User's Manual

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER

Model: LVDT-01

(Rev : 01/04/2010)

Manufactured by:

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LIMITED WARRANTY

Techno Instruments warrants this product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. Techno Instruments will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. This warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of manufacturing defect or improper use by the customer shall be made solely by Techno Instruments. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packaging of the equipment for return shipment will not be covered by the warranty). Shipping costs for returning the equipment, after repair, will be paid by Techno Instruments.

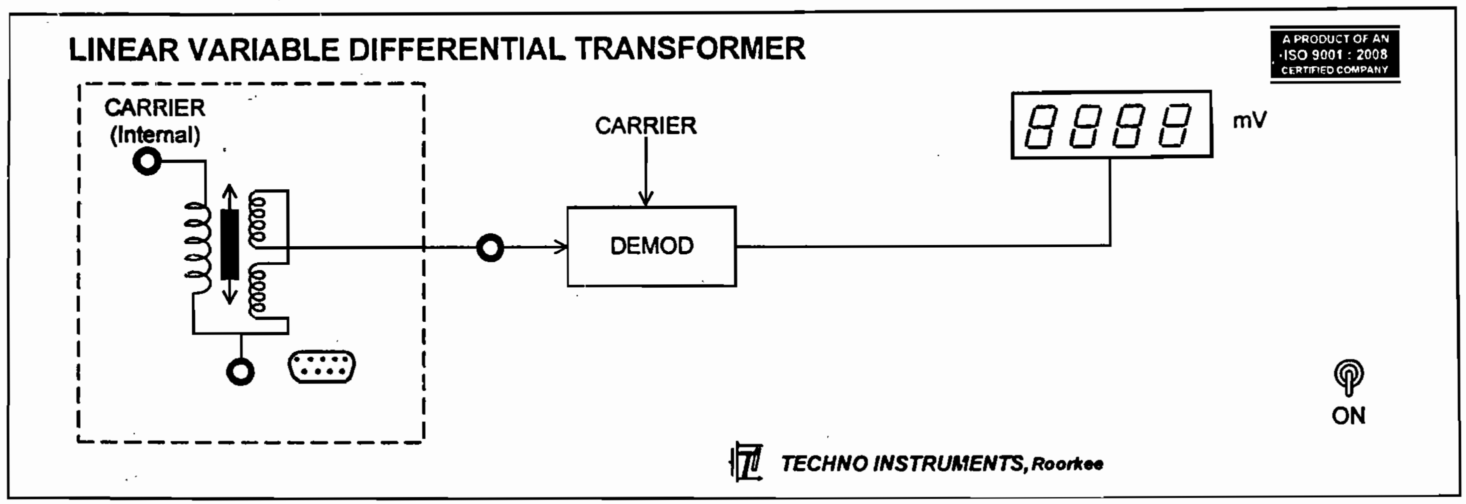
EQUIPMENT RETURN

Should this product have to be returned to Techno Instruments, for whatever reason, notify Techno Instruments BEFORE returning the product. Upon notification, the return authorization and shipping instructions will be promptly issued.

Note : No equipment will be accepted for return without an authorization.

When returning equipment for repair, the units must be packed properly. Carriers will not accept responsibility for damage by improper packing. To be certain the unit will not be damaged in shipment, observe the following rules:

1. The carton must be strong enough for the item shipped.
2. Make certain there is at least two inches of packing material between any point on the apparatus and the inside walls of the carton.
3. Make certain that the packing material can not displace in the box, or get compressed, thus letting the instrument come in contact with the edge of the box.



Panel Diagram of Linear Variable Differential Transformer. LVDT-01

1. OBJECTIVE

To study the performance characteristics of a linear variable differential transformer

2. BACKGROUND SUMMARY

The linear variable differential transformer (LVDT) is a linear displacement transducer. Fig.1 shows the schematic diagram of such a transducer. It consists of three coils - Primary, P; Secondary 1, S_1; and Secondary 2, S_2 wound on a non-magnetic former. A core, C, of some magnetic material - typically soft iron, is placed inside the coil and has suitable mechanical arrangement to allow displacement in the axial direction. An ac signal e_c, called carrier, is connected to the primary which induces voltages e_{s1}, and e_{s2} in the two secondaries. For perfectly symmetrical secondaries, with the core placed centrally, the output signal given by $e_o = e_{s1} - e_{s2}$, is zero. A displacement of the core on either side causes magnetic asymmetry with unequal voltages induced in the secondaries. This results in a non-zero output voltage. Notice that the output voltages on two sides of the null position will be 180° out of phase with respect to each other. The phase relationship between the output signal and the carrier is an indication of the direction of core movement from the centre position. A typical input displacement, x Vs. output voltage e_o, characteristics of the LVDT is shown in Fig. 2. The linear range of commercial LVDT's may be from fraction of a mm to few hundred of mm depending upon their construction and application. The sensitivity may typically be a few tens of mV per mm. The high sensitivity, good linearity, large range, infinite resolution and contactless operation are the important features of LVDT's which have resulted in a large number of diverse applications of these transducers. Some examples of applications include pressure measurement, force measurement, acceleration, torque measurement and vibration sensing.

A residual voltage is usually observed at the zero position of the core. This voltage, though very small, is due to incomplete magnetic or electrical balance, and is normally at the carrier frequency.

The mechanical force needed to move the core depends on its position, viz. minimum at the central or zero position and maximum at the two ends. The actual force is however quite small since the primary current in most designs is kept small to avoid heating of the coils. In the same way, the output impedance of the LVDT is also dependent on the position of the core and it is therefore desirable to connect a high impedance circuit at its output to minimise LVDT loading.

For zero loading, the LVDT output may be shown to be given by

$$e_O = e_C.\frac{s(M_1 - M_2)}{R_p + sL_p} \approx e_C.\left[\frac{(M_1 - M_2)}{L_p}\right], \text{for } sL_p >> R_p$$

where,

e_c is carrier amplitude; M_1, M_2 are Mutual inductance's between primary and the two secondaries. They are functions of x, the displacement; R_p, L_p are resistance and inductance of the primary coil.

Thus e_o is proportional to $(M_1\text{-}M_2)$ and also to the displacement, x of the core from the centre point.

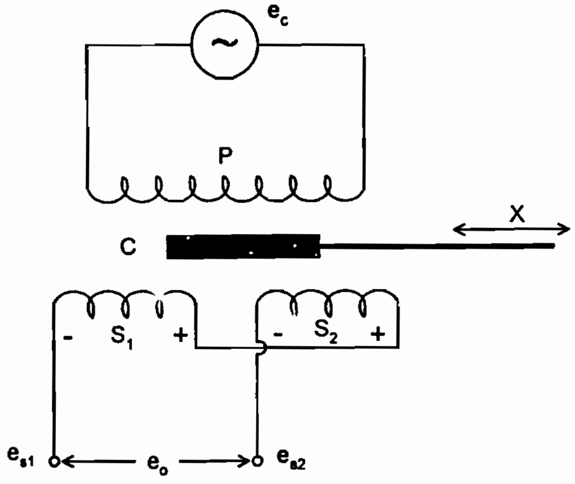


Fig. 1 Schematic Diagram of the LVDT

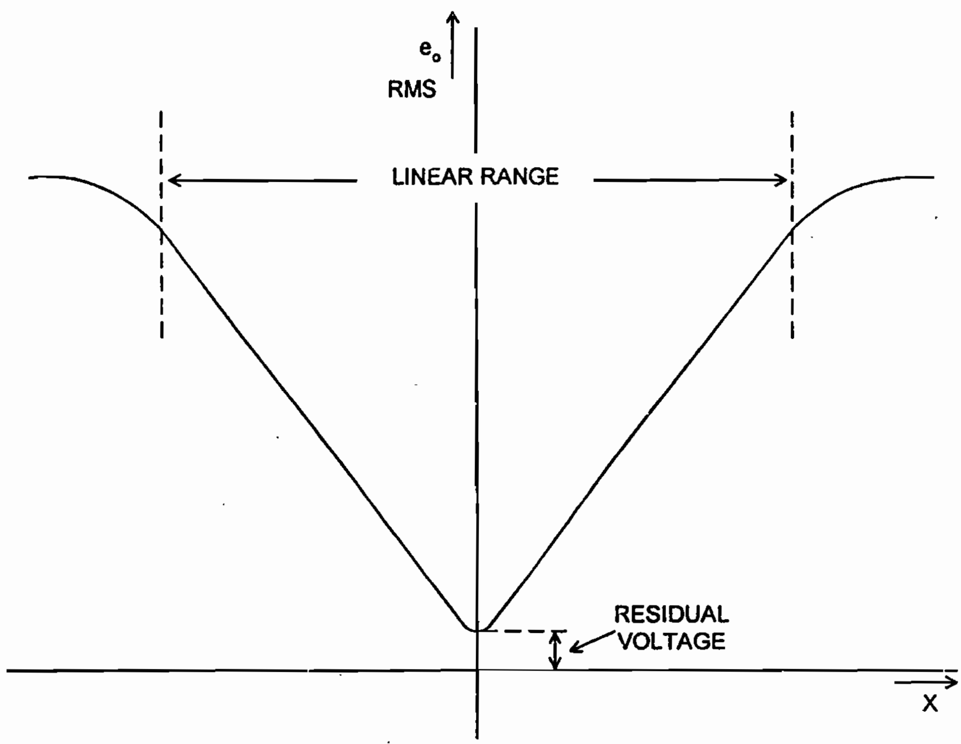


Fig. 2 Input-Output Characteristics

Assuming the carrier as $e_c = a.\cos(\omega_c t)$ and a time varying displacement x(t), it can be shown that $e_0 = 2a.x(t).\cos(\omega_c t)$, which is a suppressed carrier amplitude modulated signal, the carrier being cancelled by the series opposition connection of the two secondaries.

The process of demodulation consists of multiplying the above signal by the carrier, i.e.,

$$e_d' = \{2a.x(t).\cos \omega_c t\}.\, b \cos \omega_c t$$

$$= a\, b.x(t)\, [1 + \cos 2\omega_c t]$$

A low pass filter will recover the displacement information from above to yield $ed \cong a\, b\, x(t)$

In the present unit the balanced modulator/demodulator IC LM 1496 is used to derive a d.c. voltage proportional to the displacement of the LVDT and the same is read on the panel meter.

3. SYSTEM DESCRIPTION

The experimental set-up consists of the following two parts :

3.1 Mechanical Unit

It consists of the LVDT and provisions for fine movement of the core. The soft iron core coupled to a threaded rod is moved by a thumbwheel arrangement. The movement of plastic rod is guided by a perspex block which is constrained to move over a notch in the base plate. This ensures a smooth play-free movement. The block also acts as a marker for reading the displacement on a mm scale. The whole unit is enclosed in a metallic box with transparent top. It is connected to the electrical main unit via a 5 core cable.

3.2 Main Unit

The electronic circuits in the unit, include the carrier source, signal amplifier, demodulator, a 3½ digit panel meter and IC regulated power for the whole unit. It is connected to the mechanical unit through a D-type connector. The screen printed panel of the main unit clearly describes the overall system. The specifications and features of the various subsystems are given below:

Mechanical Unit

Core Displacement	: ± 50 mm (maximum)
Enclosure	: 450 mm x 100 mm x 70 mm with a transparent top for viewing

Main Unit

Carrier frequency	: (4.5 KHz –5.5 KHz)
Carrier voltage	: (2 V – 2.5 V) rms
LVDT output	: (0.8 V to 1.3V) rms for max. displacement
Demodulator output	: (0.130 V to 0.180 V) d.c. for max. displacement
Display	: 3½ digit, 12 mm height
Internal Supplies	: IC regulated
Operating voltage	: 220V, 50 Hz.

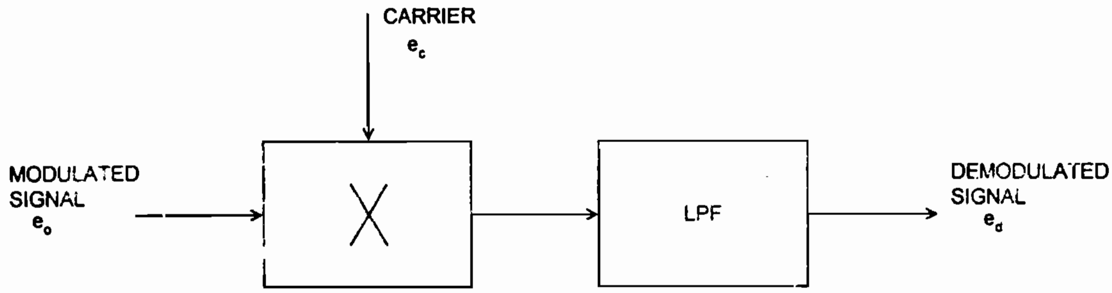


Fig. 3 Demodulation Process

4. EXPERIMENTAL WORK

The experiments mainly comprise of determining the LVDT constant and the extent of linear operating range. This may be done with both the balanced modulated output as well as the demodulated output. In addition some idea of linearity and residual voltage in the balanced condition may also be obtained.

4.1 LVDT with a.c. output

- Plug in the mechanical unit, connect the CRO to display e_0. Use e_c as an external trigger source - this ensures a steady display even for a very small value of e_0 near the balance point. Switch on the system.
- Observe the 180° phase change in e_0 as the core is moved through the balance point.
- Starting from the balance point move the core on either side by small amounts, say 5 mm, and record the amplitude of e_0. This may be done using a CRO or more accurately by using a true rms voltmeter*.
- Plot e_0 vs. displacement, x, and obtain from it
  - (i) LVDT constant $\Delta e_0/\Delta x$ in the linear range
  - (ii) Linear range in cm
  - (iii) Residual voltage at balance point

4.2 LVDT with demodulated output

- Plug in the mechanical unit and connect the DVM to the demodulator output socket. Switch on the system.
- Starting from one end move the core in small steps, say 5 mm, and record the demodulator output, e_d.
- Plot e_d vs. displacement x. Note that the output e_s changes sign while crossing the balance point. Hence the information regarding the direction of movement is retained.
- Obtain from the plot
  - (i) LVDT Coefficient $\Delta e_0/\Delta x$ in the linear range
  - (ii) Linear range in cm

* e.g. type ACM-102 manufactured by our sister concern M/s SES Instruments Pvt. Ltd., Roorkee.

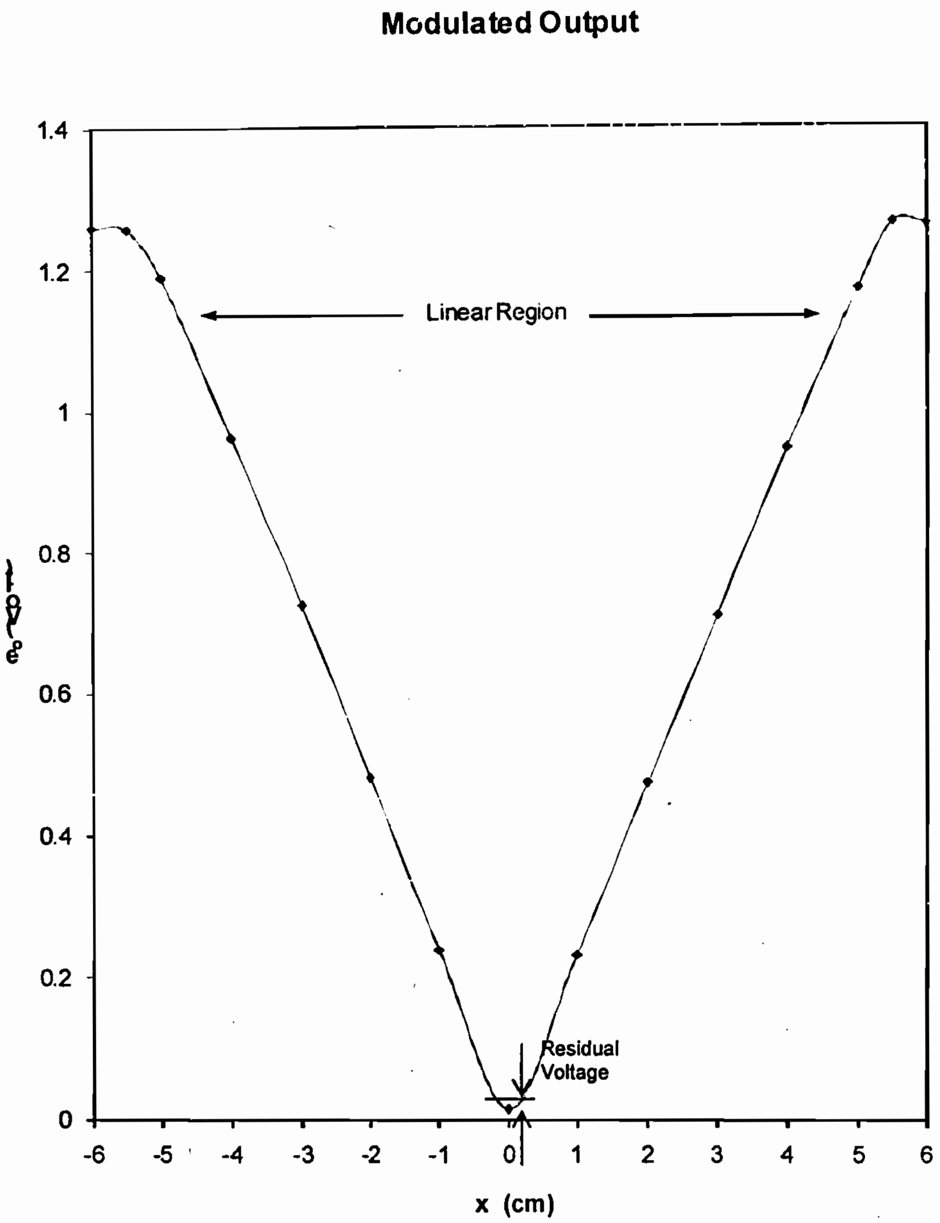


Fig. 4 Input - Output Characteristics of the LVDT

5. TYPICAL RESULTS

Given below are the typical results obtained on the prototype. Fig. 4 & 5 shows the respective plots. The actual results may however vary from unit to unit.

S. No.	Displacement, x (cm)	Modulated output, e_o (Volt)	Demodulated output, e_d (mV)
1.	- 6.00	1.260	-183.0
2.	- 5.50	1.258	-186.3
3.	- 5.00	1.190	- 169.8
4.	- 4.00	0.964	- 131.8
5.	- 3.00	0.726	- 98.7
6.	- 2.00	0.483	- 65.6
7.	- 1.00	0.239	- 32.4
8.	0.00	0.015	+ 00.2
9.	+ 1.00	0.232	+ 32.6
10.	+ 2.00	0.476	+ 65.5
11.	+ 3.00	0.713	+ 97.3
12.	+ 4.00	0.950	+ 129.4
13.	+ 5.00	1.174	+ 155.7
14.	+ 5.50	1.266	+ 163.7
15.	+ 6.00	1.264	+ 163.9

6. REFERENCES

[1] Kurt S. Lion, "Instrumentation in Scientific Research", Mc Graw Hill Book Co. 1959.

[2] Sawhney A.K., "A Course in Electrical and Electronics Measurements and Instrumentation", Dhanpat Rai & Sons 1985.

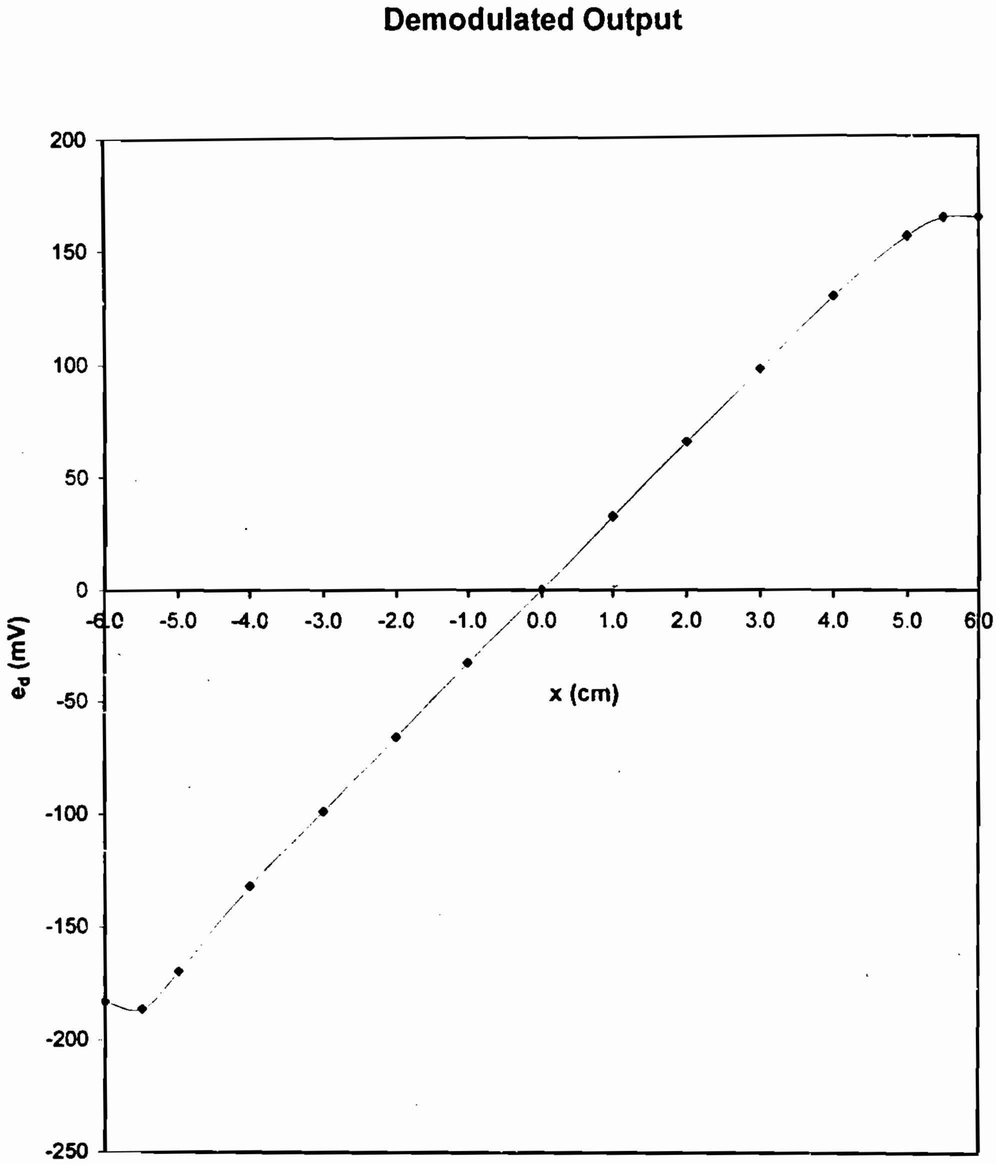


Fig. 4 Input- Output Characteristics of the LVDT

PACKING LIST

(1) Linear Variable Differential Transformer, LVDT : One

(2) Patch Cords : 3 nos
   (a) Red (3") : Two
   (b) Black (3") : One

(3) LVDT Transducer : One

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If you have any comments or suggestions about this product or this manual please let us know. **Techno Instruments** appreciates any customer feedback. Your input helps us evaluate and improve our product.

To reach Techno Instruments

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* Fax : +91-1332 - 277118
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Before you call the Techno Instruments Technical Support staff it would be helpful to prepare the following information:

- If your problem is with the Techno Instruments apparatus, note :
  - Model number and S. No (usually listed on the label at the backside of instrument).
  - Approximate age of the apparatus.
  - A detailed description of the problem/ sequences of events may please be sent by email or Fax.

- If your problem relates to the instruction manual, note;
  Model number and Revision (listed by month and year on the front cover).
  Have the manual at hand to discuss your questions.

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  Study of microprocessor control of a simulated linear system
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