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Automation
July 2011

What to Consider When Choosing a Rotary Encoder

By Tom Wyatt, HEIDENHAIN Automation Division Manager, North America

Controlled servo drives are used in many areas of automation technology, converting, printing, handling and robotics including production machines and machine tools. The selection of a rotary encoder or encoder technology for use within the system is dependent on the **accuracy requirements of the application** whether it is position and/or velocity control.

Before making an encoder decision, an engineer should examine this and all the major encoder properties that have the largest influence on important motor performance. These include:

- Positioning accuracy
- Speed stability
- Audible Noise, as little as possible
- Power loss
- Bandwidth, which determines drive command-signal response

Positioning accuracy

Positioning accuracy depends solely on the application requirements. Resolvers, for example, mostly have one signal period per revolution. Therefore the position resolution is extremely limited and the accuracy typically is in the range

of ~ ±500" (Arc seconds), assuming interpolation in the drive electronics usually results in a total of 16,384 positions per revolution.

On the other hand, an inductive scanning system as found in many rotary encoders will provide significantly higher resolution, typically in the range of 32 signal periods per revolution resulting in an accuracy of ~ ±280". The interpolation in this case is

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Contents...

Did You Know...

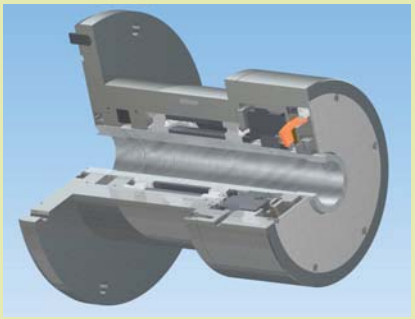
...that a Numerik Jena KIT R rotary encoder is an important component in the assembly of a highly effective rotary vacuum seal system manufactured by **Ferrotec (USA) Corporation**.

Specifically, the Numerik Jena component is used in FerroTec's FerroDrive motor-integrated vacuum rotary feedthrough product. These FerroDrive systems provide vital precision rotation sealing in a vacuum, which is necessary for assembly and processing applications in industries such as semiconductor, LED, solar cells and aerospace.

"Our FerroDrive motor-integrated feed through systems are designed to provide an integrated motor/seal subassembly for use in high vacuum manufacturing processes," said Tom Black, Ferrotec Engineering Manager. The Numerik Jena KIT R modular encoder and disk hub assembly components assist this Ferrotec system by tracking the specific position and speed of the shaft that actually penetrates a vacuum chamber and rotates.

"We appreciate the dependability of the Numerik Jena encoder in this system which provides us with a speed accuracy of ±0.1% and high stability and quality signals for smooth velocity control," continued Black.

The Numerik Jena KIT R rotary encoder series is known for its compact size, easy installation and signal interpolation of up to 100x. Through dynamic offset and amplitude control, high interpolation accuracy is achieved and further reduction of sensitivity to contamination is realized.



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internal to the encoder resulting in 131,072 positions per revolution.

Optical rotary encoders are based on very fine graduations commonly with 2048 signal periods per revolution and therefore even much higher resolutions are possible with internal interpolation electronics. The output resolution here is 25-bits, 33,554,432 absolute positions per revolution with accuracies in the range of ~ ±20".

Speed stability

To ensure smooth drive performance, an encoder must provide a large number of measuring steps per revolution as the first piece of the puzzle. However, an engineer must also pay attention to the quality of the encoder signals. In order to achieve the high resolution required, the scanning signals must be interpolated. Inadequate scanning, contamination of the measuring standard, and insufficient signal conditioning can lead to the signals deviating from the ideal shape. During interpolation, errors then occur whose periodic cycle is within one signal period. Therefore, these position errors within one signal period are also referred to as "interpolation error". With high quality encoders, these errors are typically 1…2% of the signal period (refer to figures 1 and 2).

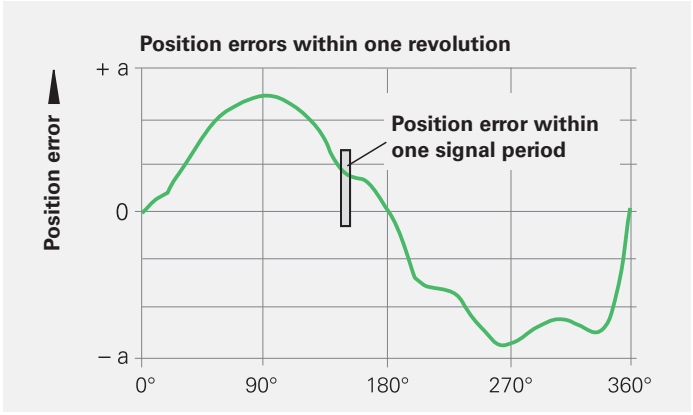

Fig. 1

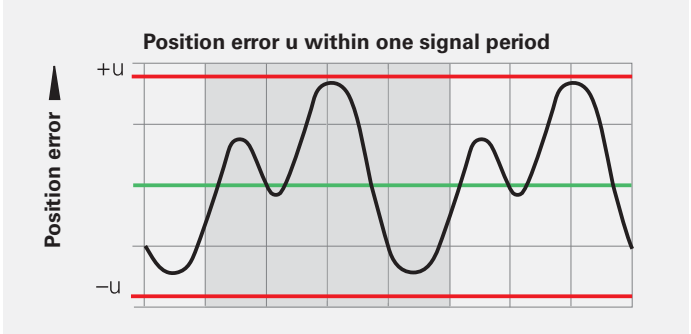

Fig. 2

The interpolation error adversely affects the positioning accuracy, and also significantly degrades the speed stability and audible noise behavior of the drive. The speed controller calculates the nominal currents used to brake or accelerate the drive depending on the error curve. At low feed rates, the feed drive lags the interpolation error. At increasing speeds, the frequency of the interpolation error also increases. Since the motor can only follow the error within the control bandwidth, its effect on the speed stability behavior decreases as the speed increases. However, the disturbances in the motor current continue to increase, which leads to disturbing noises in the drive at high control-loop gains.

Higher resolutions and accuracies also reduce disturbances in the motor current in the way of heat generation and power loss. The chart below shows a simple comparison of 3-different scanning technologies and the resulting current draw.

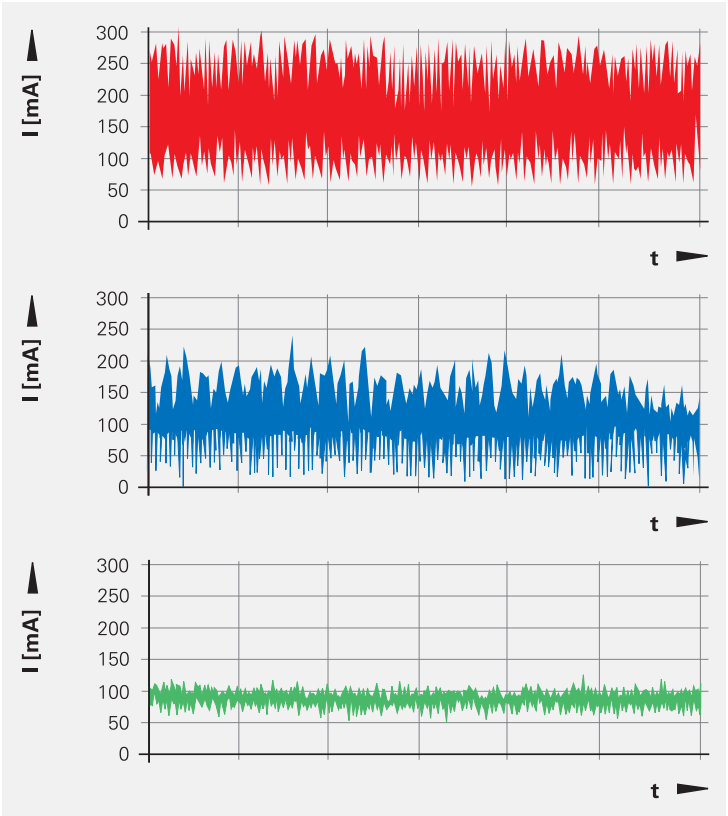

Figure 3: Current variations for different types of scanning systems in the encoders

- *Resolver*
- *Inductive*
- *Optical*

What to Consider When Choosing a Rotary Encoder *continued from Page 2*

Bandwidth
Bandwidth (relative to command response and control reliability) can be limited by the rigidity of the coupling between the motor shaft and encoder shaft as well as by the natural frequency of the coupling. Encoders are qualified to operate within a specified acceleration range. Values typically range from 55…2,000Hz. However, if the application or poor mounting cause long lasting resonant vibration, it will limit performance and possibly damage the encoder.

Natural frequencies vary depending on the stator coupling design. This frequency needs to be as high as possible for optimal performance.

The key is to ensure that the bearing of the encoder and the bearing of the motor are as close to perfect alignment as possible. Illustrated below is an example of how this is accomplished. The matching tapers of the motor shaft and encoder ensures near perfect alignment to the centerline.

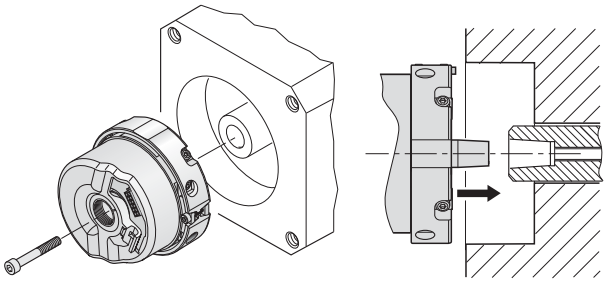

Fig. 4

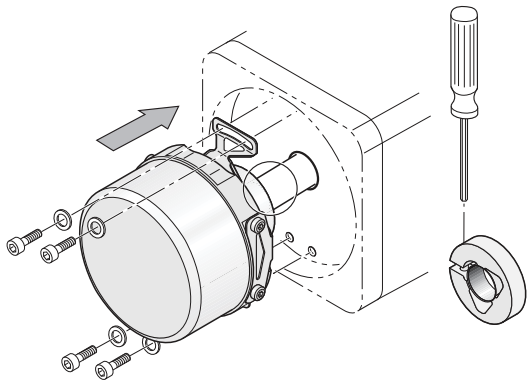

Fig. 5

This mechanical configuration will result in a holding torque approximately 4x greater than a standard hollow shaft encoder with a 2-mounting tab stator coupling (below). This will increase the bearing life of the encoder as well as provide exceptional natural frequency / acceleration properties. Additionally, this configuration will virtually eliminate any limits on the bandwidth of the drive!

In summary, many factors influence the selection of an appropriate rotary encoder for use in controlled servo drives. And while positioning accuracy requirements are paramount in the consideration process, it is important to know how other properties can and will influence the application, such as speed stability, noise, possible power loss and bandwidth. A good fit from the start will provide positive performance in the motor/drive system in the end.

Explosion-proof Rotary Encoder from Leine & Linde

In order to provide a sturdy, explosion-proof rotary encoder, Leine & Linde introduces its series model 841. ATEX and IECE-x approved, this encoder is primarily meant for motor velocity feedback and positioning of heavy motor operations or generators.

Already in use in such industries as oil and engine applications, the Leine & Linde 841 rotary encoder can handle a large temperature range. It is an optical encoder intended for measurement and control of angular speed and position. The flameproof enclosure consists of aluminum flange, housing and back cover and a stainless steel hollow shaft.

The encoder is supported directly on a motor shaft or a shaft extension, and exists in two versions for 12 or 16 mm diameter shafts. The hollow shaft is fixed by tightening a special screw in the shaft center. The encoder housing is prevented from rotation by a torque arm with two-rod ends. The torque arm can be connected to either the front or back in a variety of positions.

The electrical outputs of the Leine & Linde 841 encoders are all closed circuit protected both to OV and to supply voltage. The supply lines are protected against reverse polarity. Up to six output signals plus an optional diagnostic signal are delivered from the encoder via a certified cable gland through the housing.

The 841 series encoders are certified according to Ex d for use in Category II, Zone 1 (gas), and Zone 21 (dust). They can be delivered with Leine & Linde's Advanced Diagnostic System (ADS), a built-in system for troubleshooting and preventative maintenance in the process industry.

Lunch on Us!

By Tom Wyatt, HEIDENHAIN Automation Division Manager, North America

Tom Wyatt
National Sales Manager
Automation Division

Yes, that's right lunch is on us! All we ask for is an hour of your undivided attention to show you how we can best meet your motion control needs with the latest and greatest in precision measurement from HEIDENHAIN.

Considering all of the changes we've all seen in the last year in the way of new product introductions, re-designs and incorporations of sister companies, we are heeding the call of better education to our customers. We have found an interest in a "Lunch & Learn" program whereby we come to your offices during the lunch hour with food and information for your group, and we'd now like to offer it to all customers.

We at HEIDENHAIN understand that it is necessary to make all of our valued customers aware of what is new and improved in the encoder industry and that we are in a rare position to offer a wealth of information. Also, we know that HEIDENHAIN's product offerings are so vast that it is just too easy to overlook a particular product, and the possibility now exists that we have something available that you've had on your wish list.

In addition to catering lunch, HEIDENHAIN can also cater to your interests in the way of presentations. Perhaps a company / factory overview or simply a detailed overview of scanning technology would be of interest to your staff. Whatever your area of interest is, we will customize the presentation material!

Following are few Lunch & Learn presentations that I'd like to suggest:

- EnDat
- Functional Safety
- New and improved scanning method
- HEIDENHAIN Drive encoder overview
- HEIDENHAIN Rotary encoder overview
- LEINE and LINDE robust / heavy duty encoders
- RENCO encoders
- Angle encoders
- Linear encoders
- Gauging

Our intention is to ensure that you the customer are aware of every relevant possibility and understand our capabilities. Speaking of capabilities, let us know if you are ever in Europe whether on vacation or business. We would love for you to be our guest and take a tour of the factory in Traunreut, Germany. I guarantee you will be amazed at what you see. You are also welcome here in Schaumburg, IL at any time. Just let us know so we can make sure someone is available to help you.

Please consider our offer for the Lunch & Learn and feel free to contact me personally or your area sales manager so we can arrange a date and food preference for you. ***Have a great summer everyone!***

Tom Wyatt, 847-884-3713

Technical Tidbit:

Outgassing

by Jimmy Rago, HEIDENHAIN Product Specialist

Outgassing is a phenomenon with which many people may not be familiar. Outgassing is the release of gasses from a solid. These gasses can be internal to the solid or adhered to the surface of the solid (adsorption). Not only can a trapped gas be released from the material, but the solid can also change state from a solid to a gas (sublimation). Outgassing is usually caused by high temperatures or high vacuums. In a casting process, the gasses trapped inside the solid escape during the curing process, leaving small holes in the surface, affecting surface finish properties. The effects of outgassing are dependent on the material properties, ambient temperature and pressure, as well as other atmospheric conditions.

In the case of an encoder in a clean room environment, outgassing of the cables becomes an issue. The shielding can sublimate, leaving small particles of cable material on other equipment, such as mirrors. As a room is repeatedly depressurized, some materials will continue to sublimate each time, eventually removing enough material to affect performance. This can result in mechanical failure of the

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Technical Tidbit:

Outgassing

material, or electrical failure. Shielding between cables can dissolve, exposing wires which may touch and short circuit a device.

Some materials will only show significant outgassing one time at a specific vacuum level. One tactic used to deal with outgassing is to establish the room vacuum, allow the materials to outgass, release the vacuum, then remove the excess gas or sublimated material and re-establish the vacuum. There are also materials designed to resist outgassing at specified temperatures and pressures. These materials should be considered for vacuum situations. HEIDENHAIN offers feedback systems for vacuum applications. Please give us a call and we can discuss your application.

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

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