

## Linear Encoders for Vacuum Technology

The word "vacuum" is used to describe an empty space, meaning a volume not filled with air or any other gas. A vacuum is classified as a rough, fine, high or ultrahigh vacuum, depending on its purity.

Vacuum technology plays a significant role in many modern production procedures and research tasks. Procedures using vacuum technology have become indispensable in the electronics industry and biotechnology, in thin-film deposition technology, in the development of new materials, and in medicine and analytical technology.

The components used in a vacuum are subject to especially high demands, which of course also affect the encoders necessary for the positioning tasks. The linear encoders created by HEIDENHAIN specifically for use in high and ultrahigh vacuums satisfy these demands with their specialized design measures:

- Vacuum-compatible PCBs, adhesives and paints reduce the amount of outgassing
- Vented hollow spaces reduce the pumping time
- Temperature resistance permits high heating temperatures
- Doing without ferromagnetic materials increases the process reliability
- Production in a clean room guarantees the highest degree of cleanliness

### Vacuum classes

When air is removed from an enclosed space, it gets thinner and, as a result, exerts less pressure: a vacuum has been generated. The smaller the amount of air in an enclosed space, i.e. the lower the pressure, the higher the resulting vacuum is classified. There

are four classes of vacuum. An atmospheric pressure above 1 mbar is called a **rough vacuum**; below 1 mbar one speaks of a **fine vacuum**. A vacuum below 0.001 mbar is a **high vacuum**, and at 0.000 000 1 mbar or less it is called an **ultrahigh vacuum**.

### Applications for encoders in a vacuum

A vacuum, in the sense of enclosures free of air and therefore also of suspended particles, is required wherever the presence of "foreign" particles must be prevented. In some cases, dimensional measurements are required within the area of a vacuum, for example if very fine structures must be inspected in the submicron range or particles must be split and examined. Widely known applications for linear and angular encoders in a vacuum include electron microscopes, manipulators, multiple actuators, X-Y tables, cathode-ray microscopes, wafer inspection in the semi-conductor industry, or spectrometer axes for measuring synchrotron radiation.

*continued on next page*

## Did You Know...

...that HEIDENHAIN precision measurement components are all over an interesting instrument built in the U.S. that is used to measure automotive camshafts? It is called the **EZCam** by **Andrews Products, Inc.** ([www.andrews-products.com](http://www.andrews-products.com)), and is used by NASCAR racing teams and various automotive quality control organizations alike, worldwide.

For those organizations, it is important to check the accuracy of cams as they play an important role in automotive fuel intake, expiration of exhaust gas, etc. For quality control, this EZCam takes measurements, and the results are compared to design data to determine whether any differences are within manufacturing tolerances. The primary measurement taken is the shape or profile of the cam lobes whereby many other results can then be calculated. EZCam can measure camshafts of various lengths and diameters for both large and small engines.

Each EZCam uses three HEIDENHAIN encoders and an accompanying computer interface inside. A **HEIDENHAIN ROD 480 rotary encoder** (the left end of the picture) measures the angles, a **METRO 60K gauge** (top) measures the up-down movement of the measuring probe and a **LIDA 287 linear encoder** measures the lateral location of the probe at the time of measurement. A measurement produces a table of lift vs. degree at a specific lateral location on the camshaft. The lateral encoder gives the position feedback to control the automatic movement of the probe laterally to measure each lobe on the camshaft. The rotary encoder is also used to



*This Andrews Products auto camshaft measurement instrument uses three HEIDENHAIN encoders and a computer interface*

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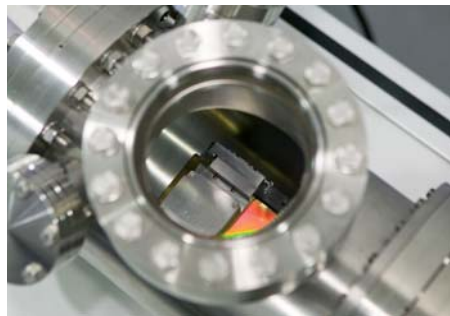
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## Linear Encoders for Vacuum Technology *continued from cover*

Vacuum	Pressure in mbar	Height in km from earth's surface	Mean free path in m without collision of two gas molecules	Time in s for covering a surface with particles
<b>Rough</b>	10 <sup>+3</sup> ... 1	< 50	< 10 <sup>-5</sup>	< 10 <sup>-5</sup>
<b>Fine</b>	1 ... 10 <sup>-3</sup>	50 ... 100	10 <sup>-5</sup> ... 10 <sup>-1</sup>	10 <sup>-5</sup> ... 10 <sup>-2</sup>
<b>High</b>	10 <sup>-3</sup> ... 10 <sup>-7</sup>	100 ... 500	10 <sup>-1</sup> ... 10 <sup>+3</sup>	10 <sup>-2</sup> ... 10 <sup>+2</sup>
<b>Ultra high</b>	< 10 <sup>-7</sup>	> 500	> 10 <sup>+3</sup>	> 100

### Requirements for encoders in a vacuum

HEIDENHAIN standard encoders are suitable for use in a rough or fine vacuum. Encoders used for applications in a high or ultrahigh vacuum need to fulfill special requirements.



### Low amounts of gas exhalation

One precondition for encoders used in vacuum applications is that outgassing is kept to a minimum, since otherwise the pressure in the vacuum chamber might increase excessively. In an ultrahigh vacuum, every component is critical. For example, some synthetic materials contained in printed circuit boards, adhesives, or coating materials exhale solvents and must be avoided in devices intended for a high vacuum. HEIDENHAIN uses PCBs and adhesives suited to vacuum applications. The usual paints have been replaced by materials appropriate for vacuum technology. In ultrahigh-vacuum environments, the number of components must be kept to

a minimum — interface and pulse-shaping electronics must be positioned outside of the vacuum chamber. HEIDENHAIN therefore offers encoders with external interfacing hardware. For high-vacuum applications, interfacing hardware within the vacuum chamber is available as an option.



### Proper ventilation of hollow spaces

To generate a vacuum, the air must be removed from an enclosed space. The time needed for attaining the required low pressure, referred to as "pumping time," should be kept to a minimum in order to enable the vacuum system to start working as soon as possible. The



pumping time is reduced if the air can escape rapidly from the hollow spaces. Therefore, the encoder housings are provided with additional air vents, blind threaded holes are opened, and air vents are drilled into hollow spaces.



### No ferromagnetic materials

Depending on the processes in the vacuum chamber, the use of certain materials in the encoders may not be permitted. Ferromagnetic materials must not be used in cathode-ray microscopes for examining microelectronic circuits. Vacuum-technology encoders from HEIDENHAIN are therefore made of nonmagnetizable materials.

### High resistance to temperature

To further reduce pumping time and attain a high class of vacuum, the vacuum chamber is heated to 100 °C or more. As a result, water molecules clinging to the encoder housing vaporize and can be pumped out more rapidly. Encoders for use in a vacuum must therefore be designed for temperatures of 100 °C and more.



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## Linear Encoders for Vacuum Technology *continued from page 2*



### High degree of cleanliness

Encoders used in a vacuum chamber must be specially cleansed and exceptionally clean. Most types of lubricants and oils, even fingerprints, emit gases in a vacuum and must be avoided. Otherwise, very fine particles or dust might be set free and, for example, destroy the microelectronic circuits to be examined, or influence the results of experiments. Consequently, our encoders must fulfill specific requirements with respect to cleanliness, the manufacturing process, and proper packaging. HEIDENHAIN manufactures its vacuum-compatible encoders in a clean room. The packaging is also specially designed. The encoder is doubly enclosed and the package is flushed with nitrogen before sealing.

### Electrical connection

HEIDENHAIN encoders are equipped with connectors for vacuum housing leadthroughs. The linear encoders of the LIP and LIF series require interface electronics for signal conversion to 1 Vpp. This interface unit is located in the D-sub connector that connects directly with the encoder for high-vacuum applications and must be located outside the vacuum chamber for ultrahigh-

vacuum applications. The LIP and LIF for high vacuum are therefore available with two cable versions. The cable between the scanning head and interface electronics can be up to 3 meters in length.

The vacuum-compatible encoders from HEIDENHAIN were derived from standard units and modified. However, only the original scanning principle, optoelectronic and optical components have remained intact. The housing, PCBs, adhesives and coatings have been adapted to the requirements of the vacuum class.



The following specialized measures characterize HEIDENHAIN encoders for use in a vacuum:

- Nonmagnetizable materials (except LED housing)
- Laser inscription instead of labels
- Air vents
- Special coating
- Specialized cleaning and packaging
- Production in a clean room
- Cable with PTFE insulation and silverplated copper braiding ■



	For high vacuum to 10 <sup>-7</sup> mbar		For ultrahigh vacuum up to 10 <sup>-11</sup> mbar
	LIF 481V	LIP 481V	LIP 481U
<b>Measuring lengths*</b>	70mm to 1040mm	10mm to 420mm	10mm to 420mm
<b>Accuracy*</b>	± 3 µm	± 1 µm, ± 0.5 µm	± 1 µm
<b>Output signals</b>	~ 1 Vpp		
<b>Signal period</b>	4 µm	2 µm	2 µm
<b>Graduation-carrier material*</b>	<ul style="list-style-type: none"> <li>• Zerodur glass ceramic <math>\alpha_{\text{therm}} \approx 0 \text{ K}^{-1}</math></li> <li>• Glass <math>\alpha_{\text{therm}} \approx 8 \cdot 10^{-6} \text{ K}^{-1}</math></li> </ul>		
<b>Bake-out temperature</b>	100 °C		120 °C
<b>Special characteristics</b>	–	<ul style="list-style-type: none"> <li>• Low power consumption</li> <li>• Heat dissipation via housing</li> </ul>	
<b>PCB Material</b>	FR4	Ceramic	Ceramic
<b>Adhesives</b>	Standard	Ultrahigh vacuum compatible, temperature resistant	Ultrahigh vacuum compatible, temperature resistant
<b>Cables, connectors</b>	<ul style="list-style-type: none"> <li>• High-vacuum-compatible round plug connection, 16-pin (APE in air)</li> <li>• Option: interface electronics integrated in connector (APE in vacuum)</li> </ul>		UHV-compatible plug connection without feedthrough (APE in air)

\* Please indicate when ordering

For more information, circle #1 on the reply card.



## HEIDENHAIN Reaches New Heights with New High Accuracy Linear Encoder

In order to continue to offer technologically leading products for cutting-edge applications, HEIDENHAIN has developed the new exposed LIP 200 linear encoder.

This scale has been designed for very high accuracy in measuring technology and meets the increasing requirements on linear encoders regarding interpolation accuracy, low position noise, high traversing speed all over increasing measuring lengths. Very high demands in these areas are placed in particular by the electronics industry, FPD productions, metrology and high-precision machining of workpieces.

This LIP 200 is an incremental linear encoder and is especially geared for measuring step needs of 0.001  $\mu\text{m}$  (1 nm) and less. This product sets new standards compared to previous, and will be showcased in July at HEIDENHAIN's booth at the SEMICON WEST show. ■

For more information, circle #2 on the reply card.

**Higher**

The LIP 200 is a linear encoder for very high accuracy in measuring technology. It distinguishes itself through its high interpolation accuracy of better than  $\pm 1 \text{ nm}$ . This was made possible by the measuring standard with the newly developed OPTODUR phase grating and by the special optical scanning principle. And it does not require doing without the proven HEIDENHAIN reference mark, nor do you have to do without simple installation or moderate mounting tolerances.

**Faster**

Improving productivity calls for ever faster machining and measuring cycles and therefore ever quicker movements. At the same time, machine accuracy must be improved. With a maximum traversing velocity of **3 m/s** and an analog signal period of 512 nm (before interpolation), the LIP 200 unites intrinsically opposite requirements: speed and accuracy!

**Farther**

Measuring tasks in the ultra-precision range also always require a maximum of flexibility in size, form, and position of the measured object. Here, with measuring lengths up to **3040 mm**, the LIP 200 sets the standard.

**LIP 200**

## New HEIDENHAIN Scale Useful For Applications with Varying Temperatures

Because not all applications operate in the same environment, HEIDENHAIN has expanded its LIDA 400 scales series to include a version that is sure to withstand temperatures that others cannot. This new LIDA 403 scale is now available with glass or glass ceramic (ROBAX®, ZERODUR®) as its graduation carrier for just this reason as its expansion coefficient makes it especially useful in varying temperatures.



period holds true for the LIDA 403. The standard accuracy grade is  $\pm 5 \mu\text{m}$  with higher accuracies available upon request, covering measuring lengths from 240 to 3040 mm (ROBAX® up to maximum of ML 1640 mm).

The scanning head on the LIDA 403 will remain the same as others in the series. There is a reference mark at midpoint (distance-coded upon request).

HEIDENHAIN's LIDA 400 series is traditionally based on a steel scale tape with a grating period of 20  $\mu\text{m}$ . This grating

The PRECIMET® adhesive film on the rear of the scale will ensure simple mounting. ■

For more information, circle #3 on the reply card.

## Special HEIDENHAIN Showing at SEMICON



This year's SEMICON show in San Francisco (July 15 – 17) promises to be the hot spot for those interested in seeing the latest advancements in the semiconductor industry, and the HEIDENHAIN booth will be no exception. This year, special private showings of another groundbreaking technology from HEIDENHAIN are planned: the release of the first working

samples of LICA, an absolute frictionless kit style linear encoder system using a 40  $\mu$ m graduation.

Using the high speed serial EnDat interface, each position along this new LICA scale is unique, thereby eliminating the need for homing sequences of the machine upon start up. Its ease of installation was another top design criteria of the encoder, and can be discussed.

To have further discussions about this product (which will only be showcased in HEIDENHAIN's on-site meeting room at booth), please contact **Kevin Kaufenberg at 847-490-0387** or send an e-mail request to [kkaufenberg@heidenhain.com](mailto:kkaufenberg@heidenhain.com) to schedule an appointment.

In the public area of HEIDENHAIN's 50' x 30' SEMICON booth, a variety of available products, from exposed linear scales to a variety of other types of encoders, will be showcased. Technical staff will be on hand to answer questions and discuss trends and thoughts for the future. ■

*Stop by HEIDENHAIN booth #6171 to learn about the latest!*

## HEIDENHAIN's 2007 Distributor of the Year

In May, distributor Automation and Metrology, Inc. in Painesville, Ohio was presented with the prestigious 2007 HEIDENHAIN Distributor of the Year Award. This coveted annual award recognizes the HEIDENHAIN distributor who best represents excellence and commitment to the servicing industry, as well as HEIDENHAIN's highest standards. ■



*Pictured here (from left to right) from Automation and Metrology are: Jennifer Bordelon (Customer Service), Dave Denman (Partner), Tom McManus (Sales/Service) and Mark Contorno (Partner). HEIDENHAIN Regional Manager Ron Hood on end. Look for a profile of Automation & Metrology in a future newsletter.*

Automation & Metrology was a 2007 HEIDENHAIN Distributor of the Year finalist as they had been previously selected as one of HEIDENHAIN's monthly winners.

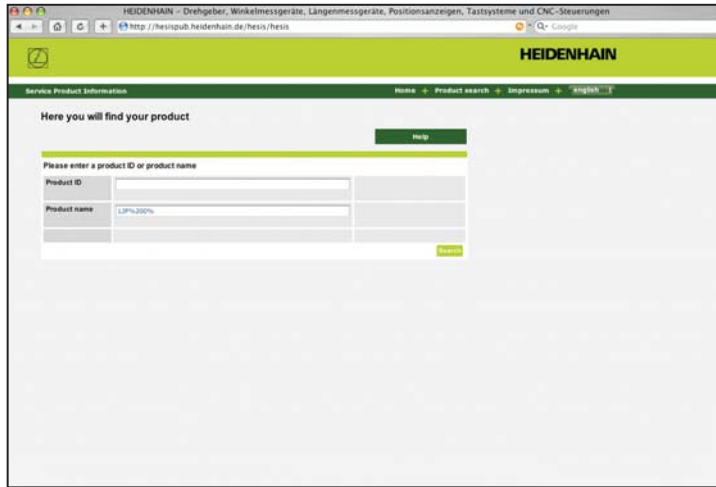
### 2007 HEIDENHAIN Distributors of the Month

January	Tool Crib Inc.
February	Controls for Motion Automation
March	CIM Technologies
April	Automation & Metrology
May	Morlin Inc.
June	Phoenix Inc.
July	S K Braly
August	Tool & Gage
September	Motion Industries
October	AMS
November	Dalatec
December	Promac

# HEIDENHAIN Web Site Expands

In response to customer's requests and to better support our wide customer base, a new section called HESIS Public has been added to **www.heidenhain.com** that will facilitate easy access to information regarding older HEIDENHAIN products for OEMs, distributors and end users.

For example, just by administering a few clicks starting with the **Services and Documentation** tab, then **Technical Service**,



all site users can access a Service Product Information page where a Product ID or Product Name field will come up allowing users to enter that information for even older product and receive mounting instruction, for example.

In the Member-Area, registered partners can be brought to HESIS-Web for even more information such as that of spare parts, testing equipment and repair descriptions for all HEIDENHAIN Products. ■

**Check it out!**

## Dear Abbé...

**Q: "Why does HEIDENHAIN talk about accuracy when many of your competitors talk only about resolution? What is the difference? How is repeatability related?"**

**A:** Accuracy, Repeatability and Resolution, while related to each other, are separate issues.

**In the example on the left, the resolution is the size of the bulls eye and rings**

• **Not all applications require accuracy**

- If you need to drill 10 holes then go back and tap them within .05", repeatability is more critical

• **Resolution determines repeatability**

- If your resolution is .0002", your repeatability cannot be better than .0002"
- If you increase your resolution (example: parameter setting on DRO) to .0001", your repeatability is now .0001"

Sincerely,  
Abbé

If you have a question for Abbé, please send it to us by filling out the "Question for Dear Abbé?" section on the reply card.

*Not accurate,  
not repeatable*

*Very repeatable,  
not very accurate*

*Very accurate,  
very repeatable*

**Accuracy** - Degree of conformity of a measure to a standard or true value.

**Repeatability** - The closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction, for full-range traverses.

**Resolution** - The least interval between two adjacent discrete details which can be distinguished one from another.

## Visit HEIDENHAIN on the Road

HEIDENHAIN will host exhibits at the following remaining 2008 trade shows. Come by and see what's hot! ■

### SEMICON

July 15-17  
Moscone Center – North  
San Francisco, California



### IMTS

Sept. 8-13  
McCormick Place  
Chicago, Illinois



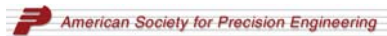
### National Manufacturing Week

September 23-25  
Donald E. Stephens Convention Center  
Rosemont, Illinois



### American Society for Precision Engineering (ASPE)

October 21-23  
Marriott Downtown Waterfront Hotel  
Portland, OR



## Did You Know...

*continued from cover*

control the rotation of the camshaft. Similarly the linear encoder helps to control the up-down movement of the probe to position it for measurement.

"HEIDENHAIN is the only company that has been able to meet all our measurement needs for this product, especially the interface card" said David P. Olson, EZCam Product Manager. "The **HEIDENHAIN IK-220 Interface cards** are, for us, the glue for attaching the encoders to an ordinary desktop computer. We've worked with HEIDENHAIN for about ten years and used various components from them, including many upgrades. They and their products have always been very flexible and allow us to plug in the encoders and upgrade our programs very quickly and easily." ■

For more information, circle #4 on the reply card.

### Technical Tidbit:

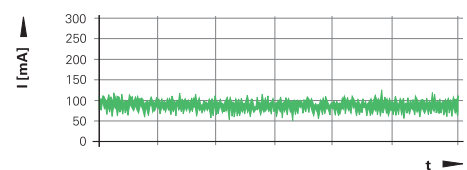
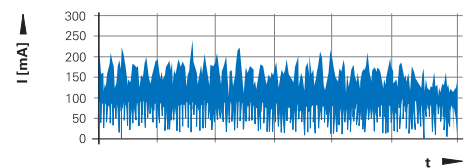
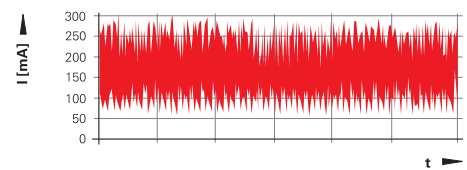
## Resolution and Velocity Control

When determining the performance of electrical drives, it is important to consider not only the design and properties of the control but also the measuring technology used. The positioning accuracy and speed stability behavior of these machine axes significantly determine the quality of the work-piece and/or processes. This necessitates a position encoder with a large number of measuring steps and high signal quality.

Irregularities in the speed stability can be caused by mechanical influences from the drive train as well as by position errors resulting from the encoder technology used. If the resolution of the measured signals is too low, or if the interpolation error is too high, wave-like errors can appear on the work-piece surface. The speed stability of certain motions in production systems can also be considered as a production parameter relevant to the quality.

Higher resolutions and accuracies can decisively improve the speed stability behavior of the motor. In addition, disturbances in the motor current are reduced significantly. The motor operates quietly and develops only a small amount of heat.

Ideal output signals with high resolution support a high bandwidth, which means that load variations only have a minimal effect on the rotational speed. ■



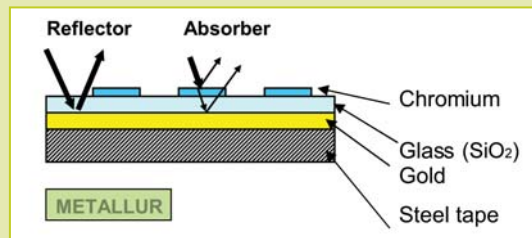
■ Resolver: 1 signal period per revolution  
■ EQI inductive rotary encoder: 32 signal periods per revolution  
■ EQN optical rotary encoder: 2048 signal periods per revolution



By Kevin Kaufenburg  
National Sales and Product Manager, Electronics

## A Graduation Technique for Modern Times: METTALUR

The advancement of R&D is a daily pursuit at HEIDENHAIN, and we are pleased to see technological developments continue. One of HEIDENHAIN's latest projects is the development of a special use of METALLUR, an impressive graduation technique soon to be applied to some of our linear scales.



This development has its start with AURODUR, a registered trademark of DR JOHANNES HEIDENHAIN GmbH, which is a manufacturing process for steel-based encoder scales that consist of gold. AURODUR is used on HEIDENHAIN's LIDA 100 and 400 series. This technique, which is over 20 years old, is a well established technology, and its graduations have been renowned for their high quality and graduation accuracy.

The specifics of this graduation consist of a highly reflective gold layer that is applied to a polished substrate of stainless steel. In the case of the LIDA 400 20 micron encoder, the gold layer is wet-etched to create 10 micron lines of highly polished gold, and 10 micron alternating lines of matte finish, which also creates a small "valley". The matte finish provides enough scatter of the light coming from the scanning unit to complete the reflected light scanning principle so that actual 20 micron counts can be generated. AURODUR technology does have some disadvantages which are the possibility of scratches due to the open face gold layers and potential problems with contamination where the "valleys" can be filled.

Enter METTALUR. HEIDENHAIN developed the METTALUR graduation in order to improve the immunity of scratches and

contamination resistance. In addition, the environmental impact with this new production process has decreased significantly due to the lack of the wet-etch processes. This new graduation is constructed of 4 layers. The base layer is still a polished stainless steel tape, but then a gold layer is added for a base reflectivity, and then a clear SiO<sub>2</sub> glass

layer is added, which fills in "valleys" that were evident in the AURODUR process. On top of the glass layer is a very thin (just a few nanometers) chromium film that creates reflective lines which are accurately spaced to generate the 20 or 40 micron graduation. These lines are burned away with laser technology. This same structure works with the existing scanning units already in the field.

The benefits of METTALUR are increased resistance to scratches, as the comparatively soft gold layer is covered by a thin glass and chromium layer, which are harder than the open face gold layer AURODUR process. I've done the scratch test where rubbing an AURODUR graduation onto a table surface will result in fine scratches. I've done the same test with a METTALUR graduation and found almost no scratches, and the scratches that were seen did not affect the scanning principle at all. Also the "valleys" are now filled and contamination only has a few nanometers to fill in. Cleaning the scale then becomes more effective if contaminations, like fingerprints, occur.

The timeline for METTALUR to be phased into worldwide production is the end of Q2 2008. Prices, mounting dimensions, and installation methods will not change with this enhancement to the LIDA 100 and 400 product line. ■

For more information, circle #5 on the reply card.