

Performance and Application of Optical Distance Measurement Systems for Motion Control and Positioning.

Linear measurement techniques

Often, in industrial motion control and positioning applications, the need for direct feedback of a driven linear position is required. Though it is quite common, and relatively simple, to gauge the position of a displaced load through direct feedback from the drive motor assembly, inaccuracies can occur using this technique over longer linear distances.

The usual method of using a servo motor's internal feedback encoder or resolver can be complicated by a number of factors. Resolvers are inherently single-turn devices and, as such, cannot be relied upon for accurate positioning beyond the linear translation of a single motor turn. Even systems based on absolute, multi-turn encoders have their limitations over longer distances, as the method of translation from the motor's rotary motion to the linear motion of the load is not always reliable or accurate enough for the needs of the application.

As typically used in shorter-distance (<1m) applications, ball or lead screw-coupled drive systems are usually quite reliable if sized and coupled correctly. For these systems, a drive-mounted or integral rotary feedback device is usually sufficient.

For distances of a few meters, a linear position sensor, typically a rod or profile-style magnetostricive sensor, is a reliable and economical choice, though response time and accuracy can be challenging near their operational length limit (typically 3 to 4m).

It is at distances of 5m or more that optical, LASER-based positioning systems become economically justifiable and preferred.

Though other means of long-range position detection are possible, usually through reverse linear to rotary translation (translation of the load's linear position through rotary conversion as opposed to that of the rotary drive system to linear motion), they are often costly and lack reliability and durability.

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Cable retractor-mounted multi-turn encoders, sometimes referred to as “rope encoders” or “string-pots” are limited by cable length and sag, and are constrained by their installation environments and operating speeds. Rack and pinion systems, where a pinion gear is attached to an encoder, which then rides back and forth on a toothed rack, are costly to install and maintain, and often jump at higher speeds. A similar system, often used on overhead crane and gantry systems, has a measuring wheel attached to an encoder, which then rolls along a flat surface. The trouble here lies in the decreasing circumference of the wheel as it wears, and frequent slippage of the wheel on the roll path.

Lighting the way

As demonstrated, few typical, mechanical systems exist that can accurately and reliably encode and transmit linear positions for use in a longer-range motion control or positioning system. It’s only with the introduction of relatively accurate, reasonably priced and easily-integrated optical position measurement systems to the industrial marketplace that the barriers to success in these application have been breached.

In a typical system, a Class 2, visible red (670 nm) LASER-based emitter/receiver is positioned opposite a target (either a flat, clean surface or a specific reflective target) and as the distance between the two is varied, the position is evaluated and a corresponding value is transmitted from the device to the control system. Typically, either the Optical Positioning Device, or its target, is fixed and the other will move relative to it, depending on location of available power and control system wiring.

The use of a specific reflective target for the system is optional on some systems but mandatory on others. Though the installation and maintenance of the reflector can be a nuisance, its use has distinct advantages. By redirecting the light back at its source through a high-grade, prismatic retro-reflector rather than simple reflection, the maximum proportion of the beam and light intensity are preserved, increasing system reliability. Also, some manufacturers will calibrate or “linearize” their devices with the included reflector, allowing their systems to perform at maximum linearity in the field.

Position output interfaces vary by manufacturer, with the serial transmission of a digital position value being the preferred option over a proportional, analog value due to its limited resolution and susceptibility to various forms of EMI corruption. Most vendors now incorporate the popular field-bus communication protocols (DeviceNet, Profibus, etc.) into their offerings as well.

Several common systems for LASER-based position measurement are available; triangulation, interferometry, time-of-flight and phase-shift measurement, with only the latter two modes finding practical, industrial application for longer distances (absolute positions of 200m or more).

Time-of-flight based systems will measure the flight time (typically in the nanosecond range) of a series of specific pulsations and, following the integration of several samples, transmit a position value to the output stage. Performance is dependant on the amount of reflected light (a high signal-to-noise ratio is required) and processing speed.

Contrastingly, phase-shift measurement systems continuously measure the shift in the intensity phase angles between the emitted and reflected (returning) light, allowing them to continually evaluate and integrate the relative position. This typically results in faster, more reliable position value integration without sacrificing position accuracy or limiting linear velocity. Full linearization of these systems can allow them to meet or surpass the linearity of time-of-flight devices.

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Repeatability over accuracy

Naturally, the ultimate test of any such system is how well it performs the required task of providing the necessary position feedback to the governing motion control system, and typically, the most commonly requested or consulted specification for any position measurement system is “accuracy”. This is, however, more or less irrelevant unless you are actually using the system to “measure” something rather than “position” the load.

In the vast majority of applications for longer-range, optical positioning systems (automated storage and retrieval, overhead crane and gantry systems, etc.), the repeatability of the system, or the ability to position and reposition to a known, fixed point is decidedly more relevant than the accuracy of the measured distance that it has travelled. As systems wear and large-scale installations migrate due to normal expansion and contraction, accuracy becomes moot as recalibration of known positions becomes necessary.

Putting it all together

Ultimately, due to the unique combination of continuous position integration and high relative repeatability, along with the inherent advantages of an optical, LASER-based system, the phase-shift measurement technique for optical position measurement stands alone in its ability to provide an overall functional balance of output value reliability and speed for closed-loop motion control and stable, reliable positioning feedback.

TECHNICAL SPECIFICATIONS:

Stroke:	0.2-125/170/195/240 m
Accuracy:	+/- 5mm
Precision:	+/- 2mm
Output Refresh:	1 ms
Resolution:	0.01 mm
Temperature:	0°C to 50°C
Option:	Pressurized air input
Interface:	SSI, PB, IBS, CAN

LE 200 Water Cooled model also available for extreme environments that has been designed to withstand heat up to 100°C with 5mm accuracy.

MORE INFORMATION?

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