HEIDENHAIN

Technical Information

New Series of Angle Encoders with Integral Bearings and Advantages for the Machine Tool Builder

For years, HEIDENHAIN has been setting the standard for angular metrology with angle encoders featuring integral bearings in hollow-shaft versions. These encoders are characterized by their simple mounting and high accuracy. They are the encoders of choice for many applications for angle measurement in accuracy grades of a few angular seconds. Particularly on rotational axes in machine tools, such as rotary tables and tilting axes, they are the best solution for position and speed control.

Based on the design of the angle encoders with integral bearings and hollow shaft, with its RCN 5000 HEIDENHAIN has developed a new series of angle encoders with a large number of persuasive properties.
The advantages are found in the following:
• The design:
- Hollow shaft Ø 35 mm together with small installation space
- Large mounting tolerances without limitation of function or accuracy
- Connectable cable assembly
• The scanning:
- Very high signal quality
- High tolerance to contamination
- High permissible shaft speeds
• The interface:
- Automatic self-configuration
- Generation of warnings when certain tolerance limits are violated
-Diagnosis by valuation numbers
-Compact connecting elements
• Safety technology:
- Single-encoder solution with purely serial interface for use in safety-related applications.

Advantages of the mechanical design
One special property of the new series is the large hollow shaft with a diameter of Ø 35 mm and very compact outside dimensions. This represents a shaft cross section more than three times larger than the RCN 200 series, which is similar in design and has a hollow shaft of Ø 20 mm. This provides more area for stiffer machine shafts and hydraulic leads, which are frequently led through hollow shafts. With an outside diameter of Ø 110 mm and an overall height of only 42 mm, the RCN 5000 requires less installation space.

Simple mounting is a further advantage of the new angle encoders. Unlike the modular angle encoders, which usually consist only of a scanning unit and a graduation carrier, the hollow-shaft angle encoders with integral bearing feature an integrated stator coupling. In this way, the components involved in scanning are ideally aligned to each other, even if there are deviations of the shaft coupling. Radial and axial error in the measured shaft is assimilated in

the stator coupling so that the coupling remains free of torsional rotation. Of course, this principle applies only within certain mounting tolerances. The new stator coupling, conceived and developed for the RCN 5000 is characterized in its axial and radial deflection and torsional rigidity by excellent behavior and operates virtually without angular error. This permits relatively generous mounting tolerances without its limiting function or accuracy. For example, together with the encoder sealing technique, which is also new, it can tolerate deviations in axial direction of up to ±0.3 mm.

The new series also has an impressive set of design details. The RCN 5000 encoders feature a pluggable cable assembly (Figure 2).

Because the separately ordered adapter cable has a quick disconnect, mounting the plug-in cable assembly to the encoder is very simple. No tools are needed. At the same time, the connecting element has a leak tightness of IP 67 to prevent ingress of liquids through the plug-in connection. The advantages of the connectable cable subassembly are particularly evident when a cable has to be configured during mounting in a tight installation space. The machine tool builder is also more likely to have the encoder on hand because it can be ordered separately and stocked without regard to a specific cable length or type of connecting element. The cable assembly can then be ordered and provided relatively quickly for the specific application. It may also be possible to do without additional cable because a wide range of pluggable cable assembly variants will be available.

Advantages of the scanning technique
The new RCN 5000 encoders operate with two graduation tracks (Figure 3).

The absolute position data on the circular scale is encrypted on one track and never recur within the same revolution. The additional incremental, higher resolution track is scanned according to the single-field scanning principle (Figure 4).

This principle uses one large grating whose grating period differs slightly from that of the scale. The scanning signals of the incremental fine track are interpolated for the position value and are processed together with the information from the serial code track to obtain absolute position values of high resolution. This enables the encoder to measure to a resolution of more than 268 million positions per revolution. At the same time, the scanning signals of the incremental, fine track are used to generate an optional incremental signal (~ 1 VPP).

Thanks to the special optical filtering of the innovative optical scanning lenses, the encoder produces scanning signals of very high quality. Up to now, test results with the RCN 5000 show that the position accuracy relevant to feedback control, often described as position error within one signal period, is superior to the absolute angle encoders of the RCN 200 series by a factor of four. Particularly

Figure 2: Plug-in adapter cable

Figure 3: Graduated disk with serial code track and incremental fine track

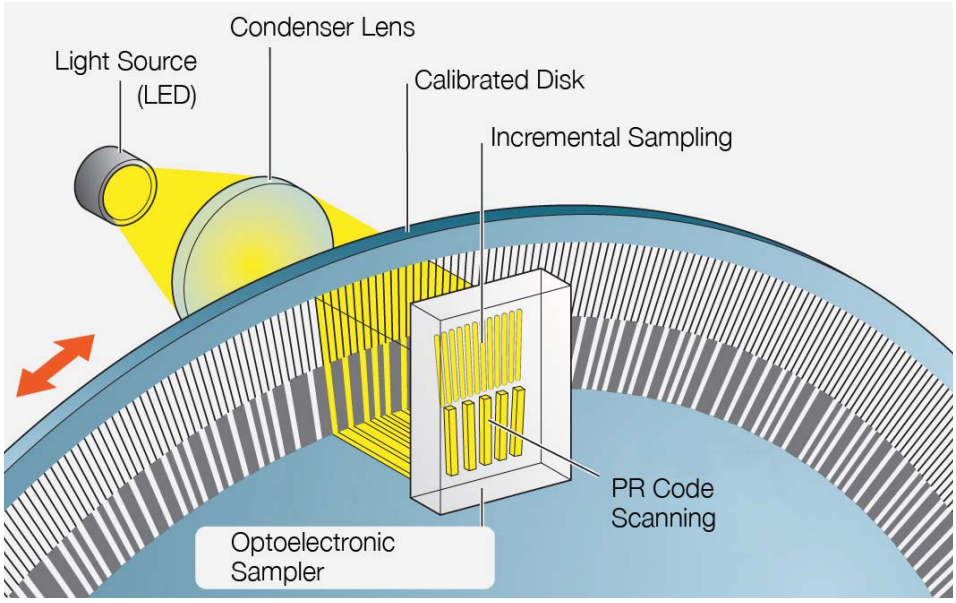

Figure 4: Single-field scanning principle

on direct drives, this high signal quality will have positive effects on the control behavior and result in noticeable quality improvements of the finished workpiece surfaces.

Although the RCN 5000 series encoders are sealed and feature an IP62 degree of protection, the goal was to further reduce the contamination risk to the point that it could no longer affect proper function. Besides its improved signal quality, the single-field scanning is characterized by a significantly reduced sensitivity to contamination. This has been achieved through the large scanning surface and the special arrangement of scanning fields. Even relatively large contaminate areas result only in slightly smaller scanning signals and somewhat increased signal deviations. In many cases, depending on the contamination, this can even prevent encoder failure where 4-field scanning, which up to now was used in the angle encoders with integral bearings, cannot. The results of testing with the encoders are also confirmed by positive experience with linear encoders. Here the single-field scanning was introduced some time ago and has since been installed in large quantities in various applications.

To be able to meet the growing demands for better performance on machine tools, design engineers are increasingly using rotational axes that distinguish themselves through high accuracy and high rotational speed. They are intended, for example, to make it economical to run turning and milling operations on the same machine. The new series RCN 5000 are up to this task as well. Thanks to the single-field scanning and the new scanning and evaluation electronics, it became possible to dramatically reduce the influence of the rotational speed on the generation of position values. This ensures that, even at high speeds, the scanning signals have high signal quality and continue to interpolate well. The RCN 5000 with purely serial interface can attain speeds of up to 3,000 rpm (however, at high speeds certain speed cycles have to be considered due to mechanical limitations). The optionally available incremental signals (~ 1 VPP) are likewise relatively stable at high speeds. The specified –3dB cutoff frequency is greater than 400 kHz. The means that with a line count of 16,384 and a speed of 1,500 rpm the maximum amplitude reduction is only 30 %.

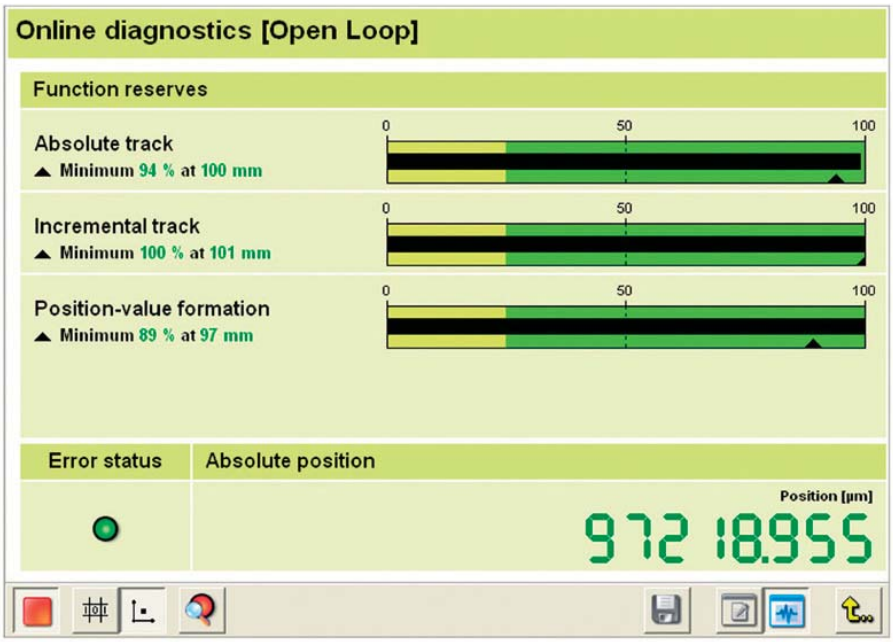

Figure 5: Example of valuation numbers on the RCN 5000

Advantages of the interface

The use of the purely serial interface EnDat provides further advantages for applications. As a serial, bidirectional interface, EnDat enables the encoder to configure itself during installation. This is made possible by a memory within the encoder with all encoder-specific information such as resolution, data on the interface, and ID number, which can be transmitted to the subsequent electronics.

In addition, it is possible to extensively monitor and diagnose the encoder. For example, the encoder generates warnings when it nears certain tolerance limits before it transmits any incorrect position values. The diagnostics make it possible to cyclically read so-called valuation numbers from the encoder. The valuation numbers provide the current state of the encoder and ascertain the encoder's "functional reserves." Proper function of the encoder is assured when the three black bars remain in the green area (Figure 5).

When one of the bars reaches into the yellow area, an examination of the mounting situation or of the encoder is recommended. This, too, does not necessarily indicate that the position value is incorrect. The monitoring and diagnostics can be used to signal the need for preventive maintenance, or it can prevent unnecessary maintenance cycles. This increases machine availability.

M12 connecting elements can also be used with the EnDat interface. This enables you to replace the previously common M23 connectors with smaller connecting elements.

Advantages due to safety technology

The benefits of a purely serial interface can also be used for safety-related applications. Safety-related applications require axes with redundant position information. To obtain independent position values, HEIDENHAIN has decided upon a single-encoder design because two encoders per axis would be both more expensive and unnecessary. HEIDENHAIN is now the only manufacturer who can offer purely serial single-encoder solutions for safety-related applications. This makes it possible to realize a purely digital machine with safe absolute positions. For the single-encoder version, two independently generated, absolute position values and error bits are produced and provided to the safe control (e.g. the iTNC 530 HSCI soon to be available).

The RCN 5000 encoders can be operated as single-encoder systems in conjunction with a safe control in applications with control category SIL-2 (according to EN 61 508) or performance level "d" (EN ISO 13 849). They represent a qualified subsystem within the larger "safe drive" system. If greatly simplifies the evaluation and realization of safety-related processes for the machine tool builder.

Summary

The new RCN 5000 series distinguishes itself with numerous impressive characteristics. For example, the RCN 5000 features a hollow shaft with a diameter of Ø 35 mm, compact outside dimensions, relative large mounting tolerances and a pluggable cable assembly. Its new scanning process and high signal quality that permits comparatively high tolerance to contamination and higher permissible shaft speeds will contribute to the success of this new series. With its monitoring and diagnostic capabilities, the EnDat interface fulfills the requirements for high system availability. It is also possible to install the RCN 5000 with its purely serial interface as a single-encoder system in safety-related applications. The RCN 5000 will prove to be the proper angle encoder for a multiplicity of applications.

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For more information:

- Brochure: *Absolute Angle Encoders with Optimized Scanning*