HEIDENHAIN INFO
Automation
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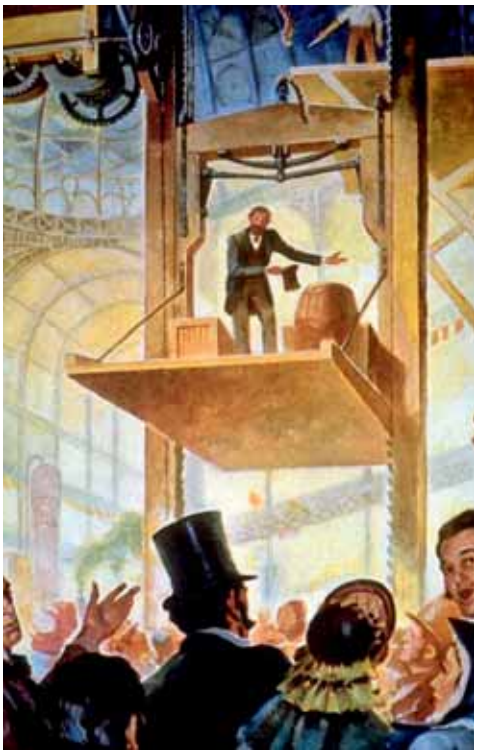
HEIDENHAIN Rotary Encoders in Elevator Technology

Every day, millions of people use elevators for transportation. Statistically speaking, every person on the earth rides an elevator once every 72 hours, and everyone considers the availability and reliability of elevators to be a matter of course.

The development of elevators began as early as the mid-1800's. At a trade show in New York, a man shocked a crowd of spectators as he stood on an elevator platform at maximum height (Fig. 1) and cut the platform's only bearer cable.

The platform sank by only a few centimeters before it immediately stopped. This pragmatic mechanic's revolutionary new safety brake ensured that the platform didn't crash. "All safe, gentlemen!" he announced. The man on the elevator platform was Elisha Graves Otis. With his safety brake, Otis



(Fig. 1) Mr. Otis demonstrates the safety brake

practically founded the elevator industry. His invention made it possible for the first time that a building–and the fantasy of architects–could continue to grow and advance the course of urbanization. At present, half the world's population lives in cities; by 2050 it will be two-thirds of the approximately nine billion people then living.

Otis sold his first safety elevator in 1853. Today–more than one and a half centuries later–Otis is the undisputed market leader with a world market share of over 25%. Every year, Otis installs more than 100,000 new elevators, from simple passenger elevators for apartment buildings to high-rise elevators such as those for the Petronas Towers in Kuala Lumpur or the Burj Dubai in the United Arab Emirates. When the latter is completed

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Contents...

Did You Know...

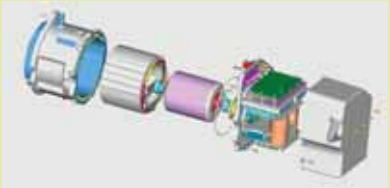
…that a RENCO rotary encoder, part of the HEIDENHAIN family, is an important part of the Mercedes electric Smart Car gearbox seen on the roads today? This vehicle promises to reduce greenhouse gases since it is powered by an electric motor/gearbox made by Zytek Electric Vehicles. This gearbox replaces the traditional engine and drivetrain found in normal gasoline-powered vehicles.

Zytek designed the motor/gearbox using an 8-pole brushless motor with integrated electronics. With such a high pole count motor, efficiency depends upon the accuracy with which the rotor position is known. To handle the job, Zytek selected the R35i from RENCO Encoders since it provides high resolution feedback for motor commutation and accurate velocity control.

With a maximum line count of 10,000, the R35i encoder met Zytek's specification for integrated commutation outputs and high resolution performance in a low cost and compact package (outside diameter of only 35 mm).

Zytek's drivetrain utilizes brushless DC motor technology that integrates electric motor, power and control electronics in a single assembly that requires only three connections – for water and high and low voltage (300V and 12V, respectively).

Smart Car conversion by Zytek.



Exploded view of the Zytek brushless motor and control electronics utilizing the RENCO encoder. The brushless motor/ gearbox is used in retrofitting the Smart Car from a gasoline-powered engine to electric-powered. Afterwards, the vehicle drives much like a normal vehicle except there is no exhaust generated.

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Rotary encoders of the ECN/ERN 1300 Series.

as planned in 2009, it will win the world's height record (Fig. 2) and use no less than 54 Otis elevators.

Together, the "big four," consisting of Otis, Schindler, ThyssenKrupp and KONE, command about 60% of the world market. This amounts to approx. 270,000 elevators out of 450,000 new installations worldwide in 2007.

Because elevators consume up to 10% of a high-rise building's energy consumption, a core goal in this industrial sector, besides increasing comfort, is higher efficiency. Elevator efficiency gains can be attained that increase the load capacity while reducing required installation space, reduce noise while increasing traversing speeds, lengthen maintenance intervals, and reduce environmental pollution in spite of increased performance.

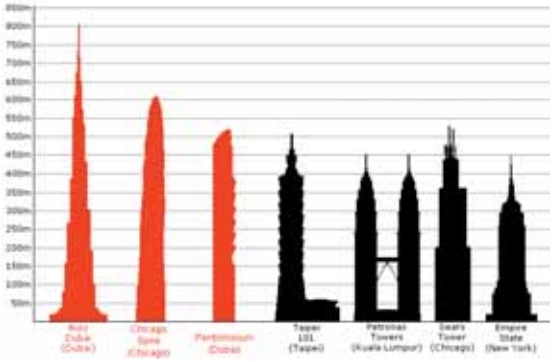

Fig. 2

The drive technology employed is an essential factor in achieving these goals. While years ago the high-volume segment still operated on drive designs with frequency-controlled gear motors and hydraulic installations (motors with pumps), the technology transformed itself in the late 1990s to direct drives (permanent-magnet actuated synchronous motors with high pole-pair numbers), also known as torque motors. For a comparison, see Table 1.

Thanks to the freedom from maintenance and the power density of torque motors, it was also possible to integrate them in the elevator shaft (see Fig. 3) and do without the machine room. This option was as welcome to architects as to building owners because it enabled them to realize new building designs and savings.

The technology of these motors frequently requires an absolute position value to ascertain the rotor position so that the motor current is controlled with the correct phase. Also, the relatively low rated speed (60 to 1500 rpm) of these drive designs made high-resolution position acquisition a must to be adequate to the short control cycle times.

Here the story begins to become interesting for HEIDENHAIN with its program of rotary encoder products.

Because of these requirements, the rotary encoders of the ExN 13xx series, which were developed for the high-quality drive control needed in machine tools and printing machines, can also find application in today's changing elevator drive technology. To be able to withstand the environmental conditions of an elevator shaft (e.g. concrete dust), some of the encoders have to be modified for a higher protection grade (sealing the housing and using sealed ball bearings). This came together with a market requirement for providing large cable lengths from the encoder (up to 10 m) without using extensions. So, with relatively few R&D expenses, the ERN 1387 rotary encoder for servo motors became an ERN 487, and the ECN 1313 became an ECN 413 for elevator motors (see Table 2, Page 3). In addition, the simple, purely axial installation of the encoders permits optimum integration in the motor design with mounted brake. Besides the encoders of the ExN 13xx/4xx series, which have established themselves in the low to medium motor power range, manufacturers also use the ExN 1xx series encoders for application in high-rise buildings.

Table 1 Comparison of elevator drive systems

	Hydraulic unit	Gear motor	Torque motor
Velocity (m/s)	0.63	1.0	1.0
Load (kg)	630	630	630
Energy consumption (kWh/y)	**7000**	**5000**	**3000**
Oil consumption (l)	**200**	**3.5**	**0**
Weight (kg)	650	430	230
Noise level (dB)	65-70	66-75	50-55
Machine room area (m²)	**5**	**12**	**0**

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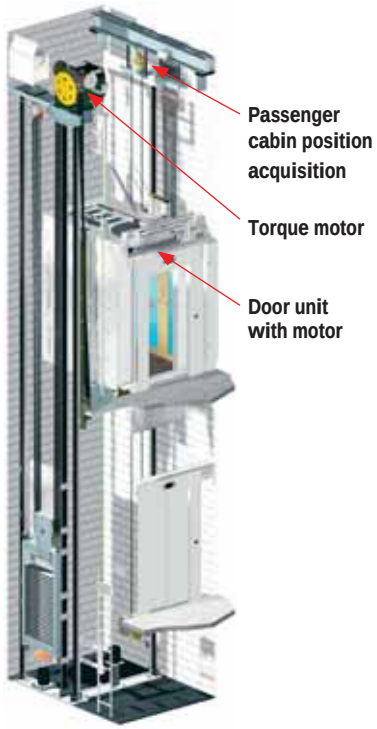
Table 2 ERN incremental rotary encoders and ECN absolute singleturn encoders

Model	Incremental signals	Signal periods/rev for absolute position values	Signal periods/rev for commutation
ERN 120 **ERN 130** **ERN 180**	⊓⊔ TTL ⊓⊔ HTL ∿ 1 V_{PP}	1000 to 5000	–
ECN113	∿ 1 V_{PP}	2048 EnDat or SS	8192 (13 bits)
ECN 125	–	– EnDat	33 554 435 (25 bits)
ERN 1321 **ERN 421**	⊓⊔ TTL	1024 to 10,000	–
ERN 1326 **ERN 426**	⊓⊔ TTL	1024, 2048, 4096 or 8192 ⊓⊔ TTL	3 signals for block commutation
ERN 1381 **ERN 481**	∿ 1 V_{PP}	512, 1024, 2048, 4096 –	
ERN 1387 **ERN 487**	∿ 1 V_{PP}	2048 ∿ 1 V_{PP}	Z1 track for sine commutation
ECN1313 **ECN413**		512 or 2048 EnDat or SSI	8192 (13 bits)
ECN 1325 **ECN 425**	–	– EnDat	33 554 435 (25 bits)

The absolute encoder's EnDat interface provided customers with other benefits. Electrical zero point setting and the capability to save customer-specific data in the encoder enable them to install and configure the encoder more efficiently. The new opportunities of encoders with optimized scanning and EnDat 2.2 will help us to ensure a competitive technological edge and, with it, our share of the market. Especially the encoder diagnostics capability and the transmission of motor winding temperature over the EnDat 2.2 protocol on the ECN 1325 should provide elevator manufacturers with new possibilities for monitoring and timely maintenance tips.

Almost all reputable manufacturers of servo amplifiers for this market segment feature an EnDat interface option for the encoder input. By now this has allowed an impressive market acceptance of HEIDENHAIN encoders for torque motors.

Particularly in China, the primary growth region for new installations (more than 150,000 units in 2007) and motor manufacturing (also for export to the USA, Europe and the Near East), the demand for our encoders is encouragingly strong.



(Fig. 3) Modern elevator design with the three possible applications for encoders

When one considers that, with an annual volume of approx. 400,000 electrically driven elevators, the current unit sales ratio of 2:1 for the gear motor as opposed to the torque motor will reverse itself in coming years to 1:2, the sales prospects in this part of the elevator industry remain outstanding.

Besides applications in drive control, encoders in elevators are sometimes used to position the passenger cabin and control the doors (see Fig. 3). Electromagnetic switches, low-resolution linear encoders (≈ 1 mm) or multiturn encoders in conjunction with cable winches are employed for passenger cabin positioning. Standard AC motors as well as DC motors are used to open and close door leaves to their end positions. In some cases, very simple kit encoders are used for position control.

Siemens Wind Turbines Thrive With Leine & Linde Encoders

Case Study - Wind Power, Denmark

Wind power is the fastest-growing renewable energy source in the world. Siemens Wind Power in Denmark is one of the players in the wind power industry to have chosen Leine & Linde to supply pulse encoders. After having completed many large projects and having been involved in the wind power industry for 25 years, specialist knowledge has become a highly-valued commodity.

L&L Encoder

Siemens Wind Power has operations in Denmark, Germany, the UK and the USA. The company has a total of 4,700 employees throughout the world, and they are promoted as its most important resource. Siemens Wind Power's extensive experience, technical expertise and commitment have resulted in hundreds of wind farms, including the world's largest onshore and offshore farms.

Karsten Jeppesen, Sales Manager at Leine & Linde in Denmark, has noticed a sharp increase in sales of encoders in the wind power sector over the past two years, largely due to an increasingly strong desire to reduce environmentally-harmful emissions in Denmark. The 58 mm absolute encoder is the most popular within this market, but both incremental and absolute encoders are used for speed feedback or positioning.

Optimizing generator speed

Siemens wind turbines have Leine & Linde pulse encoders attached to each rotor blade and installed in the actual tower. The positional information from the encoders is used by the main control system to optimize generator speed relative to wind speed and direction.

Thomas Holm Krogh is one of the development engineers at Siemens Wind Power. He explains that they chose Leine & Linde's products after endless reviewing and testing of various encoder models and makes. "The reason that we ultimately chose Leine & Linde was the unique high level of quality," says Thomas.

It is essential for the components used to be robust because wind turbines are sited in areas with very large temperature fluctuations. In addition, many wind turbines are out at sea, so the products must be reliable and durable, otherwise servicing and maintenance costs can often spiral out of control.

Thomas feels that contact with Leine & Linde is working well: "The partnership is progressing smoothly and we set great store by the rapid technical support we have received. Leine & Linde's engineers have helped us a great deal with the slightly more complex technical details. The fact that Leine & Linde have taken the initiative themselves is something we see as a huge plus."

Development for the future

Siemens Wind Power is at the forefront when it comes to development of advanced technology within fields such as aerodynamics and noise reduction.

Thomas Holm Krogh clearly recognizes the trend and the need for ever larger wind farms. Customers see wind farms as power stations and an increasing percentage are being sited offshore.

Vindeby wind farm – the world's first offshore project, constructed 1991.

Development within the field of encoders is also moving towards more advanced communication interfaces for control and monitoring. ProfiNet, which is expected to become an important protocol in wind turbines of the future, is currently being evaluated. The motive behind this is to improve performance, standardize communication and employ diagnostic functions to increase operational reliability and minimize operating and maintenance costs.

In terms of generators, the trend is moving towards use of permanently magnetized generators. This type of generator makes it possible to have wind turbines without gearboxes.

Company: Siemens Wind Power
Location: Brande, Central Jutland, Denmark
Production: Wind turbines for electricity production
Employees: 3,600 (Denmark) / 4,700 (worldwide)
Production capacity: > 2 000 MW (2008)

Automation Group Offers Options

By Bill Anderson, National Sales Manager, Automation Division

The HEIDENHAIN Automation Group primarily services markets looking for advanced motion control devices that will ensure accurate motion in a wide range of applications. Our value to the marketplace is the ability to offer an extremely large range of products that have a common technology foundation but provide a unique fit in many different applications.

The ability to service so many multiple markets so effectively is because HEIDENHAIN's Automation Group offers industry leading solutions that range from optical, inductive or magnetic feedback solutions. This product range also expands into modular encoders with incremental outputs, absolute high resolution rotary and angle encoder feedback, as well as robust bearing encoders manufactured by a sister company (Leine and Linde) that can be configured with incremental or absolute outputs. Our customers are very diverse, but the common thread amongst all of them is their dependence on products that surpass their expectations each time a solution is placed into an application.

It is a fact that HEIDENHAIN product sets the standard in the industry by delivering performance and reliability to which others are often compared. And if functional safety is a concern, HEIDENHAIN's core business of optical or inductive encoders are offered with faster absolute position feedback – acquired via a pure digital encoder interface (EnDat 2.2). This creates a development platform where engineering, operations and business goals can all be optimally addressed.

Our latest ad campaign captures HEIDENHAIN's important underlying message: In motion control, accuracy is more than a measurement. When choosing the right position feedback solution, enhanced accuracy provides a competitive advantage that can transport your automation solutions to a new destination. An elevated state of precision and performance we like to call "Destination Accuracy"!

Inductive Rotary Encoders for Resolver Systems, and with a Higher Resolution

The inductive rotary encoders of the HEIDENHAIN ExI 1100 series are now available in versions whose mating dimensions are the same as those of common types of resolvers. Depending on the respective applications and accuracy requirements, inductive or optical absolute encoders are now possible as high resolution alternatives to resolvers. These encoders are easy to mount and inexpensive, and are destined for applications that require a high degree of reliability and durability.

Furthermore, the HEIDENHAIN ExI 1100 rotary encoders with EnDat 2.1 interface feature an improved inductive scanning method, with which the singleturn resolution was increased to 18 bits (262,144 position values per revolution). This results in a higher control quality of the drive.

Servo drives with inductive rotary encoders enjoy advantages over those using resolvers in terms of positioning accuracy, speed stability and control dynamics. This is made possible by the greater control bandwidth and a significantly higher number of signal periods for the formation of the singleturn position value. The position value is produced by electronics already integrated in the encoder, and is transferred as purely digital information to the higher-level electronics over the fast bidirectional EnDat interface. As an option, the information can be transferred as an analog signal. An integrated readable and writable EEPROM makes user parameters available in the subsequent electronics at all times, enabling the encoder and its environment to self-configure over the synchronous serial interface.

The encoder's real multiturn capability frees the system from the need to be "homed" after power interruptions or switch-on. Conventional battery-supported systems requiring regular maintenance are no longer needed. Alarm and diagnostic functions ensure high system availability rates.

Introducing the new RENCO R28i Encoder

Now distributed and available through parent company HEIDENHAIN Corporation, the new RENCO R28i Modular Encoder is perfectly suited for size 11 step motor applications, providing state-of-the-art performance in a 28mm package.

The innovative design is self-aligning and self-gapping, and requires no special tooling for installation. The custom OPTO-ASIC provides a wide range of available resolutions, and sets the standard for resolution and performance.

This RENCO R28i can also accommodate motor shafts up to 7mm making it suitable for brush motor, step motor, and lead-screw applications.

RENCO R28i Modular Encoder

To provide a robust mounting, the motor can utilize the existing motor assembly screws, or dedicated mounting points for durability and reliability.

RENCO Encoders is a leader in the industry of high-quality modular and bearing encoders, offering a wide range of standard and custom products and services that meet an array of motion control needs. RENCO Encoders, a California-based company, designs and manufactures all our products on site at the Goleta, CA facility.

LEINE & LINDE Offers Robust Encoder with DeviceNet™

Now available through parent company HEIDENHAIN Corporation is the Leine & Linde 600 Series (a highly robust ø 58 mm fieldbus encoder series), now with DeviceNet™. This support for fieldbus interfaces extends the range of applications for this already useful absolute rotary encoder.

This Leine & Linde series supports 13-bit singleturn or 25-bit multiturn with screw terminal or miniature M12 connection. Mechanically, various shafted- and hollow-shafted versions are available. The DeviceNet™ encoder supports encoder profile revision 2 and the functionality has been fully tested in compliance with the ODVA conformance test.

Leine & Linde 600 Series

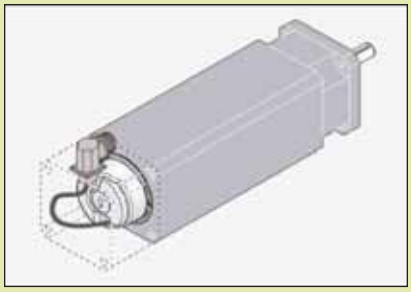
Overall, fieldbus technology is rapidly gaining acceptance and integration into automation applications worldwide. Based on network topology, system requirements and performance, various types of fieldbus systems are available, all developed and supported by individual standardization organizations. The key principle of fieldbus technology is to enhance device functionality, achieve communication transparency, simplify and standardize installations, as well as limiting the installation and maintenance costs. Sensors, like encoders, with support for various fieldbus interfaces have been available for several years and are increasingly gaining in acceptance and installed market share.

Leine & Linde is well known worldwide for offering high quality, heavy duty encoders of both the incremental and absolute types, are noted for their product robustness and designed to cope with the harshest of environments, such as those with high vibration, dirt and cold temperatures. These heavy, severe duty encoders are suited for drive and measurement applications and are often found in industries such as pulp and paper, forest and wood processing, agriculture, aggregate and mining equipment.

Technical Tidbit:

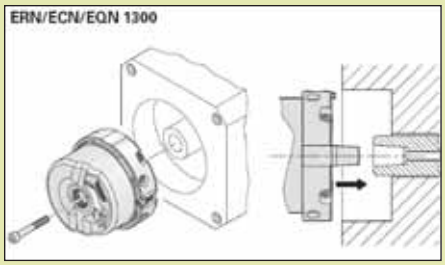
The Task of a Stator Coupling

In order to meet today's dynamic requirements on encoders with bearings and stator couplings, much design work and testing is necessary, especially for motor applications. The end result should be superior signal quality under the most demanding conditions. Stator couplings play a very important performance role here.



(Fig. 1)

The stability of a rotary encoder / drive encoder system, in large part, depends on the coupling design, material, material thickness, and form. The slightest change can and will affect the overall performance. In some cases, machine manufacturers will develop their own coupling for various reasons not realizing the changes it can cause in the overall dynamics. In every instance, these changes will have an adverse effect, damaging the encoder. (When special circumstances require adjustments, HEIDENHAIN can provide customized solutions.)



(Fig. 2)

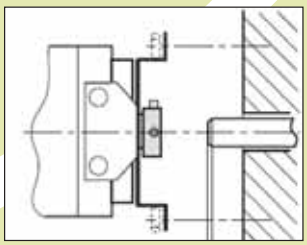
Think of the use of a stator coupling in this way: the rotary encoder along with the stator coupling form a vibrating mass system whose natural frequency should be as high as possible. Natural frequency is the frequency at which a system will begin to vibrate as it is set into motion. The goal is to make this frequency as high as possible while maintaining bearing life, signal quality and overall longevity. Not an easy task. Fig. 1 highlights a coupling design based on a servo motor application.

This unique design with mounted stator coupling and tapered shaft literally allows the encoder to become one with the motor. This design offers several benefits from a dynamic performance range to ease of installation ideal for mass production situations. The mounting process is quite simple. The tapered shaft of the encoder fits into the mating taper of the measured shaft (Fig. 2). This means the encoder is self aligning to the bearing and shaft of the motor. The only hardware required is the central mounting screw that brings the shafts together. The stator coupling of the encoder is clamped in the pocket by an axially tightened screw. As you can see in Fig 3, the screw forces the expansion of the coupling via two-nuts. At first glance, it may not seem rigid enough, however, the combination of tapered shaft and this style coupling has ~4x the holding torque than standard stator couplings. (Fig. 4)

(Fig. 3)

The task of a stator coupling goes far beyond just simply attaching the encoder to a measured shaft. In review of the benefits, we now know:

- No axial mounting tolerances between shaft and stator housing for this particular design
- High natural frequency of the coupling ≥ 1,800 Hz
- High torsional rigidity of the shaft coupling
- Lower profile, less real estate required for mounting
- Simple installation
- Up to ± 0.5 mm axial motion



(Fig. 4)

These are just some of the reasons why HEIDENHAIN leads the industry when it comes to quality and innovation.

Dear Abbé...

Providing answers to questions of accuracy

Question: What is a PWM 9?

Answer: The PWM 9 is a complete universal measuring unit for inspecting and adjusting HEIDENHAIN incremental linear and angle encoders. Instead of offering just a series of LEDs on the encoder for installation which can lead to a green light that could just be marginally green and cause issues after the machine has shipped to the customer, HEIDENHAIN offers two devices that provide detailed information on the encoder signals and allows the user to install correctly, thereby increasing the safety margin and quality of the machine overall.

First, the small low cost handheld device that displays amplitude information to a resolution of 0.1V and the quality of the home pulse is called the PWT. There are various PWTs for the various electrical interfaces and are dedicated to that interface, such as 1Vpp or TTL. The other device, a PWM 9, however has this PWT mode as well as much more detail about the encoder signals, such as phase angle of sine and cos waves, encoder current consumption and encoder voltage and offsets. The PWM 9 has a slot where various electrical interface cards can be inserted, such as Endat (incremental analog signals only), TTL, and 1Vpp. PWM 9 is German for Phasen Winkel Messung which translates to Phase Angle Measurement, and it is the 9th iteration of this device.

PWM 9 shown in PWT mode.

The PWM 9 is also valuable for safe inline usage so that a user can look at the detailed encoder signal parameters while the machine axis is put to motion. This helps the users to determine if the encoder is installed correctly and with enough safety margin through the whole range of motion of that particular axis. Encoders with LEDs cannot compare as one does not know if certain areas of the motion axis are marginally “green” or not. Encoders using just a USB interface for setup also cannot be run inline with the machine axis in motion.

The PWM 9 has a monochrome backlit LCD screen that is easy to read from any angle. It also contains 3 BNC sockets for testing encoder outputs on an oscilloscope, which is probably the best way to install encoders as the lisajous pattern is very visible and easy to interpret with the proper training.

CONTACT INFORMATION

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

HEIDENHAIN
The Measure of Excellence

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