Sensors Overview Training

Linear Positioning

January 2018
AMETEK Factory Automation, based in Clawson, Michigan, is a participating Encompass™ Product Partner in the Rockwell Automation PartnerNetwork™.

AMETEK Factory Automation provides linear, rotary and level measurement technology. AMETEK has more than 150 manufacturing locations around the world, supported by more than 100 sales and service locations across the United States and in 30 other countries.

Website www.ametekfactoryautomation.com
The need for automation is greater today than ever before

LINEAR DISPLACEMENT TRANSDUCERS (LDTs) play an important role in automation. They provide accurate, reliable, absolute position feedback to help automate today’s sophisticated machinery. Sensors must deliver value, be easy to set up, and interface easily into the host controller.

A host of linear automation solutions can provide accurate feedback of continuous position to improve productivity and efficiency. AMETEK / Gemco uses advanced Magnetostrictive technology to provide precise and absolute noncontact position feedback down to 1-micron resolution.

These sensors can be packaged to survive in the most demanding and hostile environments. The position of the magnet on the sensing element is precisely determined by a time-of-flight method.
Where do I use a Linear Transducer?

Any machine that moves up and down or back and forth, Linear position sensors can provide accurate, repeatable controls to help automate these applications.

- Machines that move up and down
- Left and right
A **proximity sensor** is the most basic type of sensor that is able to detect the presence of nearby objects without any physical contact.

A proximity sensor often emits an Electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target.

Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; whereas an inductive proximity sensor always requires a metal target.

- Low cost (+)
- Available from multiple suppliers (+)
- End Limit or Zones only (-)
- On power loss, machine cannot tell where it is at and must undergo a homing sequence (-)
• **Photoelectric sensors**, also known as photo eyes, emit a beam of light that is used to detect the presence or absence of items. When the emitted light is interrupted or reflected by the object, the change in light patterns is measured by a receiver and the target object is recognized.

• Depending on the style and manufacture of the sensor, they can be used with or without a reflector.

• There are numerous suppliers for this type of sensor.
  
  – Multiple output types and mounting configurations are available to meet your sensing needs.
Analog Laser Distance Measurement Sensors - Laser measurement sensors can solve a wide variety of analog applications.

- **Non-Contact Sensing**
  - Some need reflectors where others don’t.
- **Variety of manufactures and measuring ranges available.**
- **Line of sight cannot be obstructed.**
- **Dust, Dirt, Fog & Steam can all effect the output stability from these types of sensors.**
- **Class I and Class II sensors available – Safety concerns or shielding may need to be taken depending on sensor type.**
Linear Potentiometers are electro-mechanical devices that consist of a moveable wiper and resistive element to provide a voltage feedback.

They are available in a variety of lengths and resistances.

A voltage is applied to the sensor. As the slide (wiper) moves it will create an output that is proportional to the slider's position.

Potentiometers are subject to wear from repetitive operation and vibration, not to mention that they also drift with temperature.

Contaminants are also a problem as they can enter into the sensor's housing and interrupt the contact from the wiper to the resistive element, causing premature failure or erratic position signals.
A **string potentiometer**, sometimes also known as a **string pot**, yo-yo or draw wire sensor.

- String pots are composed of four main parts: a measuring cable, spool, spring, and rotational sensor. Inside the transducer's housing, a stainless steel cable is wound on a spool that turns as the measuring cable reels and unreels.
- As the transducer's cable extends along with the movable object, it causes the spool and sensor shafts to rotate. A voltage is typically applied to these sensors. As the cable moves it will create an output that is proportional to the potentiometers position.
- Potentiometers are subject to wear from repetitive operation and vibration, not to mention that they also drift with temperature.
- Contaminants are also a problem as they can enter into the sensors housing and interrupt the contact from the wiper to the resistive element, causing premature failure or erratic position signals.
- Care must also be taken to insure that there is a constant tension on the draw wire. Uncontrolled retraction can cause failure of cable spool mechanism.
- Sensors can range form hundreds of dollars to thousands of dollars – depending on stroke length and sensor output type.
**Inductive Linear Encoder** is a sensor or read head that is paired with a scale that encodes position. The sensor reads the scale in order to convert the encoded position into a digital signal.

- Moderate cost (+)
- Long stroke lengths (+)
- No need to specify length (+)
- Not absolute (-) – Quadrature type output
- Sensor head must maintain parallel and perpendicular to etched scale (-)
- Cable management (-)
• **LVDT** stands for Linear Variable Differential Transformer. The basic unit consists of a primary coil and two secondary coils wound on a coil form.

• A ferromagnetic core links the electromagnetic field of the primary coil to the secondary coils. The difference between the output of these coils will result in an output that is proportional to the relative movement of the core versus the coils.

• LVDT linear position sensors can measure movements as small as a few millionths of an inch up to several inches.

• Typically short stroke lengths – Used in Metrology Industry

• Not an industrial type sensor
A **Glass Scale** is an optical device that is typically found in the CNC Industry.

- They are ideal for machines and other equipment whose feed axes are in a servo loop, such as milling machines, machining centers, boring machines, lathes and grinding machines that are looking for quick response time with sub-micron resolution.

- They work off the principle of photoelectric scanning of an absolute coded glass scale. A sensor array scans several tracks of the glass scale that contain high resolution measurement information.

- These signals are typically taken to a controller that can then determine the position of the reader head.
Price vs. Performance

- LDTs
- Glass Scales
- LVDT
- Lasers
- Linear Pots
- Linear Encoders
- Proximity Photo
• The technology AMETEK / Gemco use to solve linear position applications is Magnetostriction. The product is commonly referred to as a (LDT) **Linear Displacement Transducer**

• The LDT consists of a Magnetostrictive waveguide, a sensing element and a movable magnet.

**AMETEK packages these sensors to survive in the most demanding and hostile environments**
Magnetostrictive technology isn't new, nor is it rocket science. It's a rugged technology for accurate and repeatable measurement of linear movement.

In fact, the physical principles that make it work are the same principles that make motors and generators run.

Click on link to AMETEK Video on Magnetostrictive technology
Magnetostrictive sensing in simple terms

A) Magnetostrictive Linear Transducers use a time-based position sensing, where a current pulse is sent down a Magnetostrictive wire in a specially designed waveguide.

B) The interaction of this current pulse with the magnetic field created by the movable magnet assembly produces a torsional strain pulse on the wire, which travels at sonic speed along the wire.

C) The strain pulse traveling up the wire is sensed by a small induction pickup coil in the head assembly of the LDT. The position of the movable magnet is determined with high precision by measuring the time between the launching of the current pulse and the arrival of the torsional strain pulse.

The result is highly accurate non-contact position sensing with absolutely no wear on the sensing element.
### Key Features and Benefits:
- No contact between sensing element
- Extremely Rugged Transducer
- Absolute Measurement
- Analog, Digital, SSI, Quadrature & EtherNet/IP
- Resolution to 1 micron
- Repeatability to 1 micron

### What this means to you:
- Infinite life – Nothing to wear out
- Can operate in harsh environments
- Position will not be lost on power down
- Industry standard signals compatible with most PLC systems
- Very small increments of movements can be measured
- Highly repetitive
Analog, Digital, Quadrature, SSI Networks (EtherNet/IP, Profibus & CAN bus)

- Analog signals are an industry standard – Must pay attention to cable distances and resolution of both LDT output and PLC Input.

- Digital is old technology still used in some Lumber application
  - Digital LDT measure time of flight and must be used with specialty PLC card or controller

- Quadrature is the same output signal as an Incremental encoder.
  - Units require rehoming if position is moved when power is off

- SSI (Serial Synchronous Interface)
  - Displacement value is encoded into a 24, 25, or 26 Bit format and transmitted at high speeds.
  - High resolution – regardless of stroke length

- Networks – Typically available with EtherNet/IP, Profinet and CAN bus
  - Depending on the PLC manufacture may dictate communication platform needed
    - Rockwell Automation – EtherNet/IP
    - Siemens & GE – Profinet
    - Mobile or vehicle application - CAN bus
• Many linear automation solutions can provide accurate feedback of continuous position to improve productivity and efficiency. The traditional, preferred approach typically uses analog signal feedback back into an analog input module or drive.

• However, analog signals are limited by resolution of both the sensor and input module; signals are prone to degradation over long cable runs; and each axis needs its own dedicated cable.

• Analog units are still the industry standard and are available with a wide variety of voltage or current outputs.

• Today's generation LDTs are typically available with 16-bit resolution, Diagnostic LED’s and offer programmable zero and span points.
The start/stop signal interface is a differential RS-422 digital output signal. An external device initiates an external interrogation pulse (1.0 microseconds in duration). Within 50 nanoseconds after the leading edge of the interrogation pulse is received, the LDT generates a start pulse followed by a stop pulse.

The duration of time between the leading edge of the start pulse and the leading edge of the stop pulse is proportional to the distance between the magnet and the hex head of the LDT.
What is SSI?

- To overcome the shortcomings of traditional analog sensors, users often turn to **Serial Synchronous Serial Interface** (SSI) sensors. SSI LDTs can provide a serial-clocked output of binary or Gray code positional data with 1 micron resolution, regardless of stroke length of the sensor or cable run. The displacement value (position) is encoded into a 24, 25 or 26-bit format and transmitted at high speeds.

- Synchronization in a closed loop system is made easy. A clock-pulse train from a controller is used to shift out sensor data: One bit of position data is transmitted to the controller for one clock pulse received by the sensor. The absolute position data is updated continually by the sensor and converted by the shift register into serial information.

- SSI LDTs can interface seamlessly with the 1756M02AS or any Rockwell Automation programmable controller that can talk SSI.
Quadrature Output

- A new method of interfacing Magnetostrictive transducers offers an interface as common as analog with the speed and accuracy of a digital pulsed type signaling.

- The Gemco quadrature LDTs provide quadrature output directly from the transducer to the controller. The output from the transducer can be wired directly to any incremental encoder input or counter card, without the need for a special converter module or PLC interface card designed specifically for use with pulsed output Magnetostrictive transducers. The quadrature output has the “A”, “B” and “Z” outputs.

- The Gemco Transducers offer a Burst feature that can be use to rehome the machine in event of power loss. Magnetostrictive linear transducers are inherently absolute, where as PLC with high speed counters are not. With a simple input to the Gemco transducer the LDT can “Burst” out the pulses to tell the machine exactly where it is at.
• **EtherNet/IP** is an industrial Ethernet implementation of the Common Industrial Protocol (CIP™), managed by ODVA ([www.odva.org](http://www.odva.org)). EtherNet/IP is the most developed, proven and complete industrial Ethernet network solution available for manufacturing automation.

• EtherNet/IP Network LDT provides maximum flexibility for installation and ease of use in demanding, high-performance, networked industrial applications.

• EtherNet/IP™ systems require only a single point network connection for both configuration and control, thus simplifying installation and wiring.

• The **ReadyLink™ EtherNet/IP™ LDT with RapidRecall™** supports Star, Line and DLR (Device Level Ring).
• Over the past decade, linear sensors have become smarter. Many models now can be field configurable for output type, zero position, counting direction, position and velocity format, and resolution.

• Some of the more sophisticated sensors can even support wide-ranging power supplies (7VDC to 30VDC), so the same unit can be used in stationary or mobile applications. The wide-ranging power supplies also help make the linear transducers backward-compatible with the older generations, which needed a +/- 15V bipolar supply.

• Diagnostic LEDs were added to the linear sensors years ago to help diagnose and aid in troubleshooting.

• Standardized cables (12mm Euro Style cordset) typically are available as an option from all suppliers. This can help to reduce the installed cost and make cables more readily available from a host of suppliers.

• Automatic gain, commonly referred to as AGC, was introduced years ago as a means to help compensate for the different-style magnets that can be found in hydraulic cylinders. On power-up, most of these smart sensors can measure the strength of the magnet and automatically adjusts its internal signal lengths to match that of the user's installed magnet. This is extremely beneficial in hydraulic cylinder applications when the magnet installed in the cylinder might be a different brand (strength) that that of the sensor.
Thank you for attending today's seminar

- Please stop by AMETEK / Gemco booth 38 to learn more about our product offering or visit our website at [www.ametekfactoryautomation.com](http://www.ametekfactoryautomation.com)
- For more information on the AMETEK Factory Automation product offering
  - Contact your local Kendall Electric Office
  - Blake Cawley – AMETEK - Factory Automation Product Manager
    - blake.cawley@ametek.com
    - 248-687-2032
  - Herb Burnell – AMETEK – Territory Manager
    - herb.burnell@ametek.com
    - 216-280-3367