

Schaevitz® LVDT Technology

LVDT Functional Advantages and Operation Principles



An LVDT is an electromechanical transducer that produces an electrical output proportional to the displacement of a separate movable core.

The LVDT has many commendable features that make it useful for a wide variety of applications.

Frictionless Measurement

Ordinarily, there is no physical contact between the movable core and coil structure, which means that the LVDT is a frictionless device. This permits its use in critical measurements that can tolerate the addition of the low-mass core, but cannot tolerate friction loading. Two examples of such applications are dynamic deflection or vibration tests of delicate materials and tensile or creep tests on fibers or other highly elastic materials.

Infinite Mechanical Life

The absence of friction and contact between the coil and core of an LVDT means that there is nothing to wear out. This gives an LVDT essentially infinite mechanical life. This is a paramount requirement in applications such as the fatigue-life testing of materials and structures. The infinite mechanical life is also important in high-reliability mechanisms and systems found in aircraft, missiles, space vehicles and critical industrial equipment.

Infinite Resolution

The frictionless operation of the LVDT combined with the induction principle by which the LVDT functions gives the LVDT two outstanding characteristics. The first is truly infinite resolution. This means that the LVDT can respond to even the most minute motion of the core and produce an output. The readability of the external electronics represents the only limitation on resolution.

Null Repeatability

The inherent symmetry of the LVDT construction produces the other feature—null repeatability. The null position of an LVDT is extremely stable and repeatable. Thus the LVDT can be used as an excellent null position indicator in high-gain closed-loop control systems. It is also useful in ratio systems where the resultant output is proportional to two independent variables at null.

Cross-Axis Rejection

An LVDT is predominantly sensitive to the effects of axial core motion and relatively insensitive to radial core motion. This means the LVDT can be used in applications where the core does not move in an exact straight line; as, for example, when an LVDT is coupled to the end of a bourdon tube to measure pressure.

Some of these features are unique to the LVDT and are not available in any other transducer (element). These features arise from the basic fact that the LVDT is an electrical transformer with a separable non-contacting core.

Extreme Ruggedness

The combination of the materials used in an LVDT and the techniques used for assembling them result in an extremely rugged and durable transducer. This rugged construction permits an LVDT to continue to function even after exposure to substantial shock loads and high vibration levels often encountered in industrial environments.

Core and Coil Separation

The separation between LVDT core and LVDT coil permits the isolation of media such as pressurized, corrosive, or caustic fluids from the coil assembly by a non-magnetic barrier interposed between the core and the inside of the coil. It also makes the hermetic sealing of the coil assembly possible and eliminates the need for a dynamic seal on the moving member. Only a static seal is necessary to seal the coil assembly within the pressurized system.

Environmental Compatibility

An LVDT is one of the few transducers that can operate in a variety of hostile environments. For example, a hermetically sealed LVDT is constructed of materials such as stainless steel that can be exposed to corrosive liquids or vapors.

Certain situations call for LVDT operation in extreme environments. In some cases, for example, it is necessary to operate at cryogenic temperatures, such as at the surface of liquid nitrogen. Another example of extreme conditions includes LVDTs that operate within the primary containment vessel of a nuclear reactor at temperatures ranging up to 1,000°F (550°C) coupled with radiation of 10^{11} Rads and/or neutron flux of 3×10^{20} NVT total integrated flux. Yet another extreme environment includes LVDTs that operate in pressurized fluids up to 3000 psi (210 bars).

Suitably designed LVDTs can be used in various combinations of these hostile environments. One key factor to keep in mind, however, is that unlike most other LVDTs working within their operating limits (which have virtually unlimited lives), LVDTs for hostile environments do have lives limited by their operating conditions which must be considered on a case by case basis.

Input/Output Isolation

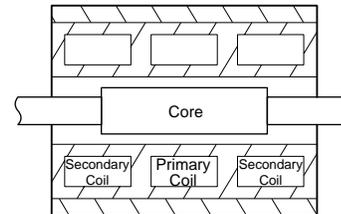
The fact that the LVDT is a transformer means that there is complete isolation between excitation input (primary) and output (secondaries). This makes an LVDT an effective analog computing element without the need for buffer amplifiers. It also facilitates the isolation of the signal ground from excitation ground in high-performance measurement and control loops.

New Captive Core Option

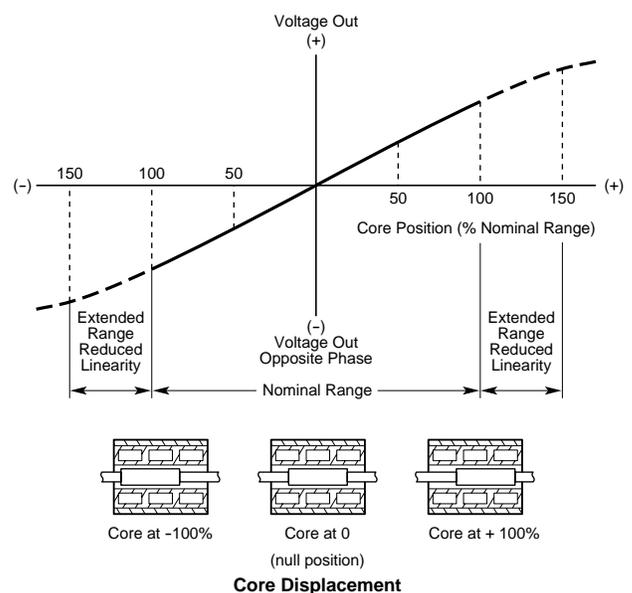
Many Schaevitz® LVDTs feature a captive core design that greatly simplifies installation. The design utilizes a core rod and bearing assembly that is captured and guided within the LVDT providing low friction travel throughout the stroke length. The assembly incorporates two Delrin bearings on the core rod traveling through the stainless steel boreliner. A bronze bearing on the front end utilizes a self-aligning feature to accommodate lateral LVDT movement during operation. The core rod and bearing assembly are field replaceable.

How LVDTs Works

The LVDT is an electromechanical device that produces an electrical output proportional to the displacement of a separate movable core. It consists of a primary coil and two secondary coils symmetrically spaced on a cylindrical form. A free-moving, rod-shaped magnetic core inside the coil assembly provides a path for the magnetic flux linking the coils.



When the primary coil is energized by an external AC source, voltages are induced in the two secondary coils. These are connected series opposing so the two voltages are of opposite polarity. Therefore, the net output of the transducer is the difference between these voltages, which is zero when the core is at the center or null position. When the core is moved from the null position, the induced voltage in the coil toward which the core is moved increases, while the induced voltage in the opposite coil decreases. This action produces a differential voltage output that varies linearly with changes in core position. The phase of this output voltage changes abruptly by 180° as the core is moved from one side of null to the other. (The core must always be fully within the coil assembly during operation of the LVDT, otherwise gross non-linearity will occur.)



Schaevitz® LVDT Technology

LVDT Design and Construction



Stainless steel housing and end lids provide electrostatic and electromagnetic shielding

Vacuum and pressure impregnation with high-grade electrical varnish adds additional moisture proofing, thermal stability, and structural integrity to the coils

Housing is spun-swagged over end lids to produce tight seal

DC LVDTs incorporate a small, encapsulated carrier generator/signal conditioning module

Epoxy encapsulation assures proper heat transfer and bonding of coils to housing

High density, glass-filled polymer coil form has low moisture absorption and excellent thermal stability. Coil movement due to moisture breathing is eliminated

High permeability, nickel-iron hydrogen-annealed core for low harmonics, low null voltage, and high sensitivity

How a Schaevitz® LVDT is Constructed

There is an extremely wide variety of LVDT types, sizes, ranges, and physical configurations commercially available. This bulletin describes those which approach optimum design characteristics and satisfy the majority of user requirements.

Each series of Schaevitz® LVDTs represents the culmination of several decades of refinement in the application of electromagnetic principles as well as improved methods of construction. A primary design

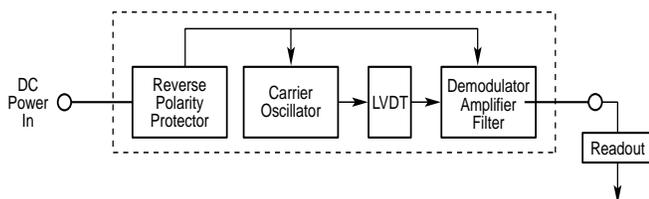
consideration has been the determination of a combination of windings which produces excellent linearity without compromising other desirable performance characteristics.

In recent years, the computer has played a vital role in the refinement of these construction techniques. In addition, state-of-the-art materials are continually replacing more traditional materials as they prove suitable for LVDT construction.

DC-Operated LVDTs

The DC-LVDT maintains all of the desirable characteristics of the AC-LVDT, but has the simplicity of DC operation. It is composed of two integral parts: an AC-LVDT and a carrier generator/signal conditioning module. Small, yet rugged, the carrier system eliminates most of the volume, weight, and cost of conventional external AC signal conditioning equipment. The self-contained LVDT operates from a simple DC power supply or, in some cases, a battery. Virtually any DC meter can be employed as readout.

As can be seen from the block diagram below, the Schaevitz® DC LVDT module operates from a DC power source. It is protected against damage resulting from accidental misconnection to the wrong polarity of the power supply. The DC input power is routed to the carrier oscillator and to the signal amplifiers.



Block Diagram of DC LVDT

The carrier oscillator produces a constant amplitude sine wave to excite the primary of the LVDT. The sinusoidal excitation provides superior performance to earlier square wave oscillator designs.

With continuing advances in technology, the DC LVDT is further refined to produce a high performance, economical unit. These transducers contain all the electronics necessary to excite the LVDT, and to demodulate and amplify the analog output signal. The entire signal conditioning module, mounted in tandem with the LVDT, adds only slightly to the overall length of the transducer.

Position Transmitter Systems

In addition to the full line of AC and DC operated LVDTs, Schaevitz® offers several 2-wire current loop position transmitter systems. These loop powered transmitters are especially suited to valve and other position indication applications for the process industry. These systems consist of an LVDT position sensor with matching electronics (either built in or remotely located) to provide 4-20 mA output into a 2-wire current loop.

Position transmitter systems are packaged in rugged, splash proof or hermetic housings, designed for the most adverse installations. Their design is particularly suitable for use in valve position feedback and other process industry remote sensing applications in which AC power is not readily available to operate external signal conditioning.



The CTS Transmitter System is a 2-wire current loop, position transmitter system that combines an LVDT with matching electronics to provide 4-20 mA output.

Schaevitz® LVDT Technology

Selection Overview

Design Considerations

Linear Range

Linear range is the distance the LVDT is designed to operate and meet factory specifications.

Method of Measurement

Most Schaevitz® LVDTs are designed to be mechanically linked to the object being measured. If a physical connection between the transducer and object is undesirable, consider Schaevitz® spring loaded and non-contacting gage heads or our new non-contacting laser sensors.



New Product

Our new captive core option simplifies installation by eliminating alignment difficulties. The option is available with the HCA, DC-EC, DC-SE, HCD and HCT Series.



New Product

The DC-SE offers single-ended input and output for compatibility with unipolar analog-to-digital converters and PLCs.

AC-Operated LVDTs

HR Series



Page 38

- AC operated
- Eleven models from $\pm 0.05"$ to $\pm 10.0"$ linear range
- Mild radiation resistance available
- $13/16"$ diameter housing

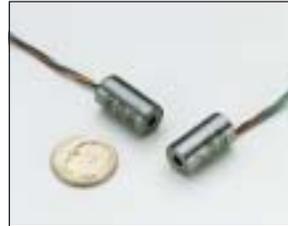
MP Series



Page 40

- AC operated
- Seven models from $\pm 0.5"$ to $\pm 10.0"$ linear range
- $1.25"W \times 1.25"H$ housing
- Flange mounting for easy installation

MHR Series



Page 42

- AC operated
- Sixteen models from $\pm 0.005"$ to $\pm 1.0"$ linear range
- Light weight, $7/64"$ diameter core
- $3/8"$ diameter housing

HCA Series



Page 44

- AC operated
- Nine models from $\pm 0.05"$ to $\pm 10.0"$ linear range
- Hermetically sealed
- $3/4"$ diameter housing
- Mild radiation resistance
- Captive core option

E Series



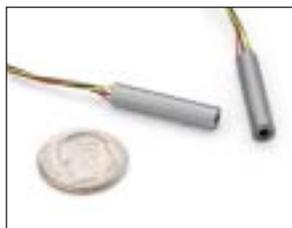
Page 46

- AC operated
- Low cost
- Six models from $\pm 0.100"$ to $\pm 2.00"$ linear range
- $3/4"$ diameter housing

Note: AC LVDTs are sold as components and as such, are not subject to regulation under current CE requirements.

AC-Operated LVDTs for Specialized Applications

XS-B Series



Page 48

- AC operated
- Two models from $\pm 0.100''$ to $\pm 0.250''$ linear range
- Miniature design $3/16''$ diameter housing
- Very low mass $1/16''$ diameter core

XS-C Series



Page 50

- AC operated
- Three models from $\pm 0.250''$ to $\pm 1.000''$ linear range
- High pressure sealed for operation at 3000 psi
- $3/4''$ diameter housing with $7/8-14$ UNF-2A thread for bulkhead mounting

XS-D Series



Page 52

- AC operated
- Five models from $\pm 1.00''$ to $\pm 10.0''$ linear range
- Longest stroke to body length
- $13/16''$ diameter housing

XS-ZTR Series



Page 54

- AC operated
- Four models from $\pm 0.100''$ to $\pm 1.000''$ linear range
- Radiation resistant— withstands total integrated neutron flux levels to 3×10^{20} NVT or 10^{11} rads gamma
- Withstands continuous operating temperatures of -320°F (-195°C) to $1,022^\circ\text{F}$ (550°C)
- $1''$ diameter housing; $3/16''$ diameter core

DC-Operated LVDTs

DC-EC Series



Page 56

- DC operated
- Nine models from $\pm 0.05''$ to $\pm 10.0''$ linear range
- Captive core option available
- CE compliant
- $3/4''$ diameter housing

DC-Operated LVDTs

DC-SE Series



Page 58

- DC operated
- Single ended
- Nine models from 0 to $0.1''$ to 0 to $6.0''$ linear range
- Captive core option
- CE compliant
- $3/4''$ diameter housing

HCD Series



Page 60

- DC operated
- Nine models from $\pm 0.05''$ to $\pm 10.0''$ linear range
- Hermetically sealed
- Captive core option
- CE compliant
- $3/4''$ diameter housing

LVDT Transmitter Systems

HCT/HCT IS Series



Page 62

- $4-20$ mA, 2-wire operation— HCT IS model intrinsically safe approved
- Six models from 0 to $\pm 0.25''$ to 0 to $\pm 10.0''$ linear range
- Self-contained electronics in a compact $3/4''$ diameter housing
- Hermetically sealed
- Captive core option

PTS Series



Page 66

- $4-20$ mA, 2-wire operation
- Six models from 0 to $\pm 0.25''$ to 0 to $\pm 10.0''$ linear range
- Self-contained electronics
- Zero and span adjustments
- Rugged splashproof housing

CTS Series



Page 68

- $4-20$ mA, 2-wire operation
- Seven models from 0 to $\pm 0.25''$ to 0 to $\pm 10.0''$ linear range
- Electronics mounted up to 25 feet from hermetically sealed LVDT
- Optional splashproof housing for electronics