TE LVDT TECHNOLOGY

Application Note

THE LVDT

An LVDT (Linear Variable Differential Transformer) is an electromechanical transducer that produces an electrical output proportional to the displacement of a separate movable core. The LVDT has many commendable features, making it ideal and highly reliable for a wide variety of application.

FRICTIONLESS MEASUREMENT

Ordinarily, there is no physical contact between the movable core and the coil structure, which means that the LVDT is a frictionless device. This permits its use in critical measurements that can afford 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 or 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 vital for high-reliability mechanisms and systems found in aircraft, missiles, space vehicles, and critical industrial equipment.

INFINITE RESOLUTION

The frictionless operation, 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 minutest motion of the core and produce an output. The readability of the external electronics represents the only limitation on resolution.

NULL POSITON REPEATABILITY

The inherent symmetry of the LVDT construction provides its second outstanding characteristic: The null position (zero) 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.

CROSS-AXIS REJECTION

An LVDT is predominantly sensitive to axial and relatively insensitive to radial core motion. This means that it 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. This feature and others are unique to the LVDT. They arise from the basic fact that the LVDT is an electrical transformer with a separable non-contacting core.

CORE AND COIL SEPARATION

The separation between the LVDT core and the coil permits the isolation of media such as pressurized, corrosive, or caustic fluids from the coil assembly, by adding a non-magnetic barrier (pressure isolation vessel) 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.

Many of our LVDTs incorporate this feature (i.e. HC Series; XS-C); TE Connectivity also designs and manufactures LVDTs with separate media isolation vessels. Major applications are found in hydraulic systems (valves, actuators, reservoirs, etc.).

EXTREME ROBUSTESSE

The combination of the materials used in TE Connectivity LVDTs and the techniques we use for assembling them result in extremely rugged and durable transducers. This rugged construction permits our LVDTs to continue functioning even after exposure to substantial shock loads and high vibration levels often encountered in industrial environments.

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 uses stainless steel, which allows exposure to corrosive liquids or vapors.

Certain situations call for LVDT operation in more extreme environments. It could be necessary to operate at cryogenic temperatures, such as at the surface of liquid nitrogen; or within the primary containment vessel of a nuclear reactor, at temperatures ranging up to 1,000°F (540°C) coupled with total integrated radiation of 10^{11} Rads (10^{9} Gray) and/or total integrated neutron flux of 3 x 10^{20} NVT. TE Connectivity XS-ZTR is well suited for these applications. Yet another extreme environment is the operation in fluids pressurized up to 20,000 psi (1,400 Bars).

Suitably designed LVDTs can be used in various combinations of these hostile environments. However, their life may be limited by the severity of the operating conditions; this must be considered on a case by case basis.

INPUT/OUTPUT ISOLATION

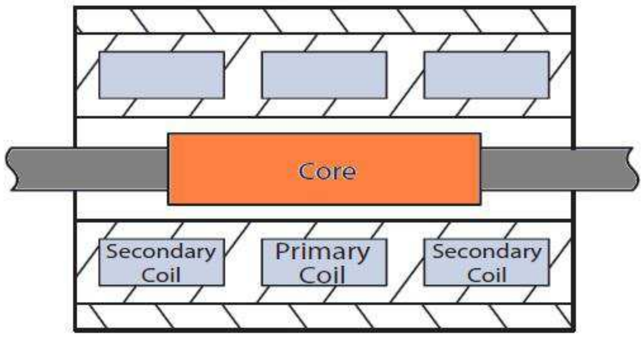
The fact that the LVDT is a transformer means that there is complete physical isolation between the excitation input (primary) and the outputs (secondary). This feature allows its use without the need for buffer amplifiers. It also provides galvanic isolation between the signal and the excitation grounds for high-performance measurement and control loops.

CAPTIVE CORE OPTION

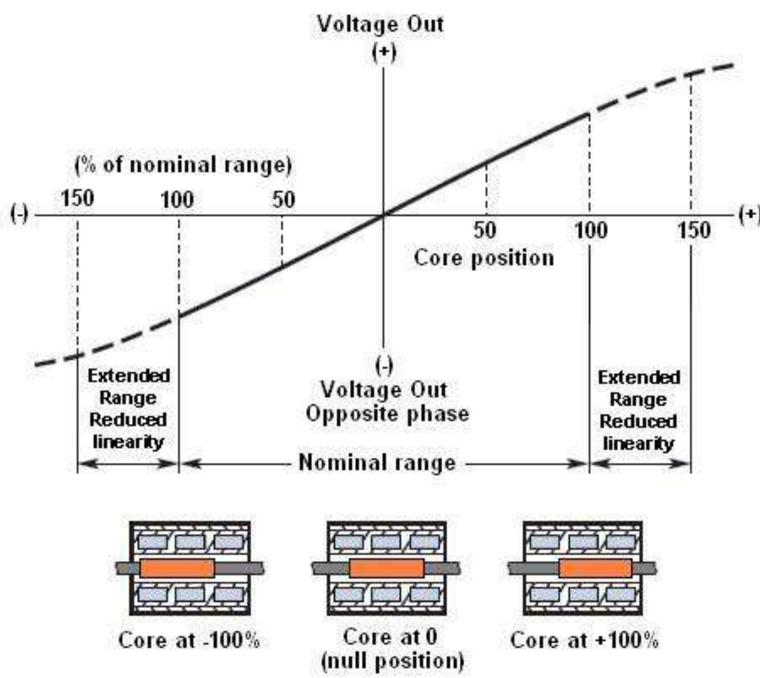
Many TE Connectivity LVDTs offer a captive core option that greatly simplifies installation. This option utilizes an assembly that captures and guides the core within the LVDT. The assembly incorporates a PTFE sleeve over the core, a connecting rod, and a stainless steel tube, providing low friction travel along the stroke length. A bronze bearing on the LVDT front end accommodates lateral movement of the rod during operation while keeping the core inside the tube. The components of the assembly are field replaceable.

HOW THE LVDT WORKS

The LVDT is an electromechanical device that produces an electrical signal 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. The free-moving, rod-shaped ferromagnetic 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 (excitation), voltages are induced in the two secondary coils. These secondary coils are connected series opposing, therefore, the net output of the transducer is the difference between these voltages which is zero when the core is at the center (null position). When the core is moved away from the null position, the induced voltage in the secondary 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 signal 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 and the coils could even overheat.



TE CONNECTIVITY LVDT DESIGN AND CONSTRUCTION

TE Connectivity has an extremely wide variety of LVDT types, sizes, ranges, and physical configurations commercially available. Each series of LVDTs represents the culmination of several decades of refinement in the application of electromagnetic principles as well as improved methods of construction.

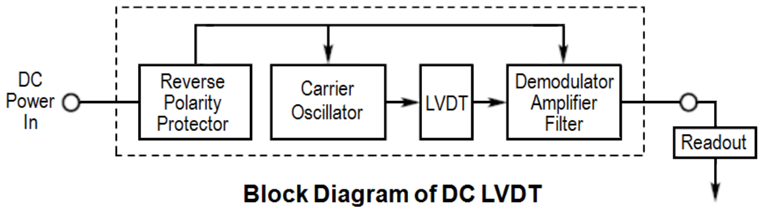
A primary design consideration has been the determination of a combination of windings which produces excellent linearity without compromising other desirable performance characteristics.

The personal computer has played a vital role in the refinement of these construction techniques. Today TE Connectivity uses computerized winding machines and test stations. In addition, state-of-the-art materials are continually replacing more traditional materials as they prove suitable for LVDT construction.

DC-OPERATED LVDT

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 electronic module 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. The output of the DC LVDT can either be a DC voltage or current loop (4 to 20mA).

As can be seen from the block diagram below, our electronic module operates from a DC power source. It is protected against damage resulting from accidental misconnection to the wrong polarity of the power supply.



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 square waves.

With continuing advances in technology, the DC LVDTs are further refined to produce high performance, economical units. The entire signal conditioning module, mounted in tandem with the LVDT, adds only slightly to the overall length of the transducer.

DIGITAL I/O LVDT

TE Connectivity LVDTs with direct digital output such as HC-485 or GC-485 eliminate the need for external analog to digital conversion. The analog output is scaled into calibrated displacement engineering units (imperial or metric) by the internal microprocessor, thus providing a traceable measurement without need of an on-site calibration.

The two-wire addressable RS-485 output supports the standard Modbus RTU, Modbus ASCII, Generic ASCII, and I-series ASCII protocols. Internal MIN, MAX and TIR functions store peak and valley readings at a maximum update rate of 600 samples per second to deliver the information to the host, on demand. An internal tare or zero function allows unipolar or bipolar output, as the application dictates.

TE Connectivity has expertise to develop digital I/O LVDTs based on other protocols, such as CANopen.

POSITION TRANSMITTER SYSTEMS

In addition to the full line of AC and DC operated LVDTs, TE Connectivity offers 2-wire current loop position transmitter systems. These loop powered transmitter systems are especially suited to valve position feedback and other position indication applications for the process industry.

These systems consist of an LVDT or an RVDT with matching electronics (to be remotely located) to provide 4-20mA output into a 2-wire loop. They allow remote sensing in applications in which local AC power is not readily available, or where the temperatures are too high for sensor-integrated electronics.

CTS-420 Position Transmitter System

TE Connectivity offers many other types of sensors and signal conditioners. Data sheets can be downloaded from our web site:
http://www.te.com/usa-en/products/sensors.html

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