



## The NEW Generation of Angle Encoders Come of Age

The NEW series RCN 2000, RCN 5000 and RCN 8000 angle encoders are characterized by their simple mounting and very high accuracy. Particularly on rotational axes in machine tools, such as rotary tables and tilting axes, they are the best solution for position and speed control.

HEIDENHAIN's angle encoders with integral bearing have long been the standard for applications where angular measurement in the range of a few angular seconds is necessary. The encoders are characterized by their simple mounting and very high accuracy. Particularly on rotational axes in machine tools, such as rotary tables and tilting axes, they are the best solution for position and speed control.



*The new family of angle encoders with integral bearing*

HEIDENHAIN has now developed a new generation of absolute angle encoders with integral bearing based on the field-proven encoders. The goal was to retain the positive properties of the angle encoders while at the same time adding numerous new and useful features. So that the new encoders can be used in existing machine designs, it was ensured that their dimensions are compatible to those of their predecessors.

Comprehensive analyses and simulations were necessary in order to set another milestone in angular metrology. The knowledge thus gained resulted in a new generation of angle encoders that is completely different from the previous generation: not a single component remained the same.

The new, absolute RCN 2000, RCN 5000 and RCN 8000 angle encoders have shafts ranging from 20 mm to 100 mm in diameter, and are characterized by numerous outstanding properties regarding scanning, design and signal interface.

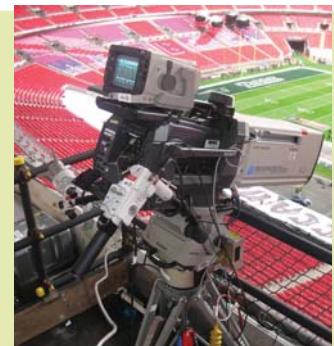
## Did You Know...

...that HEIDENHAIN ERN series encoders are used to position lenses in many of those large, high quality television cameras used in professional sports? Sportvision, Inc., well known for their virtual Yellow 1st and Ten™ Line seen when viewing NFL football, uses HEIDENHAIN encoders to ensure accurate implementation of that process – and more – within the cameras.

"We have enhanced probably 200 lenses throughout the country with HEIDENHAIN's encoders," explained Rand Pendleton, Senior Scientist and Advisor in Sportvision's Mountain View, CA location. "Besides our Yellow Line for football, our camera modifications facilitate all kinds of virtual effects including adding a lead-off line or the K-zone™ pitch effect in baseball, a "Glowing Puck" for NHL or putting a pointer to a car in NASCAR."

Sportvision is a leading innovator of digital sports content and broadcast enhancements, producing digital content and live TV enhancements on over 3,000 live events all over the world. "We are in the business to provide visual enhancements to sporting events in order to bring better appreciation to the game for the fans."

Pendleton estimates that each television camera modified by Sportvision contains a \$50,000 - \$100,000 glass lens, and that their alterations allow the operator to do effects at every video frame, where they know the state of the lens, and basically where the camera is, where it is pointed, and what the field-of-view is. "From there, we can do our magic, from going from 2D to 3D or back."



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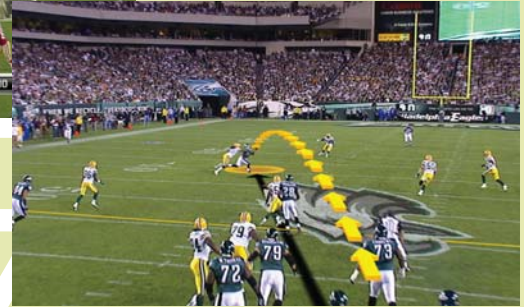
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He explains that the modifications with the HEIDENHAIN encoders came at the same time of HD technology and the necessity to be more precise. The key parameter of the lens is the accuracy of the field-of-view "which is why we mount the HEIDENHAIN encoders on an internal shaft in the lens that is mechanically adjusting the telescoping lens element inside the larger lens body.

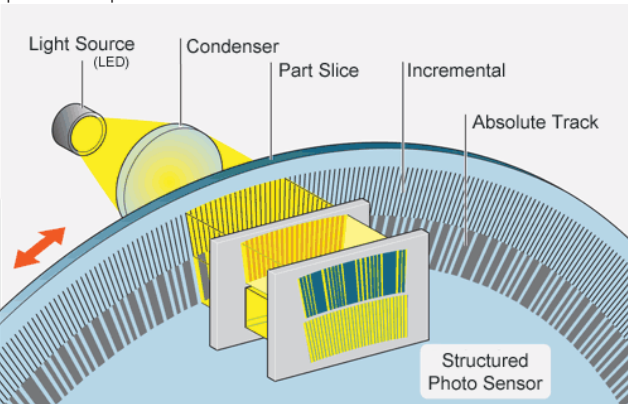
"If it is an HD lens, it will have the HEIDENHAIN encoder in it," said Pendleton, "and one that is performing well since once it's in, we don't even have to think about it. Then as part of every pre-game process, each lens is calibrated to go from encoder count to actual angular field of view, and thus the magic begins."



**The NEW Generation of Angle Encoders Come of Age** *continued from Page 1*

**Scanning**

The new angle encoders of the RCN series operate with two graduation tracks. The absolute position data on the circular scale is encrypted on one track and never recurs within the same revolution. The additional incremental, higher resolution track is scanned according to the single-field scanning principle. 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, for example, the RCN 8000 to measure to a resolution of more than 536 million positions per revolution.



*Single-field scanning principle*

Thanks to the special optical filtering of the innovative scanning components, the encoder produces scanning signals of very high

quality. Test results with the new RCN encoders show that the position accuracy relevant to feedback control, often described as position error within one signal period, is typically superior to the absolute angle encoders of the respective previous series by a factor of three. The optimized scanning now makes it possible to specify the subdivision accuracy values as better than  $\pm 0.5\%$  (the value for the previous RCN encoders was  $\pm 1\%$ ). Particularly on direct drives, the high signal quality has positive effects on the control behavior and results in noticeable quality improvements of the finished workpiece surfaces.

Although the angle encoders with integral bearing are sealed and feature the IP64 degree of protection, the contamination risk was to be reduced further to the point that this risk could practically be excluded. This goal was met with single-field scanning, which is characterized by its improved signal quality and a significantly reduced sensitivity to contamination. This has been achieved through large scanning windows and the special arrangement of the scanning fields. Even relatively large contaminated areas result only in slightly weaker scanning signals and somewhat increased signal deviations. In many cases, depending on the contamination, this can even prevent encoder failure where four-field scanning, which up to now was used in the angle encoders with integral bearings, cannot. The results of testing with the angle encoders are also confirmed by positive experience with linear encoders, which have been using this scanning principle for some time now.

To be able to meet the growing demands for better performance

## The NEW Generation of Angle Encoders Come of Age *continued from Page 2*

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 milling and turning operations on the same machine. The new, absolute angle encoders fulfill these demands as well. The single-field scanning and the new scanning and evaluation electronics made it 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 a high signal quality and continue to interpolate well. For example, the RCN 2000 with its purely serial interface achieves speeds up to 3000 min<sup>-1</sup>.

### Design

The simple mounting of the new angle encoders is also impressive. 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 it is ensured that the components involved in scanning are ideally aligned to each other, even if there are deviations within the defined mating tolerances 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. The new stator coupling, conceived and developed for the RCN encoders 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 limiting the 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  $\pm 0.3$  mm.

The new angle encoders have an even more impressive set of design details. The encoders feature a plug-in cable assembly. Because the separate adapter cable has a quick disconnect (push-pull design), 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 high leak tightness of IP67, preventing ingress of liquids through this connection. The advantages of the plug-in cable assembly are particularly evident when a cable has to be routed through a tight installation space during mounting. The machine tool manufacturer 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 RCN 5000 series consists of angle encoders with compact overall dimensions but large hollow shafts. With a hollow shaft diameter of 35 mm, the cross-section of the RCN 5000

encoders is over three times larger than that of the RCN 2000 encoders, whose hollow shaft only measures 20 mm. This means that there is more room for stiffer machine shafts and hydraulic leads, which are frequently led through hollow shafts.



*RCN 5000 series with plug-in electrical connection*

### Interface

The bidirectional EnDat interface enables the encoder to configure itself during installation without additional transmission lines, since all encoder-specific information such as resolution, ID number, etc. is stored in the encoder and transmitted to the subsequent electronics via EnDat.

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. Valuation numbers can be read from the encoder cyclically for diagnostic purposes. The valuation numbers provide the current state of the encoder and ascertain the encoder's "functional reserves." The monitoring and diagnostics can be used to signal the need for preventive maintenance, and can prevent unnecessary maintenance cycles. This increases machine availability.

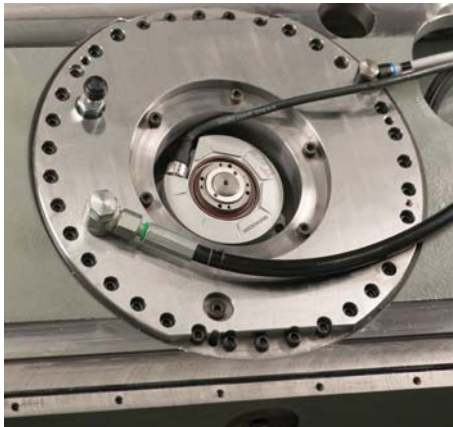
Cables with M12 connecting elements at the ends can also be used with the purely serial EnDat interface. This enables you to replace the previously common M23 connectors with smaller connecting elements.

### 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 currently the only manufacturer who can offer purely serial single-encoder solutions for safety-related applications. For the single-encoder version, two independently generated, absolute position values

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are provided to the safe control (e.g. the iTNC 530 HSCI from HEIDENHAIN) via the EnDat protocol. This makes it possible to realize a purely digital machine with safe absolute positions.



Mounting situation

In addition to the data interface, the mechanical connection of the encoder to the motor is also relevant to safety, since it is not guaranteed that such faults can be detected by the control. Therefore HEIDENHAIN secures the encoders with special methods

that fulfill the requirements for excluding the possibility of the mechanical connection coming loose.

The new RCN encoders with functional safety will be available soon. They can be operated as single-encoder systems in combination with a safe control in applications with control

category SIL-2 (according to EN 61 508) or performance level "d" (of EN ISO 13 849). They form a qualified subsystem within the larger "safe drive" system. It greatly simplifies the evaluation and realization of safety-related processes for the machine tool builder. This makes a simple, purely serial solution possible, especially for axes with direct drive.

### Summary

The new series of angle encoders with integral bearing distinguish themselves with numerous impressive characteristics. Thanks to the new scanning process, the signal quality is improved once more, the tolerance to contamination is optimized, and higher shaft speeds are permitted. The relatively large mounting tolerances and the plug-in cable assembly help make mounting much easier. The EnDat interface with its diagnostic capabilities enables preventive monitoring of the encoder without requiring an additional transmission line. Encoders with purely serial interface can also be installed as qualified subsystems in safety-related applications. There is also the new RCN 5000 series, whose hollow shaft with a diameter of 35 mm is impressive considering its compact outside dimensions. The RCN 5000 will prove to be the proper angle encoder for a multiplicity of applications, and will likely even replace many absolute angle encoders with a hollow-shaft diameter of 20 mm.

## HEIDENHAIN Introduces a NEW Compact Battery-Buffered Rotary Encoder

New to the market is HEIDENHAIN's innovative EBI 1135 inductive rotary encoder. The modular design of this absolute multiturn encoder without ball bearings and its battery-buffered revolution counter permit very compact dimensions. This, along with its use of the EnDat 2.2 digital interface, makes it an ideal solution for use on highly dynamic servo motors with small dimensions for automation technology and industrial robots.



With an overall length of less than 13 mm and a housing outside diameter of only 37 mm, the EBI 1135 attains a total resolution of 34 bits (singleturn: 18 bits, multiturn: 16 bits) and joins the ranks of the shortest rotary encoders in the world with multiturn scanning. With the optimized inductive scanning,

these encoders provide twice the accuracy of their predecessors, coming in at  $\pm 120$  arc seconds.

The realization of a counter-based battery-buffered multiturn solution, especially in conjunction with the inductive technology, yields a particularly robust encoder. This is because the mechanical multiturn gear, which is influenced by magnetic fields and mechanical loads (vibration,

shock), is no longer necessary and there are no optical components (glass circular scale, LED) that could be affected by contamination, vibration/shock and high temperatures. The higher permissible axial scanning gap tolerance of  $\pm 0.3$  mm and the expanded voltage range of 3.6 to 14 V specifically increase the reserves in its applications.

## HEIDENHAIN'S Museum Donation Makes an Impact



Photo Courtesy of Medora Hebert

HEIDENHAIN's Danny Vitullo showcases Donation at APM

"This significant addition from HEIDENHAIN helps us showcase the old with the new," said Ann Lawless, APM Executive Director, "This is an incredible leap forward."

"Here at the American Precision Museum (APM), we need to be able to share the news about the significance of machine tools to the development of our world, as well as into our future" said Ann Lawless, APM Executive Director, "and this wonderful and forward-thinking gift from HEIDENHAIN is now helping us better do that." Lawless is referring to HEIDENHAIN'S recent donation of a 1980s Bridgeport 9x48 Series One mill and a new Acu-Rite MILLPWR® 3 control, a HEIDENHAIN product.

Both machines were delivered to APM this summer, along with HEIDENHAIN Product Specialist Danny Vitullo who, in July, dedicated a week to setup and training the summer interns, local high school students primarily from the River Valley Technical Center (RVTC), in its operation. RVTC (Springfield, VT) is in its fourth year of partnering with the museum.

APM is located in Windsor, VT within the 1846 Robbins & Lawrence Armory where the concept of interchangeable parts was borne, and gives visitors a look into the history of early machines and their impact on society. Besides the largest collection of static

historic machine tools in the nation, APM also houses a Working Machine Shop section where now nine pieces of equipment are on demonstration. "This new huge variable speed machine given to us by HEIDENHAIN is a game-changer for us," said Lawless. "This is an incredible leap forward."

APM's Working Machine Shop houses equipment from as early as a 1890s hand-operated shaper to a 1990s 3-axis table-top CNC mill for light machines.

"This new Bridgeport and control are great additions to the shop," explained Chris Gray, instructor of the RVTC's Mechanical Design and Innovation Program where most of the high school intern operators have originated. "Thanks to Danny's work, the Bridgeport operates like a brand new machine. It's a real pleasure to operate a vertical mill where everything is tight and really accurate. The students have worked through the tutorials included in the Acu-Rite control manual and now easily run several of those parts. It's a really good control."

"This significant addition from HEIDENHAIN helps us showcase the old with the new," added Lawless.

Rick Korte, president of HEIDENHAIN Corporation, added, "We enthusiastically support the efforts of APM and are proud to be members of such a significant and historically

strong representation of precise manufacturing and the Industrial Revolution. The many technological advancements we enjoy today are due to the development of machine tools of yesterday, and there's no end in sight. Our donation to this museum helps showcase just one more aspect."

Open daily from Memorial Day weekend through October, visitors to the APM will see collections of not only significant machine tools, but also early firearms, measuring

devices, sewing machines, typewriters and other unique products of manufacturing. Museum information is available at [www.americanprecision.org](http://www.americanprecision.org)



## Technical Tidbit:

# Accuracy, Repeatability and Resolution— What's the Difference?

by Jimmy Rago, HEIDENHAIN Product Specialist

Three terms that are well used in the feedback industry are “accuracy”, “repeatability” and “resolution”. These words are sometimes used interchangeably. This causes confusion when choosing an encoder or discussing encoder specifications with another person. A clear definition and illustration of each term may help to clear up this confusion.

Accuracy - designates how close a measured value is to the true quantity of what is being measured. Without comparison to a standard, accuracy cannot be determined. The accuracy of HEIDENHAIN products is always stated in comparison to a formal, agreed upon standard in the industry.

Repeatability - describes how well a system or device can reproduce an outcome in unchanged conditions. In some applications, repeatability is more important than accuracy. If the system is repeatable, an error can be mapped and compensated for.

Resolution - is the smallest increment the system can display or measure. A system can have a high resolution with poor repeatability and accuracy. Resolution is a primary concern in applications regarding speed control or surface finish.

Think of a clock. If the clock is mechanically sound, it should be very repeatable. Each movement of the second hand should happen at a constant interval. The clock can be used to reliably time events, from start to finish, but it may display the incorrect time. Until the time on the clock is compared to some established measurement of time, there is no way

to tell how accurate the clock is. Once compared to a known standard, the accuracy of the clock can be determined. The resolution of the clock can be determined by the number of ticks in a minute or the amount of increments shown on the face. If the clock has no second hand, the highest resolution you can achieve is to half minutes. If the clock only had an hour hand, you would only be able to determine the closest half hour. Most people would prefer to use an accurate and repeatable clock, with a decent resolution. The importance of these three factors is wholly dependent on the application.

Another example would be hits on a target. A rifle aimed at the bullseye and fired from the same position each time, puts bullet holes in a target. If the holes have a large spread, the rifle is neither accurate nor repeatable. If the holes are tightly grouped, but off from the bullseye, the rifle is repeatable but inaccurate. If the rifle is accurate and repeatable, the bullet holes will be in the bullseye. The sights of the rifle can be used to compensate for the inaccuracy of the rifle.

HEIDENHAIN offers many measurement products that cover varying degrees of accuracy, repeatability and resolution in order to meet the needs of customer applications. If you have any questions about these topics or our products, please let us know.

**Jimmy Rago, 847-519-4213**

# EnDat 2.2 The Bidirectional Protocol for Position Encoders from HEIDENHAIN

By Tom Wyatt, HEIDENHAIN Automation Division Manager, North America



**Tom Wyatt**  
National Sales Manager  
Automation Division

HEIDENHAIN's Bidirectional Protocol EnDat 2.2 is a 100% digital interface, allowing users save money in a few key areas.

As I am sure most of you are already aware, HEIDENHAIN's EnDat 2.2 bidirectional encoder interface protocol for encoders has been released to the market and is in the process of being implemented by several of our customers.

I would like to review the basic benefits of this "pure digital" interface for those

who are not aware or have thought about it but haven't yet made a decision.

The outstanding benefit of EnDat 2.2 is the fact that it is a 100% digital interface, meaning incremental signals are not necessary! With this, users save money in a few key areas, for example:

- 1) The number of wires as well as shielding requirements is reduced.
- 2) The subsequent electronics will no longer need to process / interpolate incremental signals.
- 3) Simpler, more economical power supply: (3.6...14 V)

Aside from cost savings, it is also important to consider how EnDat 2.2 relates to the future. Safety Technology, already prevalent in Europe, is slowly making its way to North America. Conceived for safety-related machine designs, EnDat 2.2 provides:

- Two independent position information sources for error detection
- Two independent error messages
- Checksums and acknowledgements
- Forced dynamic sampling of error messages and CRC formation by the subsequent electronics

These provisions are integral to any machine safety system.

I'd also like to mention that we understand the concern that some may have regarding a pure digital interface is the course calculation time of the position value and recovery time. However, the increased clock frequency of 16 MHz along with a value acquisition time of 5µs and recovery time of 1.25µs should ease the concern!

Finally, you should also know that all future feedback development from HEIDENHAIN will utilize the new and highly dynamic EnDat 2.2 protocol. I urge you to contact your local area sales manager for additional detailed information. We will be more than happy to support your implementation efforts! And, as always, we look forward to hearing from you.

**Tom Wyatt, 847-884-3713**

## 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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