Temposonics®

Magnetostrictive, Absolute, Non-contact
Linear-Position Sensors

MTS SENSORS

Replacing Linear Encoders with Magnetostrictive Technology

White Paper

Document Part Number
551282 Revision B

Model RP Profile-style position sensor

Model AP Linear Encoder

New Sensors Combine Absolute and Incremental Linear Measurement to Provide Better Performance

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Historically, design engineers have had to make a choice of whether to use incremental or absolute encoders to meet application needs. New products are making that decision easier in many applications and opening the door to the benefits of magnetostrictive technology for key industries.

What is a Linear Encoder?

A linear encoder is basically a ruler (scale) that is marked with increments that a reading head counts as it travels over the marks. Each mark encodes a specific distance such that the encoder can determine how far it has moved from a reference point. It is a critical part of a motion control system, providing continuous, linear position feedback to drive the motor position. Linear encoders improve the positioning accuracy of an electro-mechanical actuator by providing direct position feedback at the load to compensate for backlash or other sources of error. They are also used as the primary feedback device for linear motors that directly convert electrical energy into linear motion.

Linear motors are used for a wide range of applications because they offer many advantages based on their functional principle. Linear motors have efficient energy conversion compared with traditional mechanical components used for converting the rotary motion of an electric motor into linear motion (gear head, belts and pulley efficiency is in 90% range or lower) resulting in energy savings and less maintenance costs. This is ideal for high-end applications in the electronics, automotive, printing or robotics industries, or in the general mechanical engineering fields of machine tools, cutting machines, handling and assembly or packaging machines. Due to high dynamics, positioning accuracy, durability and reduced maintenance requirements, the linear drive improves the quality and the efficiency of the production, but requires a suitable linear position feedback device. There are multiple technologies to provide continuous position feedback, so the choice comes down to the specific application implementation.

How do Technologies Differ?

Productivity improvements, frequent product changes, and sophisticated machining tasks are constant challenges in linear actuator applications. Traditionally, optical, magnetic or inductive linear encoders have been used to provide the required position feedback.

An additional option that has seen increased usage in the past few years is magnetostriction. Design engineers are increasingly finding that magnetostrictive linear position sensors can replace their encoders in applications, improving productivity and decreasing cost of ownership. Designed for precise and robust position measurement, magnetostrictive sensors can be installed wherever high-accuracy, dynamic positioning tasks must be performed, including electrical linear motors, electro-mechanical actuators, and pneumatic, hydraulic, spindle or power-grip belt drives. Applications include assembly lines, material handling, component feed equipment, quick positioning systems, quick-change systems for work-piece holders, packaging applications and machine tools.

Many designers, even those who see the inherent benefits of absolute, magnetostrictive sensors (not to be confused with magnetic linear encoders), hesitate to use them simply because they are unfamiliar. They continue to specify optical, magnetic, or inductive linear encoders for applications that would work well with magnetostrictive sensors because they have always used incremental linear encoders. Additionally, there are some applications where incremental encoders are still required. Despite the presence of a strong magnetic field in some applications such as linear motors, numerous solutions have been implemented with magnetostrictive sensors providing feedback without issue.

What Advantages Does Magnetostriction Offer?

Magnetostrictive sensors have not traditionally competed with optical encoders. Optical linear encoders have exhibited a range of performance at the upper end that could achieve resolutions and accuracy that magnetostrictive sensors could not meet. Advancements in magnetostrictive technology over the years, however, have now increased the overlap in performance capability so they now fit into applications that could previously only use linear encoders. Magnetostrictive sensors provide precise, dynamic measurement of absolute position and velocities and are capable of measuring signals in the sub-millisecond range. They can reach sub-micron resolutions, which permits displacements at very low speeds of only 0.5 mm/s, measurement cycle times down to 100 microseconds, a linearity of <± 0.01%, and typical repeatability of 2.5 microns. Real-time linearity correction is available to get measurement accuracy down to 20 microns or better. Another advantage of magnetostrictive technology is that it is not sensitive to contamination in harsh environments. An optical encoder's reading head, which is a piece of glass and a laser that is counting the marks, can be contaminated by dust or oil, causing loss of the optical signal which means the reader is unable to count the marks.

Also, glass is a fragile material not suitable for an environment where mechanical vibrations can occur. Optical encoders require reader head maintenance and sensitive care with added cost. The magnetostrictive sensor's parts are enclosed within the sensor, and the magnet provides non-wear technology that ensures robustness of the sensor for the life of the equipment. Some magnetostrictive sensors are designed with double-shielding to eliminate electrical interference, which ensures a high signal-to-noise ratio and allows them to be used even in applications where other sensors cannot be used.

Another disadvantage of the optical encoder is its use of a moving cable. In the typical encoder, the electronics are embedded inside the reading head that is moving back and forth, requiring an attached cable, which can create design challenges. With magnetostrictive technology, the only moving part is a passive position magnet. No electronics or cables are attached to the position magnet; there is only the moving machine part. This makes the magnetostrictive position sensors more rugged and reliable than optical encoders. In addition, the position magnet does not need to be physically tethered to the sensor, but could, for example, be attached to a moving carriage that comes in and out of range of the sensor.

Another advantage of magnetostrictive technology is that it can report multiple positions from a single sensor using interfaces such as Profibus, EtherCAT, and Ethernet/IP. For each measurement cycle, a position value can reported for every position magnet (up to 30) along the axis.

Why Use Absolute Position Feedback?

Absolute positioning offers inherent and easily apparent benefits when compared to incremental linear encoders. Incremental linear encoders have speed limitations, namely a maximum and minimum speed at which the reading head can travel before losing track of the marks it has scanned. Dropping below the minimum speed creates a cogging effect due to the "in-between marks" time that do not produce feedback for the amplifier and thus force the amplifier to increase speed until the next signal is received. The result is an uncontrolled jerky movement not acceptable in most of the low speed applications. Contamination and disturbances can also interfere with the encoder's ability to read the marks.

Unlike incremental encoders, magnetostrictive position sensors do not have a maximum or minimum speed limitation because they are inherently absolute position devices; they continue sampling absolute position at a fixed rate and resolution regardless of the application velocity. There may be limitations in the speed of the controller interface, but the sensor will not "lose count" of where the magnet is located. Absolute position sensors also eliminate the need for moving to a reference mark or home position after a power reset. At any point in time, the absolute position sensor can report where it is without requiring a movement. Many applications are now moving beyond incremental encoders and are advancing to absolute position feedback for improve safety, productivity and reduced cost for additional proximity switches. There are multiple solutions available that can provide absolute, linear position feedback using magnetostrictive technology.

Why Combine Absolute and Incremental Encoder Technologies?

While absolute position feedback is advantageous for numerous reasons, many applications use drives that require an incremental signal, either a digital TTL A/B quadrature signal or an analog 1Vpp sin/cos signal. The incremental signal provides an encoder count that can be used to determine both position and velocity. While the drive may use an incremental signal, the PLC controlling the motion profile could use an absolute position provided by SSI or other absolute encoder interface.

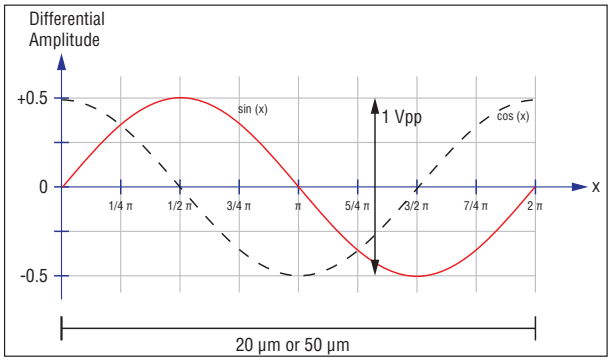

Fig. 1: *Differential Amplitude and Signal Period*

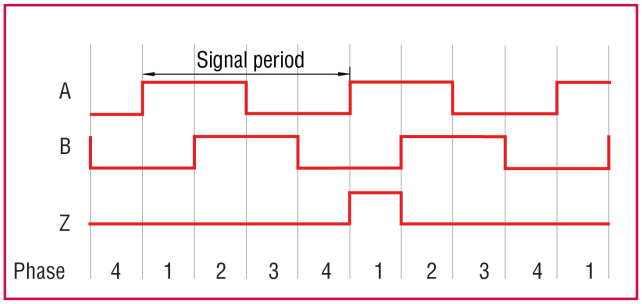

Fig. 2: *Gated to Leading Signal Edge*

Adding absolute, linear position feedback to an application currently using an incremental interface previously required adding an additional encoder or proximity switch. New sensors introduced to the market overcome that obstacle by combining an incremental and absolute encoder interface in a single sensor package. The incremental interface provides position and velocity feedback for the amplifier, while the absolute interface offers position feedback for the motion controller. When combined with magnetostrictive technology, these new sensors provide significant technology benefits such as robustness and cable management, as well the safety and productivity benefits of combining absolute and incremental encoders in a single sensor.

When it comes to choosing the best encoder solution for an application, there are multiple technology options and an array of requirements to consider. What are the interface requirements? What is the environment like? Is there a risk of contamination, shock, or vibration? There are still applications that are best suited for traditional linear encoders because of specific requirements, but today's magnetostrictive technology is increasingly meeting the needs of a wide range of applications and provides significant productivity and cost of ownership benefits.

For more information on MTS Sensors, please visit www.mtssensors.com or contact a local MTS representative.

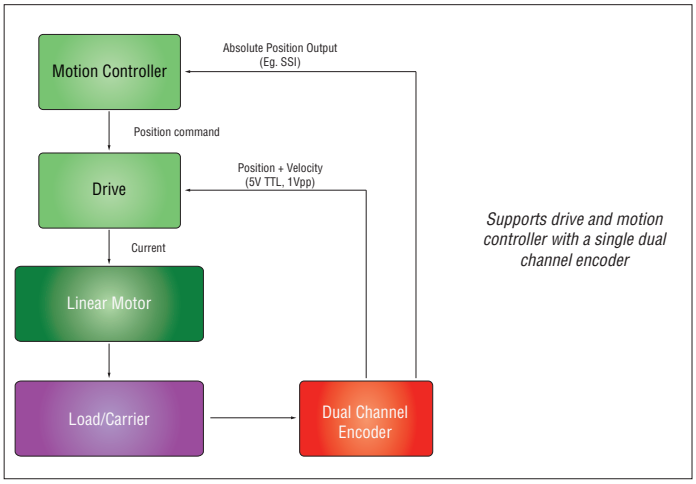

Fig. 3: Dual Channel Encoder

ISO 9001 CERTIFIED CE

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LEGAL NOTICES

Document Part Number:
551282 Revision B (EN) 08/2014

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