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Automation

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Linear Encoders for Linear Motors for Direct Drives

Introduction

Linear motors have made irreversible inroads into highly dynamic applications such as manufacturing and measuring equipment in the semiconductor industry, in PCB assembly machines, textile machines and in automation. Direct drives for open and closed-loop control require continuous real-time and exact information on the position of the slide. The accuracy, performance and reliability of the individual axes depend on the linear measuring devices used. In connection with linear motors, this task is now performed primarily by compact, contact-free measuring devices—called exposed linear encoders.

The decisive advantage of direct drive technology is the very stiff coupling of the drive to the feed component without any other mechanical transfer elements. This allows significantly higher gain in the control loop than with a conventional drive. Here, the efficiency of a linear motor is greatly influenced by the selection of the position encoder. High control-loop gain can only be reached if the encoder provides high-quality position signals. With the high gain required in the control loops, even minor disturbances in the encoder output signal can cause serious trouble in drive performance. The higher quality of the position information noticeably improves velocity control and positioning. In addition, the motor operates quietly and develops only a small amount of heat.

Velocity measurement on direct drives

On direct drives, there is no additional encoder for measuring the speed. Both position and speed are measured by the position encoder: linear encoders for linear motors, angle encoders for rotating motors. Since there is no mechanical transmission between the speed encoder and the feed unit, the position encoder must have a correspondingly high resolution in order to enable exact velocity control, particularly

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Did You Know...

…that a RENCO encoder is used in camera stabilization equipment found on many boats and moving platforms that film for television and movies, allowing filmmakers to get steady shots during high speed boat chases, for example? Chosen by Motion Picture Marine in California, the RENCO encoder has been part of their PERFECT HORIZON camera stabilization head for many years.

PERFECT HORIZON Founder and President David Grober on the set of Talladega Nights

"Our company started in 1977 and was one of the first maritime coordination and film production companies of its type," explained David Grober, company founder and president. Their PERFECT HORIZON camera stabilizer has been used in many films such as *James Bond, Harry Potter, Blue Crush and Step into Liquid*, to name a few. "This head allows a cameraman to film from a moving a boat, removing the pitch and roll from the vessel so it appears that he is on solid ground. All he needs to do is follow his subject."

The PERFECT HORIZON unit is mounted between the camera and its support, such as a crane, tripod or other device. The RENCO encoder within this stabilizer serves as the feedback device for the motor, which compensates for two dimensions of motion in the horizontal plane, keeping the horizon consistent at all times. In the past, similar devices attempted to use gyroscopes to stabilize the camera, but the gyroscopes would also fight the movements of the cameraman. The breakthrough of electric sensors and a computing system make the PERFECT HORIZON an effective, useful tool in the filming industry.

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Did You Know... *continued from Page 1*

"After doing some research, we chose the RENCO encoder for our PERFECT HORIZON because of its small size and reputation. It was important to us," said Grober. "They have worked great, and the longevity of the encoder has proven itself."

The PERFECT HORIZON is used in many strenuous filming applications such as where cameras are secured to not only boats but also jet skis, cars, snowmobiles or floating platforms. Footage taken with this system can be seen in not only motion pictures, but also in television car commercials as well as coverage of surfing competitions and many other sporting events.

The PERFECT HORIZON camera stabilization unit

Motion Picture Marine not only provides the PERFECT HORIZON for the actual filming, but also does full maritime film production work such as coordinating ocean sequences for feature films and television by putting together boats, skippers, crews and stunt work for above water action.

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at slow traversing speeds. The velocity is calculated here from the distance traversed per unit of time. This method—which is also applied to conventional axes—represents a numerical differentiation that amplifies periodic disturbances or noise in the signal. The significantly higher control loop gain on direct drives dramatically increases the influence of the signal quality on drive performance.

Linear encoders that generate a high-quality position signal with only small interpolation error are therefore essential for the meaningful operation of direct drives. Encoders that use photoelectric scanning are particularly suited here for this task, since very fine graduations can be used as measuring standards by this method. These encoders provide benefits in the positioning, speed stability, and thermal behavior of a direct drive. Up to now, an absolute position value calculation and the associated availability of the position value immediately after encoder switch-on without any axis movement were not yet available with exposed linear encoders. Sealed absolute linear encoders are not always used on direct drives because they often required compact dimensions. Exposed encoders, which thanks to their lack of an enclosure have very small dimensions and therefore low weight, were previously available only in incremental versions. With the new LIC 4000 exposed linear encoder, HEIDENHAIN now also offers an absolute and exposed linear encoder with EnDat 2.2 serial interface.

The graduation carrier—a METALLUR scale tape

HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. They are characterized by their high edge definition and excellent homogeneity—a fundamental prerequisite for low interpolation error, and therefore for smooth operating performance and high control loop gain.

The quasi-planar graduation structure, which is applied in the METALLUR process, is extremely tolerant to contamination and thereby greatly enhances encoder reliability.

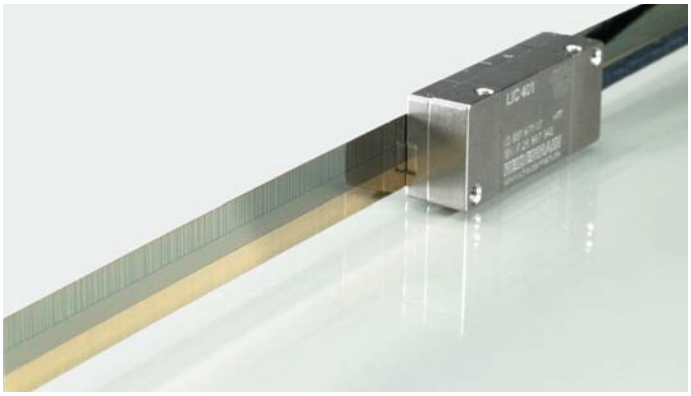

Figure 1: Scale tape of the LIC

In the LIC 4000 series with its absolute graduation, the position value is available from the encoder immediately upon machine switch-on. There is no need to move the axes over the reference marks to find the reference position. The absolute position information is scanned from the scale graduation, which is configured as a pseudo-random-coded track (PRC) and a separate incremental track. The position information is ascertained with a newly developed scanning method through the evaluation of the PRC track and the incremental track. A highly integrated opto-ASIC makes it possible to achieve new dimensions in terms of accuracy and reliability of position information.

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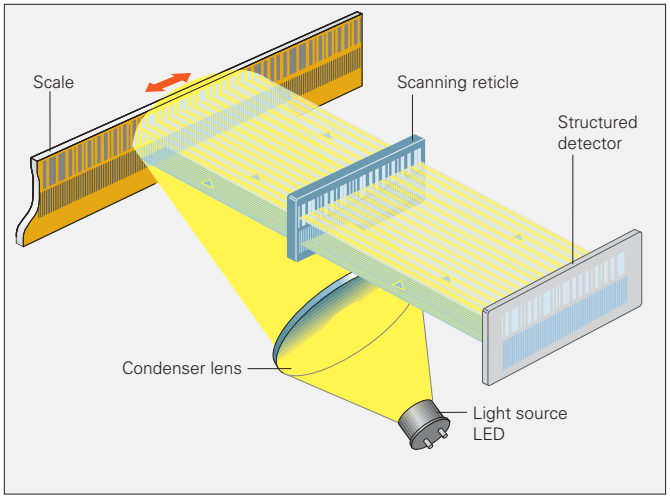

Figure 2: Design and functional principle of the optical scanning method of the LIC 4000

Measuring accuracy and high reliability contribute to machine safety

The newly developed scanning method is based on the high quality of the graduation and provides absolute position values with a specified interpolation error of less than ± 40 nm. Exposed linear encoders of the LIC 4000 series are therefore optimized for use on fast, precise machines. In spite of its exposed design, the LIC 4000 is extremely tolerant of contamination and therefore contributes greatly to the optimization of machine availability in its various applications. Everyday contamination resulting from small quantities of oil, dust, fingerprints, hair or small metal objects applied were tested intensively in a laboratory and show few effects on operational reliability. The measuring accuracy of the LIC 4000 is also hardly influenced by the tested types of contamination (Figure 3).

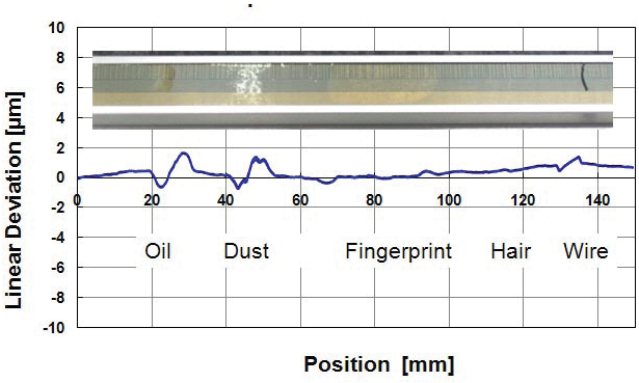

Figure 3: Contamination on the graduation: measuring accuracy of the LIC without the application of electronic corrective measures

Benefits of serial position transmission with EnDat 2.2

The scanning signals of the LIC 4000 series are digitized directly in the scanning head and are converted into a high-resolution position value. This eliminates the previously prevailing transmission of analog signals from the scanning head for drive control. With digital position transmission via EnDat 2.2, these advantages of the new absolute scanning process in terms of accuracy and resolution can be exploited without loss in the transmission. Both the speed stability and positioning behavior of linear direct drives can therefore be increased significantly because of the LIC 4000. Highly dynamic drives running on position signals from the LIC 4000, also with very high proportional gain in the velocity controller, feature quietness in operation. The high control loop gain would not have been possible without the high clock frequency of the EnDat interface and the resulting short read-out times. EnDat 2.2 is now the fastest purely serial interface for position encoders based on the RS-485 transmission characteristics.

Simple installation with diagnostic capabilities

The absolute encoders of the LIC 4000 series are particularly easy to install. The valuation numbers provided over EnDat 2.2 for the absolute track, incremental track and position value calculation provide a real-time status report on the condition of the encoder. Well proven mounting tolerances in conjunction with valuation numbers make reliable mounting possible without having to do without a safety margin in the field. The valuation numbers can be called through EnDat 2.2 during motor operation without sacrifices in the performance of the servo control. The diagnostic system generates error messages and warnings, and therefore makes an important contribution to ensuring the availability of the overall system.

Summary

Applications with direct drives often place special requirements on control and measuring technology. Encoders for acquisition of position and drive velocity need to provide high-quality signals. Short-range errors in the position measuring signal are particularly critical for direct-driven feed axes because they can result in positioning error, speed ripple, loud noise and additional heat generation. Encoders that use optical scanning and provide small signal periods have proven to be particularly effective by enabling machines to operate with high accuracy and resolution values.

An absolute encoder with high resolution of one nanometer (1 nm) is now available in the LIC 4000 compact exposed linear encoder. The well proven EnDat 2.2 serial interface provides fast data transfer. Besides position information, the EnDat protocol makes it possible to transfer various data that can be used, for example, for system diagnostics. For demanding positioning and control tasks in various applications such as in the semiconductor industry, metrology, medical technology, automation and textile machines, machine tool builders and plant manufacturers are now flanked by an exposed absolute encoder that contributes to a decisive degree to the accuracy, performance and reliability of individual axes both for today's and for future generations.

Leine & Linde's New Thin Encoder Broadens Assortment Offered for Drives

An encoder is mounted at the rear of a motor and therefore affects the motor's overall length. In tight spaces, the build length can be restricted. That's why Leine & Linde has developed a new thinner encoder series.

Compact design
The new Leine & Linde 700 series features a thin design and a large hollow shaft up to 25.4 mm, which means that these encoders can often be mounted directly on a motor's shaft without an intermediate adapter for shaft reduction. This characteristic contributes to minimizing the overall build length, and at the same time facilitates mounting. It is compact and robust.

Despite its compactness, the encoder is designed for the tough environments where a typical Leine & Linde product is used. Mechanically it features a dual set of heavy duty bearings and a well-encapsulated enclosure. Electronically it is built for reliability in tough environments where it is subjected to vibrations and electrical disturbances.

Complete assortment
The 700 series complements Leine & Linde's previous assortment of encoders for drives. With respect to robustness, it is positioned midway between Leine & Linde's established models in the 500 and 800 series. The 500 series covers the industry's standard options for Ø58 mm encoders, while the 800 series is larger and especially adapted for heavy duty applications. Regardless of the demands a motor places on encoder size, robustness and function, Leine & Linde offers a solution.

Modules
For use with these encoders, Leine & Linde offers a wide range of electrical interfaces to choose from, each adapted to different frequencies, temperatures and cable lengths. This is why there is always a solution optimized for the particular application where the encoder is needed. The signals can consist of square waves, sinus waves or even be optical with the help of a gateway for OptoLink transmission.

On the mechanical side, there is multitude of different shaft variants that cover the market's standards for both inch- and millimeter-based dimensions.

Technical Tidbit:

Importance of Mounting Tolerances for Modular Encoders

James Rago
Product Specialist

by Jimmy Rago, HEIDENHAIN Product Specialist

Modular encoders are very susceptible to mounting misalignment. Since modular encoders have no bearing, they rely solely on the accuracy of the motor and encoder manufacturing process. If the motor dimensions are not within the mounting specifications or the encoders physical dimensions are all near tolerance limits, then the encoder may not operate correctly. There are several factors, which are of primary concern when mounting modular encoders.

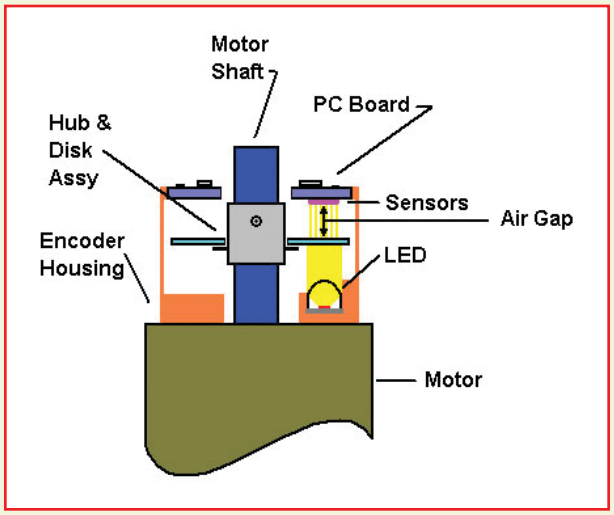

Figure 1: Encoder Installed on a Motor

Concentricity of the encoder housing with the shaft centerline is an important factor to consider. The encoder housing holds the LED and the sensors and positions them relative to the shaft centerline. If the concentricity error is too great, the lines on the disc will not line up correctly with the sensors, which can cause an increase or reduction in counts and the loss of the index or commutation channels.

Perpendicularity of the motor shaft centerline to the mounting surface can affect the gap relationship between the disc and the sensors. If the encoder housing is rotated relative to the motor shaft, the space between the disc and sensors can change, affecting signal amplitude and quality. The change in the gap will be dependent on the placement of the photo head on the mounting surface. Disc rotation will not affect the gap distance once the housing is secured.

Axial endplay of the motor shaft will cause the disc to move toward or away from the pc board sensors. The encoders are designed to handle small amounts of axial and radial run out, but if the axial run out is too large, the encoder disc can contact the sensors which may damage the lines on the disc or the sensors on the pc board. The perpendicularity of the shaft and mounting surface must also be taken into account when dealing with axial end play. The perpendicularity error must be added or subtracted depending on whether the perpendicularity error increases or decreases the gap between disc and sensors.

Tolerance between the encoder hub and disc assembly and the motor shaft affects the disc alignment to the sensors. If the inside diameter of the hub is at its maximum tolerance and the motor shaft at its minimum tolerance, this may affect the encoders output. An encoder in this situation will also be more susceptible to variations due to temperature changes.

Radial run out of the shaft will cause the data tracks under the sensors to be non- concentric. This can cause the index or commutation outputs to become non-functional.

Mounting the encoder according to the specified mounting tolerances can ensure proper operation and will likely allow the encoder to remain in service longer. For more detailed information about mounting specifications or for an example of how mounting stack ups may affect encoder performance, please contact us.

Jimmy Rago, 847-519-4213

Total Customer Satisfaction improvement thrives on customer input

By John Thormodsgard, National Sales Manager, Automation, Semiconductor & Metrology Division

John Thormodsgard
National Sales Manager, Automation, Semiconductor & Metrology Division

Positive change was a strong focus for HEIDENHAIN in 2011, and a new initiative aimed at finding ways to better serve our customers was at the top of that list. To do that, HEIDENHAIN implemented a continuous process improvement program that we named Total Customer Satisfaction (TCS). To its credit, we are realizing some very positive improvements.

This all started early 2011 with HEIDENHAIN management taking an introspective view of how we might improve our service. One of the steps identified was to improve our listening – perhaps summed up as 'listen twice as much as we talk'. TCS is a step in this direction but is also expanded to include a thorough root cause analysis and corrective action process. Complaints or ideas for improvement are documented in a dedicated IT system, processed via the TCS team, implemented, and then communicated.

The heart of the TCS initiative is a cross-functional team consisting of employees from each department of our company as well as our upper management. The team meets regularly to discuss any new complaints or suggestions and will determine if improvement can be made through immediate collaboration or if further analysis is needed.

Often, TCS suggestions must be assigned to an individual or subset of the full group to research the issue and the processes involved. In such cases, recommendations are made at a later TCS meeting. Because senior management as well as employees from across all functions of the company is represented on the team, improvements can be realized quite quickly. Over time, incremental improvements realized through TCS should have a significant impact in the form of improved processes.

Of course, this system only works when we hear from you. Please contact me or anyone else from HEIDENHAIN when you have a complaint or suggestion for improvement. Through TCS, we will strive to improve our service to you.

Sincerely,
John Thormodsgard
847-519-3399

CONTACT INFORMATION

For more information about HEIDENHAIN and any of the products or services mentioned here, please feel free to contact us.

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