modulus:

$$es_1 = \frac{A\omega M_1}{\sqrt{R_p^2 + \omega^2 L_p^2}} sin(\omega t + \phi)$$

$$es_2 = \frac{A\omega M_2}{\sqrt{R_p^2 + \omega^2 L_p^2}} sin(\omega t + \phi)$$

where, $\phi = 90° - \tan^{-1}(\frac{\omega L_p}{R_p})$
The output will be a sine wave that has a change in phase as well as magnitude as compared to the input wave. There is same phase difference between primary and secondary.
We get different waveforms for different x and the voltmeter can only measure amplitude or rms value but not phase for that we have to use two channel oscilloscope. Mutual inductance depends on the turns linking inductance.

$$M_1 \propto L_1 - x$$

$$M_2 \propto L_2 + x$$

and hence the difference is proportional to x.

$$es_1 = \frac{A\omega |M_1 - M_2|}{\sqrt{R_p^2 + \omega^2 L_p^2}} \pm sin(\omega t + \phi)$$

$$\widehat{e_o} = \pm E_o sin(\omega t + \phi)$$

As, $e_o \propto$ x and therefore, average value of $e_o \propto x$.
For taking the average value of e_o we use a LPF and for taking the mod of the signal we use a half wave rectifier. After conditioning the signal using the half wave rectifier and LPF. we get,

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

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

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

Average value is the DC value and is the 0 frequency component of the signal and we can remove the pulsating portions using an LPF and finally we get the output e_{LPF} proportional to x.
For selecting the value of capacitor we use the cut-off frequency of the LPF. The thevinin resistance of the circuit as seen by the capacitor is 2R which is 20KΩ in this case. Let the input frequency be f so we have to select the value of C such that,

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

2.3 Procedure

1. We give the input to the LVDT as a sinusoidal wave of peak to peak amplitude of 4V and frequency of 20KHz generated by function generator.
2. The output from the secondary windings are connected to DSO along with the input.
3. Using the micrometer we will apply a force on the LVDT arm to move the core present inside.
4. We will lock the micrometer at different different positions and take the readings.
5. Now, we will make the signal conditioning circuit of the LVDT on the breadboard.
6. We will form a half wave rectifier and add a capacitor to it so that it will work as a LPF.
7. We will again move the micrometer to change the position of core and take the readings from the multimeter.

2.4 Inference

1. The DSO is required to observe both the waveforms.
2. There is a phase shift of 180°when it is behind the NULL point or the emf in second secondary coil is greater.
3. There is no phase shift when the emf induced in the Ls1 is more.
4. By using LPF and Half wave rectifier we can use multimeter to observe the average value.
5. Multimeter can detect the rms value but not the phase.

3 RTD - Resistance Temperature Detector

A Resistance Temperature Detector (also known as a Resistance Thermometer or RTD) is an electronic device used to determine the temperature by measuring the resistance of an electrical wire. This wire is referred to as a temperature sensor. If we want to measure temperature with high accuracy, an RTD is the ideal solution, as it has good linear characteristics over a wide range of temperatures.

3.1 Equipments Required

1. PT100
2. Instrumentation Module transducer kit TK2941A or Wheatstone bridge
3. Voltage source
4. Decade Resistance Box
5. Voltmeter
6. Temeprature source or heat source
7. Heat Sink
8. Notch scale
9. Calibration tank
10. Thermometer
11. Connecting wires

3.2 Theory

RTDs work on a basic correlation between metals and temperature. As the temperature of a metal increases, the metal's resistance to the flow of electricity increases. Similarly, as the temperature of the RTD resistance element increases, the electrical resistance, measured in ohms increases. The variation of resistance of the metal with the variation of the temperature is given as:

$$R_T = R_o(1 + \alpha(T - T_o) + \beta(T - T_o)^2 + \gamma(T - T_o)^2 + ...)$$

where, $\alpha, \beta and \gamma are constants that depends on the metal.$
The unit of α is $(°C)^{-1}$ and the unit of β is $(°C^2)^{-1}$ and the unit of γ is $(°C^3)^{-1}$.
We are using **PT-100** in lab which has the equation of the form

$$R_T = R_o(1 + \alpha(T - T_o) + \beta(T - T_o)^2)$$

The values of α and β for PT-100 are $3.9083 \times 10^{-3}(°C)^{-1}$ and $-5.775 \times 10^{-7}(°C)^{-2}$ and the value of R_o for PT-100 is 100 Ω at 0°C.
Putting, the above values in the equation we get,

$$R_{PT-100} = 100(1 + 3.9083 \times 10^{-3}\ T - 5.775 \times 10^{-7}\ T^2)$$

We connect the RTD to the Notch scale between the source and the heat sink and then connect it to the Instrumentation module's wheatstone bridge as R_4. We set the value of R_1 and R_2 as 1 KΩ and take R_3 to the Decade Resistance Box. we connect or supply 5V power to the wheatstone bridge and connect a multimeter between its two arms. The notch scale has different temperature at different notches. maximum at the heat source side and minimum at the sink side.
The RTD is placed in a calibration tank along with a thermometer we take some 10 to 15 minutes for the tank temperature to reach and constant value or in stable state and measure the temperature

from the thermometer. As, the temperature increases the value of the RTD resistance changes and because, of that we will get a deflection or some voltage value in the voltmeter. To get the 0 voltage or deflection in the voltmeter we will change the value of R_3 from the decade resistance box until we see 0 in the voltmeter.
The balance condition or the **0 deflection condition** of the wheatstone bridge is:

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

As, in our experiment we choose $R_1 = R_2$ we get,$R_3 = R_4$ when the voltage on the voltmeter is 0V.
Here we have $R_3 = R_x$ and $R_4 = R_{RTD}$ and from the above equation we get the resistance of the RTD at a particular temperature by using the **0 deflection condition** of the wheatstone bridge which is $R_x = R_{RTD}$.

3.3 Procedure

1. We will make all the connections give 5V power suplly to the Instrumentation module, select the value of resistances and connect the voltmeter.
2. We will measure the room temperature from the thermometer.
3. Then we will try to balance the wheatstone bridge by changing the values of resistance from the decade box till we get Null point.
4. We will put the thermometer and RTD in the calibration tank and wait for some time till it reaches the steady state temperature.
5. We will note the temperature value and balance the RTD by changing the R_3.
6. We will repeat the process by increasing the temperature and then plotting the curve between R_{RTD} and T.

3.4 Inference

1. Taking different values of R_1 and R_2 increases the complexity of calculation.
2. The RTD should be given enough time to reach a stable temperature.
3. Connecting wires will also contribute to the extra resistance.
4. The calibration tank is filled with water that transfers the temperature from the rig to the RTD and thermometer.

4 Optical Sensors

4.1 Equipments Required

1. Multimeter

2. Linear Transducer Test Rig TK294
3. Cell Mount
4. Instrumentation Module transducer kit TK2941A
5. LDR
6. Light Source
7. Power Supply
8. Lens
9. Connecting Wires
10. Light Transducer
11. Different colour sheets

4.2 Theory

4.2.1 LDR

A photoresistor or LDR is an electronic component whose resistance decreases with increasing incident light intensity. It can also be referred to as a lightdependent resistor (LDR), photoconductor, or photocell. It has light sensitive material in **Zig - Zag** shape.
The resistance of the semiconductor is

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

where, ρ is the resistivity, l is the length and A is the cross-sectional area. The resistivity for a semiconductor is given by

$$\frac{1}{\rho} = \sigma = q(\mu_n n + \mu_p p)$$

Here, n is the number of electrons and μ is the mobility. So, the conductivity depends on electron-hole pair.
The light dependent resistor works on the principle of **photo conductivity**. When the light falls on its surface,the material's conductivity reduces and the electrons present in the valence band are excited to the conduction band. For the electron hole pair generation, the photons in the incident light must have energy greater than the **band gap** of the semiconductor material. This makes the electrons to jump from the valence band toconduction band.
When light falls on the LDR it's resistance decreases.

4.2.2 Photodiode

A silicon photodiode is a solid state light detector that consists of a shallow diffused P-N junction. When the top surface is illuminated, photons of light penetrate into the silicon to a depth determined by the photon energy and are absorbed by the silicon generating electron-hole pairs.The electron-hole pairs are free to diffuse throughout the body of the semiconductor photo diode until

they recombine with a hole.
The standard diode equation is:

$$I = I_o \left[exp\left(\frac{qV}{kT}\right) - 1 \right]$$

where I_o, is the saturation current and V is the applied voltage (negative for reverse bias and positive for forward bias).
The average time before recombination is the **minority carrier lifetime**. At the junction there is a strong electric field region known as **depletion region**. It is formed due the potential difference that exists between the P and N part. Those light generated carriers that comes into contact with this field are swept across the junction.If an external connection is made to both sides of the junction a photo current is induced that will flow as long as light falls upon the photodiode.

4.2.3 Phototransistor

Photo-Transistor is a bit like a Photo-Diode in the fact that it detects light waves, however photo-transistors, like transistor are designed to be like a fast switch and is used for light wave communications and as light or infrared sensors. The most common form of photo-transistor is the NPN collector and emitter transistor with no base lead. Light or photons entering the base (which is the inside of the phototransistor) replace the base - emitter current of normal transistors.

4.3 Procedure

1. Set up a the lamp on the bench to act as a light source.
2. Connect the Voltage to the LDR and adjust the voltage to get 8mA at the maximum intensity point.
3. Measure the dark resistance of the LDR.
4. Sensor should be at 0°.
5. Now we will move the cell mount at different distances from the sensor and hence, Intensity changes.
6. We then get the values of distance and corresponding current values.
7. Next, we will change the angle of incidence of the incident light by rotating the mount and keeping distance constant .
8. We will get the value of current through resistance at different angle of incidence.
9. Next, We will fix the distance and change the wavelength of the incident light by covering the opening with different colour sheets.
10. We will get the value of current through the resistor at different wavelengths or different colours.
11. Next we will perform the same experiment for Photodiode and phototransitor.
12. For phototransitor we will change the bias voltage or perform the experiment at different bias voltages.

4.4 Inferences

1. The illumination decreases with increase in distance.
2. As we decreases the illumination the current of LDR decreases.
3. A decreases in current at constant voltage shows an increase in resistance of LDR.
4. As angle increases, the resistance of LDR increases or the current decreases.
5. The maximum current alloud through the LDR is 8mV. We set the Voltage at a given illumination to get 8mV in the ammeter.
6. As wavelength increases, the current decreases.
7. As the wavelength of incident light increases the resistance value decreases.
8. We can observe a similar dependency of current on relative illumination for the photodiode.
9. With increase in illumination, the current through photodiode increases.
10. As angle of incidence increases, the current decreases.
11. As, wavelength of light increases the current increases.
12. The phototransistor also shows similar kind of behaviour.

5 Simulation

5.1 LVDT - Linear Variable Differentiable Transformer

5.1.1 Circuit Diagram

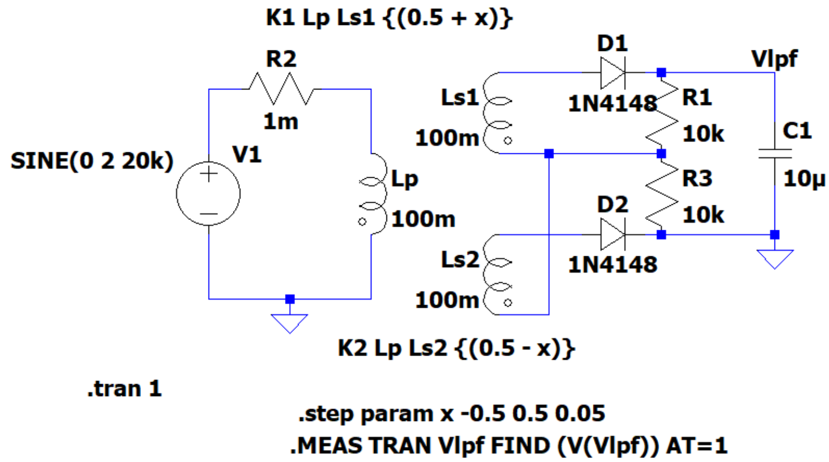


Figure 1: LVDT $L_T Spice$ Model

5.1.2 Concept

The concept is to make a transformer and taking the output of the transformer to a half wave rectifier and then to a LPF. But, here we have to change the windings or effective number of windings or we need **variable Mutual inductance** to mimic a LVDT as the Mutual Inductance changes in LVDT as the core moves.
Making the circuit is an easy task but to mimic the variable Mutual Inductance part is the trick.

5.1.3 Design

We first construct the circuit as mentioned above and see the output at different stages like at the transformer output and then by adding a half wave rectifier and finally adding a LPF. After getting the desired output we will move towards our ultimate aim.
First we tried changing the inductance value by making it variable and then using the .step command but the resultant output was way away from being a linear one.
Therefore instead of changing the inductance of the inductors we tried to change the **Mutual Coupling Coefficient** which gives a graph that is proportional to x after reading about a bit and understanding what mutual coupling coefficient is, we came a relation between Mutual inductance and mutual coupling coefficient that is:

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

and we understand that actually K is proportional to x and in turn with the relation to mutual inductance we get,

$$M \propto x$$

We form a transformer in $L_T Spice$ using inductors and then using the **K statement** we couple the inductors to work as a transformer. We give a sinusoidal signal to the primary winding and couple it with the other two secondary windings.
We use the **.step** function to change the value of x and hence the value of coupling coefficient. We use the **.meas** command to measure the voltage across the capacitor at t= 1 sec.
We performed the transient analysis on the circuit and obtain the plot of e_{LPF} vs time.
Assuming that a change of 1cm in length will change the value of k by 10%.

5.1.4 Simulation Results

The output from the transformer is shown in the Figure 2. We can see that the frequency is same as the input frequency of 20KHz and from the Figure 2 we can also observe that frequency remains the same for different values of x.
After, passing the signal shown in Figure 2 from Half wave rectifier. We can see that only half part remains and the other half is blocked by the diodes. There is also a shift due to the diode voltages.

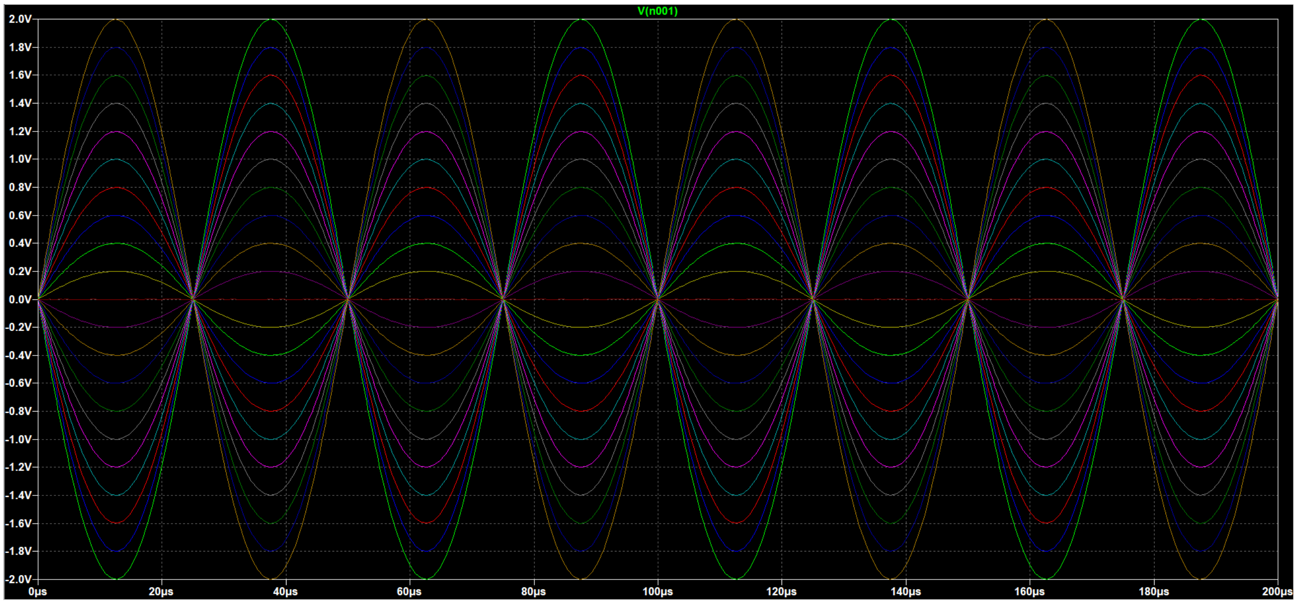


Figure 2: LVDT $L_T Spice$ Simulation Output - Transformer

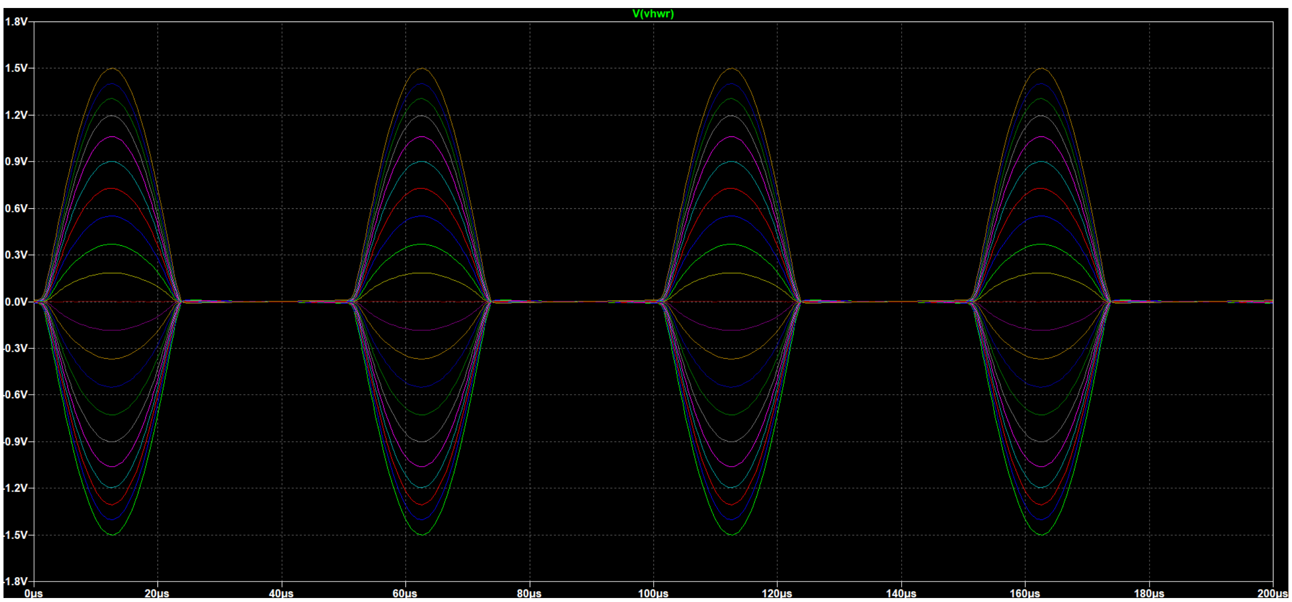


Figure 3: LVDT $L_T Spice$ Simulation Output - Half Wave Rectifier

We then pass the signal shown in Figure 3 from a Low Pass Filter whose cut-off frequency is much less than the input frequency we get a DC signal as shown in Figure 4.

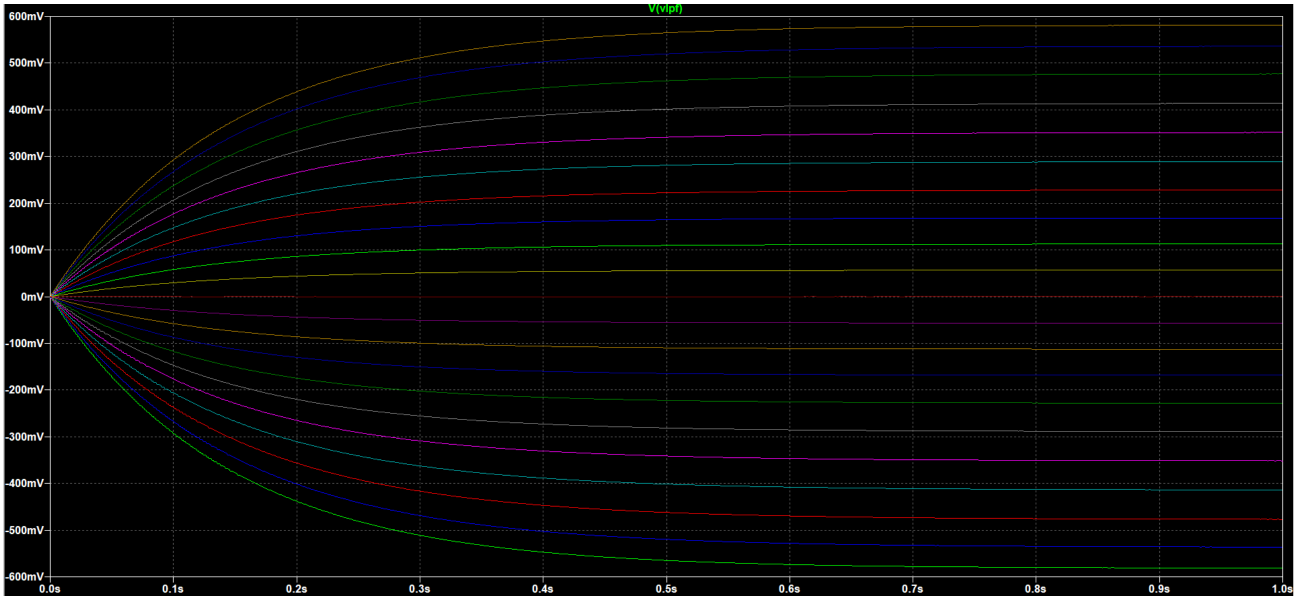


Figure 4: LVDT $L_T Spice$ Simulation Output - LPF

After measuring the DC value from Figure 4. We will plot a graph of $V_{LPF}\ vs\ x$ which is shown in Figure 5. We can see that the graph is approximately linear.

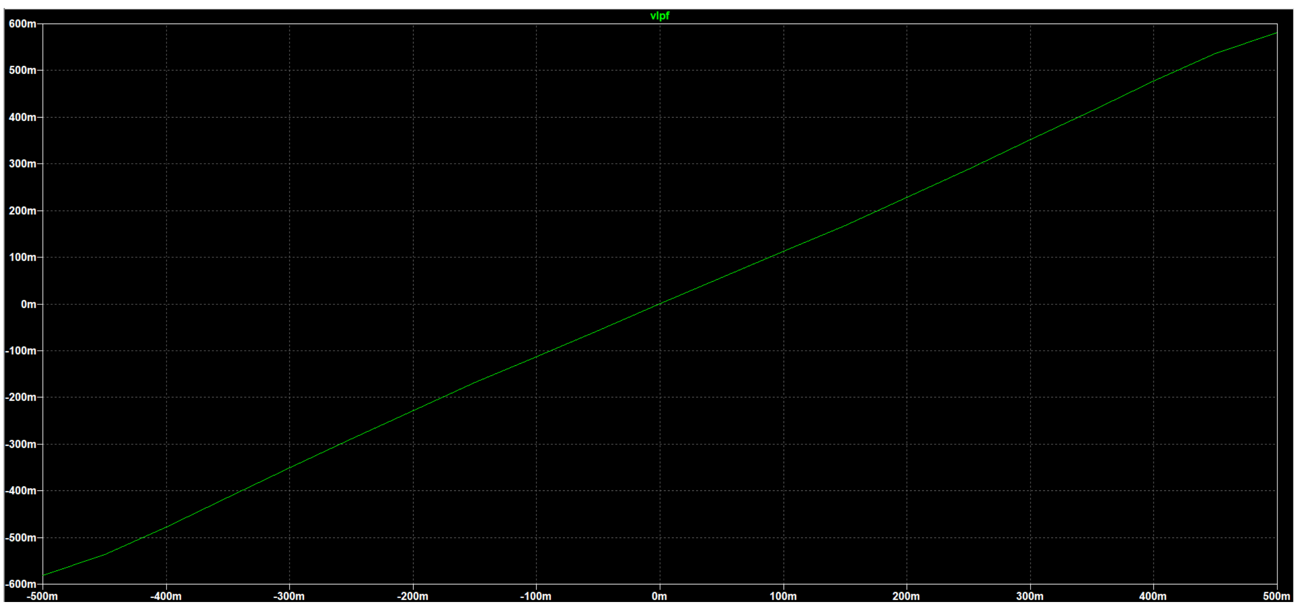


Figure 5: LVDT $L_T Spice$ Simulation Output - $V_{LPF}\ vs\ x$

In the Figure 6 we plot the absolute value of V_{LPF} vs x. We get the standard plot and here we can see the linear operating range of our designed LVDT.

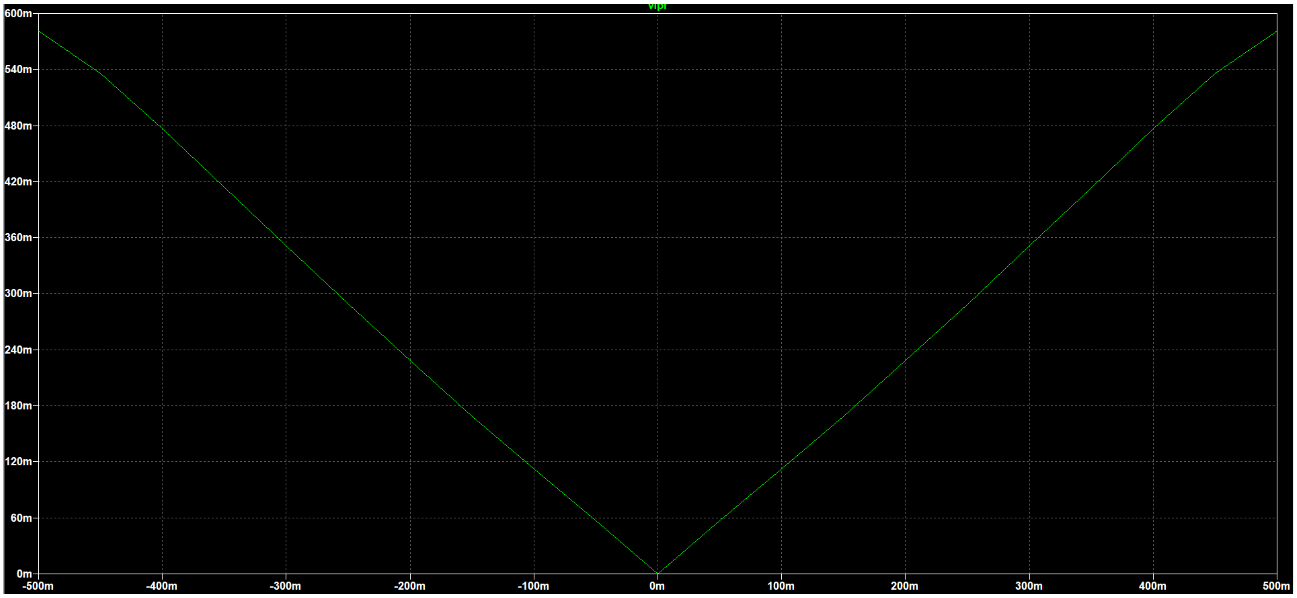
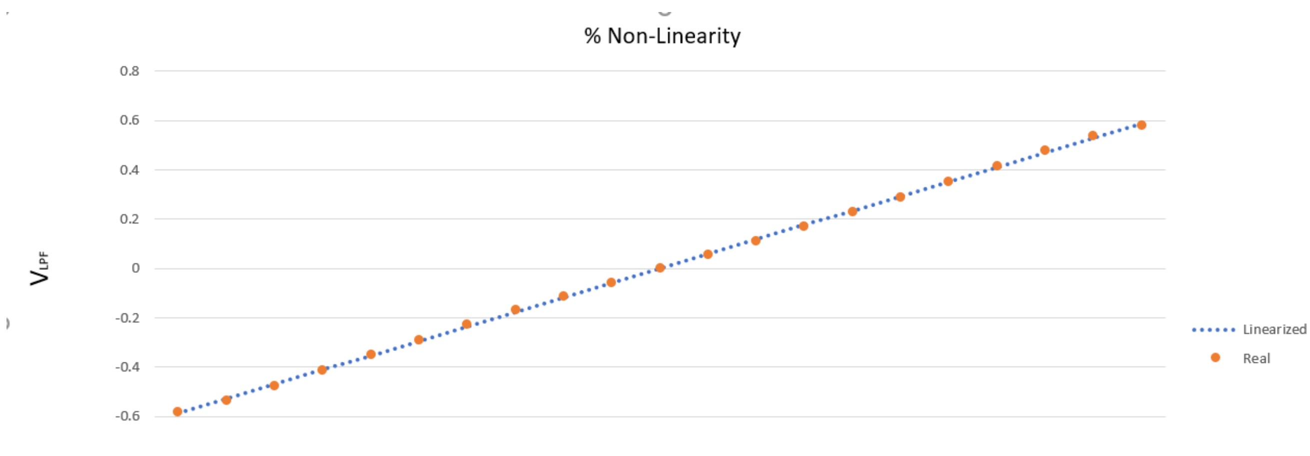


Figure 6: LVDT $L_T Spice$ Simulation Output - $abs(V_{LPF})$ vs x

5.1.5 % Non-Linearity

x	VLPF	Predicted VLPF	***Residuals***	***% Non-Linearity***
-0.5	-0.581324	-0.58709267	0.00576867	0.49618914
-0.45	-0.536165	-0.528383355	-0.007781645	-0.669334158
-0.4	-0.47685	-0.469674039	-0.007175961	-0.61723653
-0.35	-0.413889	-0.410964723	-0.002924277	-0.251530122
-0.3	-0.351497	-0.352255408	0.000758408	0.065234049
-0.25	-0.288761	-0.293546092	0.004785092	0.4115872
-0.2	-0.228146	-0.234836777	0.006690777	0.575503647
-0.15	-0.168449	-0.176127461	0.007678461	0.660458805
-0.1	-0.11265	-0.117418145	0.004768145	0.410129534
-0.05	-0.0565934	-0.05870883	0.00211543	0.181957592
-6.93889E-17	3.79995E-15	4.85714E-07	-4.85714E-07	-4.17785E-05
0.05	0.0566076	0.058709801	-0.002102201	-0.180819744
0.1	0.112633	0.117419117	-0.004786117	-0.411675337
0.15	0.168472	0.176128432	-0.007656432	-0.658564029
0.2	0.228211	0.234837748	-0.006626748	-0.569996263
0.25	0.288829	0.293547064	-0.004718064	-0.405821773
0.3	0.351517	0.352256379	-0.000739379	-0.063597316
0.35	0.413788	0.410965695	0.002822305	0.242759103
0.4	0.476847	0.46967501	0.00717199	0.61689493
0.45	0.536159	0.528384326	0.007774674	0.668734514
0.5	0.581271	0.587093642	-0.005822642	-0.500831464

Table 2: % Non-Linearity Table - LVDT



	-0.5	-0.45	-0.4	-0.35	-0.3	-0.25	-0.2	-0.15	-0.1	-0.05	-6.93889E-17	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Linearized	-0.587	-0.528	-0.47	-0.411	-0.352	-0.294	-0.235	-0.176	-0.117	-0.059	5E-07	0.0587	0.1174	0.1761	0.2348	0.2935	0.3523	0.411	0.4697	0.5284	0.5871
Real	-0.581	-0.536	-0.477	-0.414	-0.351	-0.289	-0.228	-0.168	-0.113	-0.057	4E-15	0.0566	0.1126	0.1685	0.2282	0.2888	0.3515	0.4138	0.4768	0.5362	0.5813

X

Figure 7: Line Fit Plot - LVDT

We calculated the % Non-Linearity by using

$$\%Non\ Linearity = \frac{Residual}{Output\ Span} \times 100 = \frac{y - \widehat{y}}{Output\ Span}$$

The overall % non-linearity of the sensor 0.669334158% .

5.1.6 Inference

1. The coil resistance is selected as to be small to get low voltage drop because of it.
2. The maximum Non-linearity is observed at the edges.
3. The percentage Non-linearity appeared to be symmetrical about NULL point.
4. There is a phase shift of 180°when the emf induces in Ls2 is more.
5. There is no phase shift or the output is in phase with the input Voltage when the emf induced in Ls1 is more.

5.1.7 Results

We designed and simulated the LVTD and its signal conditioning circuit using $L_T Spice$ with a % non-linearity of 0.669334158% . The plots, circuit diagram and non-linearity table are shown above.

5.2 RTD - Resistance temperature Detector

5.2.1 Circuit Diagram

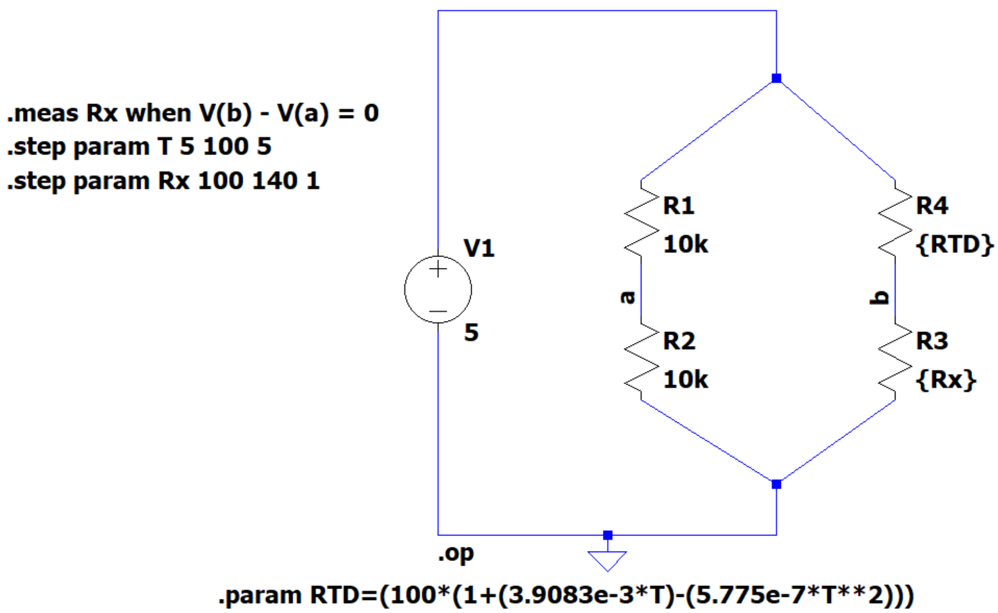


Figure 8: RTD $L_T Spice$ Model

5.2.2 Concept

The concept is to make a resistor or PT-100 whose resistance varies with temperature and then to create a wheat stone bridge with a 5V constant DC supply. But to measure the value of RTD at different temperatures by changing the values of R_3 to mimic the actual working that we did in lab is the tricky part.

5.2.3 Design

We first construct a wheatstone bridge give a 5V power supply. Next, we searched for PT-100 and find the equation which establish the relation between it's resistance and the surround temperature. Using these value we model the RTD after that we use the .step command to change the value of Temperature.
We marks the 2 branches or the ends of the Wheatstone bridge as **a** and **b** and then we use . step command to vary the value of R_3.
As, we know that at 0°C the resistance value is 100 Ω therefore, we start the iteration of R_3 from 100 Ω till 140Ω as the value of RTD resistance is 139 Ω at 100°C with a step of 1.
We plot the graph between V(b) - V(a) against R_3 and from that cure we find the value of R_3 when V(b) - V(a)=0 using .meas command and from here, we get out value of R_{RTD}.

5.2.4 Simulation Results

The output of the simulated circuit is shown in Figure 9. Here, we can see that the voltage difference V(b) - V(a) varies with changing R_x and hence, we measure the value of R_x when the voltage difference is 0.

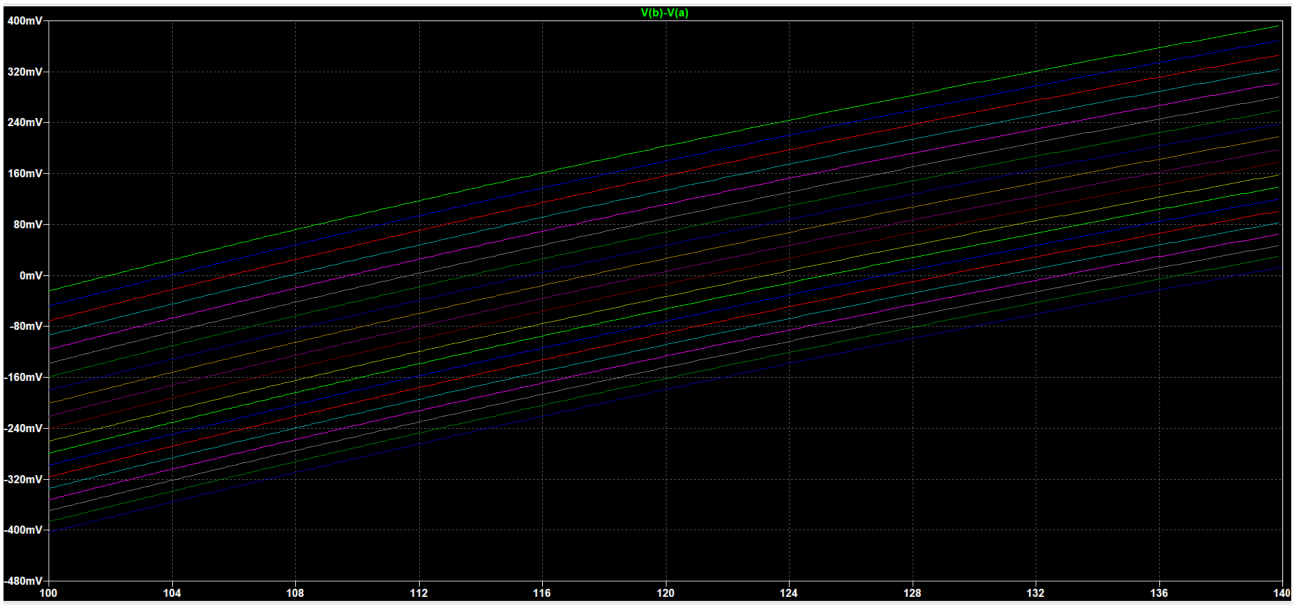


Figure 9: RTD $L_T Spice$ Simulation Output

We calculated the value of R_x from the Figure 9 graph using .meas command and then use those values to plot R_x vs T which is shown in Figure 10.

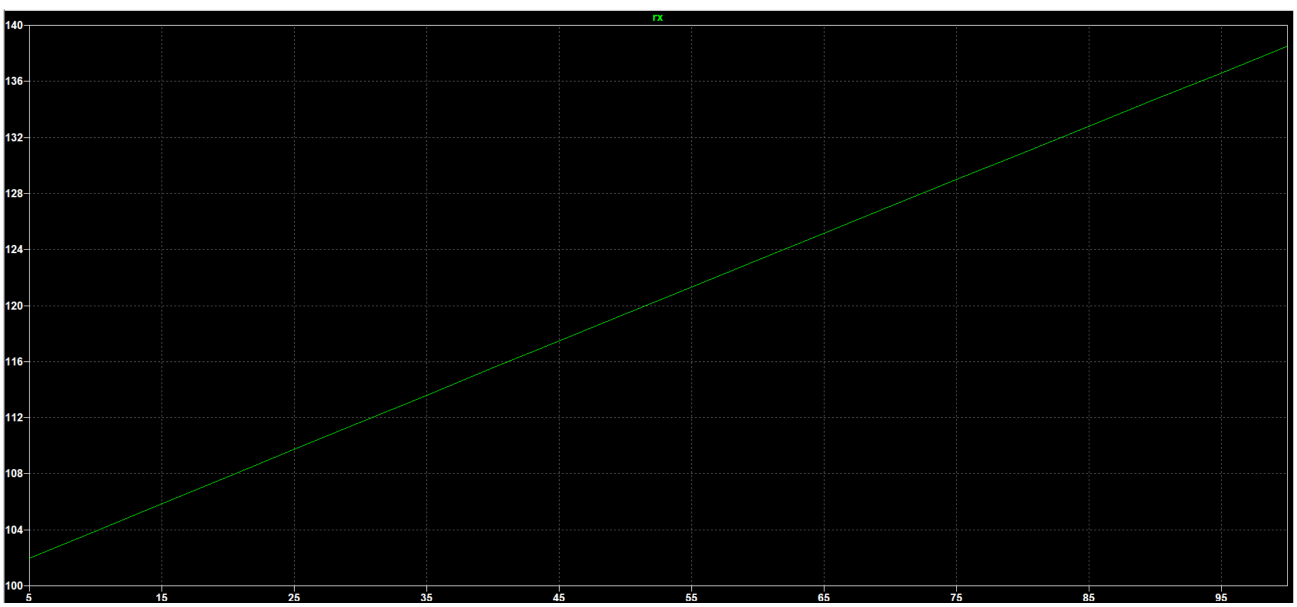


Figure 10: RTD $L_T Spice$ Simulation Output - R_x vs T

5.2.5 % Non-Linearity

Temperature	Resistance (RTD)	Predicted Resistance (RTD)	Residuals	% Non-Linearity
5	101.953	102.0357	-0.0827	-0.22624682
10	103.903	103.9595263	-0.056526316	-0.15464207
15	105.85	105.8833526	-0.033352632	-0.091244581
20	107.794	107.8071789	-0.013178947	-0.036054352
25	109.736	109.7310053	0.004994737	0.013664369
30	111.674	111.6548316	0.019168421	0.052440076
35	113.609	113.5786579	0.030342105	0.083008523
40	115.542	115.5024842	0.039515789	0.108105462
45	117.471	117.4263105	0.044689474	0.122259387
50	119.398	119.3501368	0.047863158	0.130941805
55	121.322	121.2739632	0.048036842	0.131416962
60	123.243	123.1977895	0.045210526	0.123684858
65	125.16	125.1216158	0.038384211	0.105009741
70	127.075	127.0454421	0.029557895	0.080863116
75	128.987	128.9692684	0.017731579	0.04850923
80	130.897	130.8930947	0.003905263	0.010683838
85	132.804	132.8169211	-0.012921053	-0.035348816
90	134.708	134.7407474	-0.032747368	-0.08958873
95	136.609	136.6645737	-0.055573684	-0.152035905
100	138.506	138.5884	-0.0824	-0.225426094

Table 3: % Non-Linearity Table - RTD

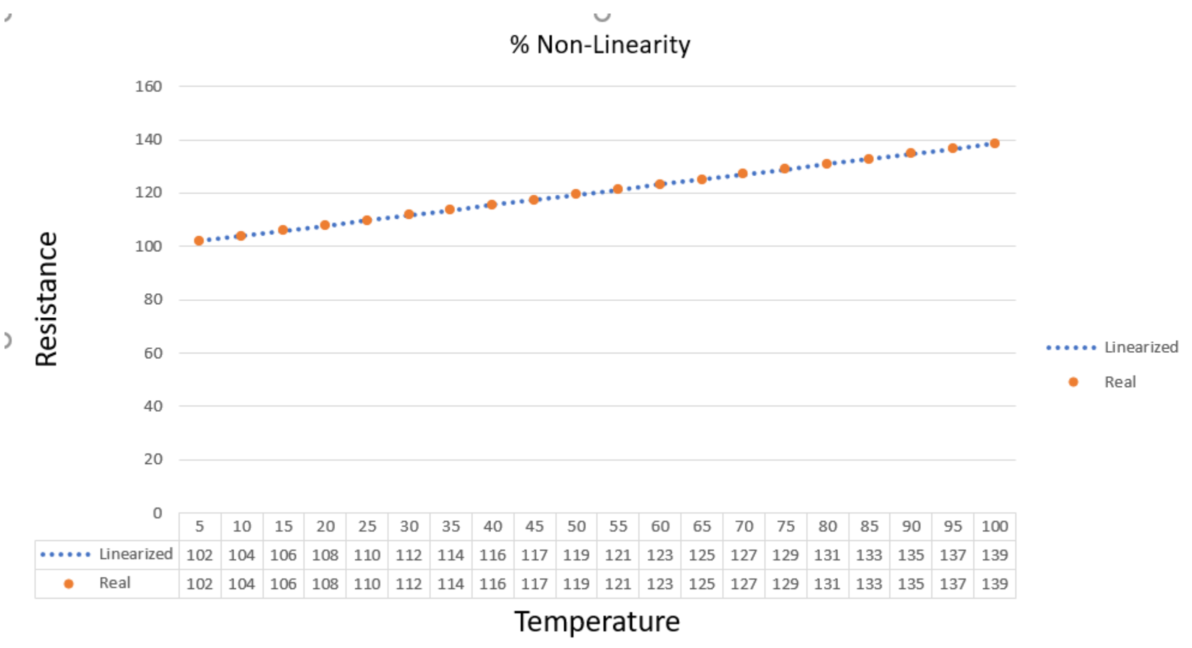


Figure 11: Line Fit Plot - RTD

We calculated the % Non-Linearity by using

$$\%Non\ Linearity = \frac{Residual}{Output\ Span} \times 100 = \frac{y - \widehat{y}}{Output\ Span}$$

The overall % non-linearity of the sensore 0.22624682% .

5.2.6 Inference

1. The graph is linear but the non-linearity arises due to the fact that we designed or mode the PT-100 as non-linear.
2. As, PT-100 is modelled to be non-linear we still get a linear cure this is because the value β is small.
3. The least count of R_3 is 1Ω thats'why we used the graph of V(b)-V(a) v/s R_3 to find the exact value of R_3.

5.2.7 Results

We designed and simulated the RTD and its signal conditioning circuit using L_TSpice with a % non-linearity of 0.22624682% . The plots, circuit diagram and non-linearity table are shown above.

6 Commercial Models

6.1 LVDT - Linear Variable Differentiable Transformer

We choose 813 Series AC/AC LVDT of Sentech INC. The 813 series LVDT is suitable for most applications. Combined with its rugged construction, not only does it offer high performance and reliability but will also resist the shocks and vibrations occurring in most industrial environments.

6.1.1 Specifications

LVDT 813-00-05000
TECHNICAL SPECIFICATIONS @ 2.5KHz

Linear Range - ±5.000 $inches$
Sensitivity - 0.15 $mV_{out}/mil/V_{in}$
Coil Length "A" - 18.00$inches$
Coil Length "B" - 7.00$inches$

PERFORMANCE

Non-Linearity - ±0.25% $of\ Full\ Scale$
Operating Temperature Range - (-50°C to 150°C)

ELECTRICAL

Input Voltage - 3 Volts AC RMS (Nominal)
Input Frequency - 400Hz ti 10KHz
Null Voltage - Less than 0.5% of Full Scale Output

6.1.2 Applications

The application of above LVDT are X, Y, Z stage position feedback, Wire-die bonding machines, Cylinder position feedback, Voice coil testing, Materials testing machines, Space restricted installations, etc.

6.1.3 Signal Conditioners

The signal conditioner is AD598 of Analog circuits.The AD598 is a complete, monolithic Linear Variable Differential Transformer (LVDT) signal conditioning subsystem. It is used in conjunction with LVDTs to convert transducer mechanical position to a unipolar or bipolar dc voltage with a high degree of accuracy and repeatability.
The features of the signal conditioner are that it contains a Single chip, contains internal oscillators. No adjustments are requered and it is also insensitive to Transducer Null Voltage. It can work on either single or dual power supply and can give either unipolar or bipolar output. Position output can drive up to 1000 Feet of cable.
It also has Outstanding Peroformance. It provides:
Linearity - 0.05% of FS max
Output Voltage - ± 11V min
Frequency Range - 20Hz to 20KHZ

6.2 RTD - Resistance temperature Detector

We choose PT-100 RTD sensor. The PT100 sensor is just like a variable resistor, whose resistance varies with respect to the environment temperature. There are many types of PT100 sensors, the one we use here is a two wire one.

6.2.1 Specifications

Platinum Resistant Thermometer (PRT)

Temperature Range: -200°C to 850°C
Resistance Range: 100Ω to 1KΩ
Accuracy: ±0.1°C
Nominal Resistance: 100Ω at 0°C
Sensitivity: +0.4Ω/°C

6.2.2 Applications

The PT-100 measures high range temperatures and is used in rugged in construction hence can be used in harsh environments, measure duct temperatures can measure a wide range of temperature with decent accuracy. The applocations of RTD are for sensing the over the temperature of amplifiers, transistor gain stabilizers, to measure the engine temperature, an oil level sensor, intake air temperature sensors, etc.

6.2.3 Signal Conditioners

The signal conditioner is ADS1247/48 of Texas Instruments. It has on chip Oscillator, temperature sensor, burnout detector,dual matched current DACs(50 - 1500μA).

The features of the device are as follows:
• 2/4 Differential or 3/7 Single-Ended
• True Bipolar ± 2.5V or Unipolar 5V
• Max Data Rate – 2kSPS
• Low Noise PGA: 40nV @ G = 128
• 50/60Hz Simultaneous Rejection Mode (20SPS)

6.3 Optical Sensors

We choose **GL0056 LDR** sensor. The GL series of photoresistors or light-dependent resistor (LDR) or photocell which 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 and dark activated switching circuits.

6.3.1 Specifications

Model: GL5506
Maximum Voltage: 150v DC
Maximum Wattage: 100mw
Spectral Peak: 540nm
Light Resistance: 2K to 5K ohm
Dark Resistance: 0.2M ohm
Response Time (ms): Up: 20/ Down: 30
Material: Carbon
Size: 5 x 3mm/0.2 x 0.12”

6.3.2 Applications

There are many uses of a LDR. The LDR found it’s applications in Photoswitch, Photoelectric Control, Auto Flash for Camera, Electronic Toys, Industrial Control, etc.

6.3.3 Signal Conditioners

A typical signal conditioner of a LDR can be easily formed using an Opamp and configuring it as a Differential Amplifier. When the light level sensed by the LDR falls below a reference the output from the op-amp changes state activating the relay and switching the connected load. The hysteresis of the two switching points is set by the feedback resistor Rf can be chosen to give any suitable voltage gain of the amplifier.

7 Refrences

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