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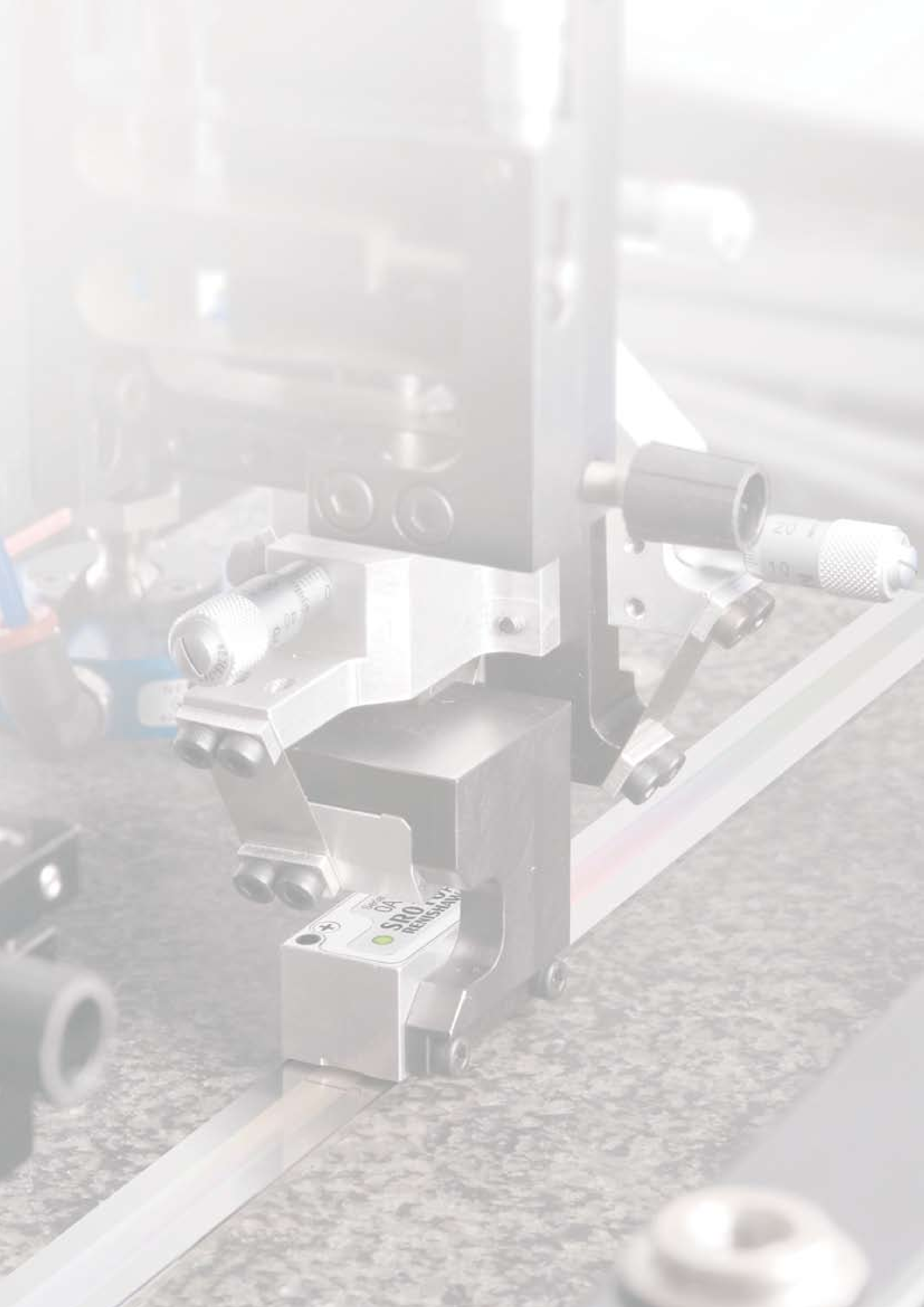
Non-contact position encoders


SRO

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Product range

SiGNUM™ RELM high accuracy linear encoders — 5

- 20 µm pitch robust Invar scale
- Accuracy to ±1 µm, resolutions to 5 nm and ±30 nm cyclic error
- Bi-directionally repeatable *IN-TRAC*™ optical reference mark

RG2 20 µm and RG4 40 µm optical linear encoders — 10

- 20 µm and 40 µm pitch RGS tape scale
- Resolutions to 10 nm and accuracy to ±3 µm/m
- 40 µm chrome on glass scale

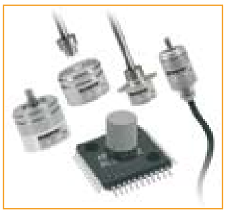
SiGNUM™ RESM, REXM and the RESR optical angle encoder — 16

- Precision angular measurement in a wide range of diameters
- Angular resolutions to 0.004 arc second and accuracy to ±0.5 arc second
- DSi (Dual SiGNUM™ interface) for ultra-high accuracy

Accessories — 23

- Interpolators/interfaces and DROs
- Scale applicators
- Special mounting options and custom solutions

Magnetic rotary encoders — 24

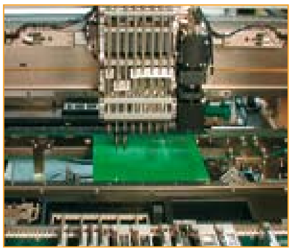


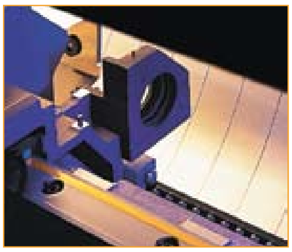
- Resolutions to 13-bit (8,192 counts per revolution)
- Absolute and incremental output versions
- Ingress protection to IP68

Laser interferometer solutions — 28

- Resolutions to 38.6 picometres
- 'Bolt down, dial in' simplicity
- User selectable configurations

Welcome





Renishaw offers a wide range of compact optical and magnetic encoder systems to meet the diverse requirements of industrial automation. This product catalogue details an extensive selection of high speed optical linear encoders, precision angle encoders, robust rotary magnetic encoders and a range of laser interferometers.

Renishaw's optical encoder systems are based on an innovative non-contact optical arrangement which provides zero mechanical hysteresis and excellent metrology, yet can withstand a variety of contaminants such as dust, light oils and scratches without compromising the signal's integrity. This ensures customers' machines run reliably with little or no maintenance.

In addition to these benefits, Renishaw's encoders have an established reputation for being easy to install and set-up. Scale is available in many lengths with special formula self-adhesive backing, removing the need for drilling and tapping, saving time and money.

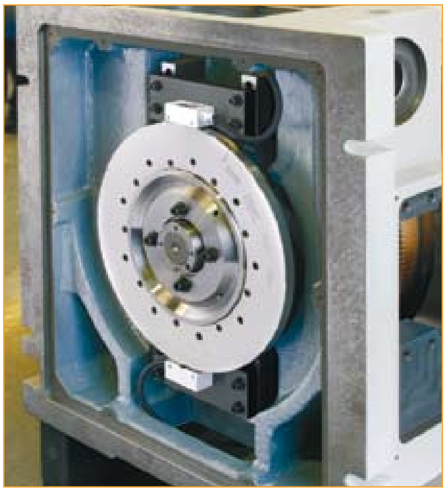
All optical readhead and interface combinations feature a patented set-up LED which speeds installation and removes the need for complex set-up equipment or oscilloscopes.

In addition to leading product performance, Renishaw provides unequalled engineering back-up with a global team of experienced engineers always on hand to offer application advice and expert installation support.

Also, to ensure that we never hold up your production, stock is held at over 30 Renishaw operations worldwide and thanks to flexible manufacturing techniques, even out-of-stock items can be manufactured and shipped promptly.

Renishaw's encoder systems are used in all sectors of industrial automation such as semiconductor, electronics, medical, scanning, printing, scientific research, space research, photography, specialist machine tools, including precision metrology and motion systems. Basically, precision motion control needs precision feedback encoders.

Cover photograph (right): Rotary table built by Rotary Precision Instruments-RPI (www.rpiuk.com) using REXM and DSi to achieve ±1 arc second accuracy.



SiGNUM™ RELM high accuracy linear encoders

The RELM high accuracy linear scale redefines encoder performance, offering high speed, non-contact performance, combined with advanced features including the ***IN-TRAC™*** auto-phase optical reference mark.
The system comprises the SR readhead, Si interface and RELM 20 µm pitch Invar spar. RELM is extremely robust yet offers a level of performance previously available only from more delicate fine pitch encoder systems. With accuracy to ±1 µm, low coefficient of expansion ≈0.6 µm/m/°C (0 °C to 30 °C), and resolution to 5 nm, RELM satisfies the most demanding precision motion requirements.

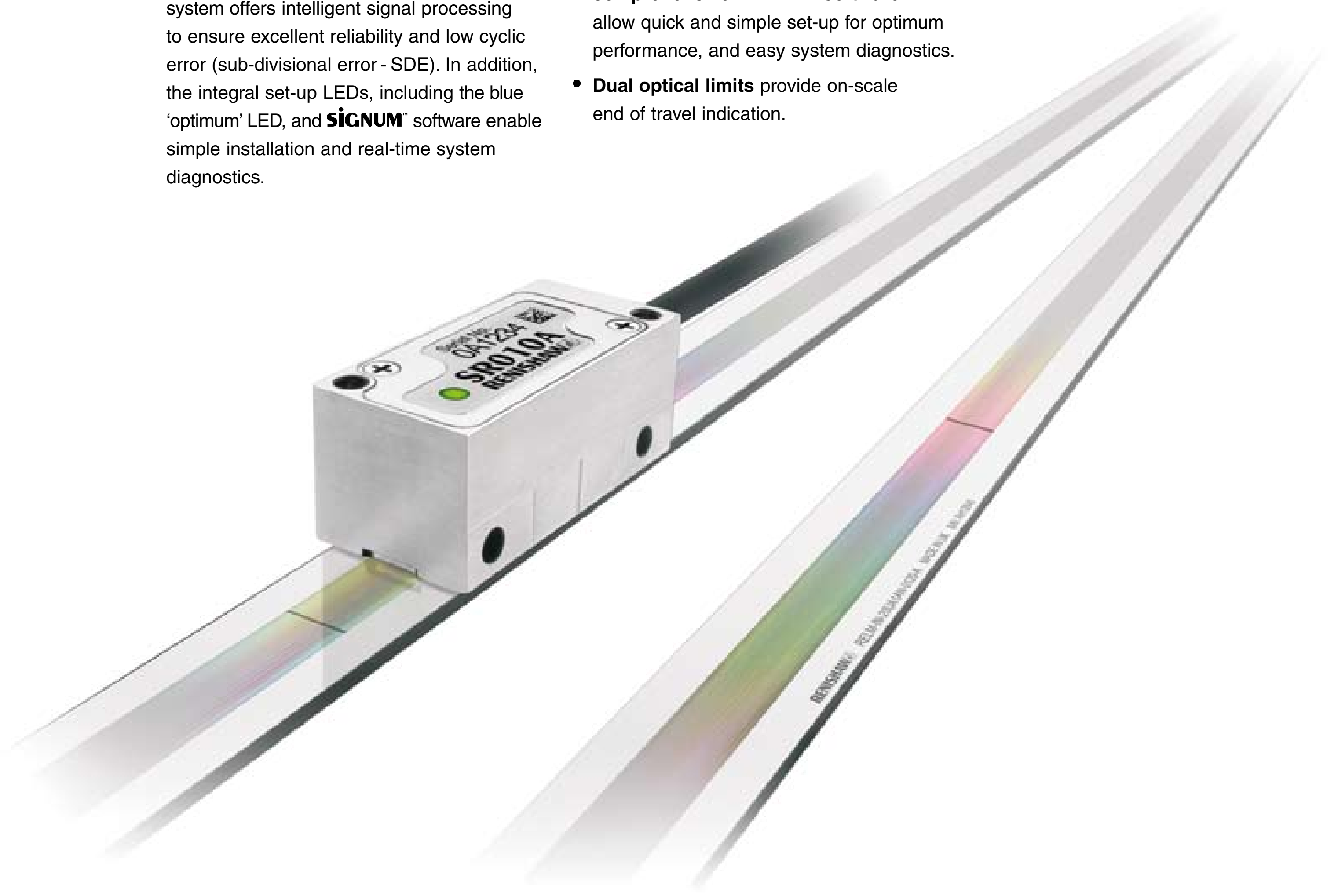
Capable of operation up to 12.5 m/s, the SR readhead features Renishaw's unique filtering optics to provide excellent immunity to dirt, dust and scratches. The position of the reference mark can be specified either in the centre of the scale (RELM) or 20 mm from the scale end (RELE). The Si interface can be mounted remotely and the small connector on the readhead cable can easily be fed through machines where access is restricted. Like all **SiGNUM™** encoders, the RELM encoder system offers intelligent signal processing to ensure excellent reliability and low cyclic error (sub-divisional error - SDE). In addition, the integral set-up LEDs, including the blue 'optimum' LED, and **SiGNUM™** software enable simple installation and real-time system diagnostics.

Why RELM?

- **The *IN-TRAC™* auto-phase optical reference mark** is bi-directionally repeatable, even at maximum speed (12.5 m/s).
- Dynamic signal control ensures **SDE of ±30 nm.** Levels of performance that previously demanded fine pitch encoders can now be achieved with the dirt immunity and simple installation associated with 20 µm pitch systems.
- RELM spar is manufactured using a **robust, low-expansion stabilised alloy**, Invar, for ease of handling and installation.
- **High accuracy, certified to ±1 µm,** and defined thermal behaviour ≈0.6 µm/m/°C (0 °C to 30 °C) make RELM Invar spar suitable for the most precise motion applications.
- **Easy to install.** Can be mounted directly to the substrate using mechanical clips or a specially formulated adhesive backing tape.
- **Integral setup indicator LEDs and comprehensive SiGNUM™ software** allow quick and simple set-up for optimum performance, and easy system diagnostics.
- **Dual optical limits** provide on-scale end of travel indication.

SiGNUM™ RELM system

SiGNUM™ software



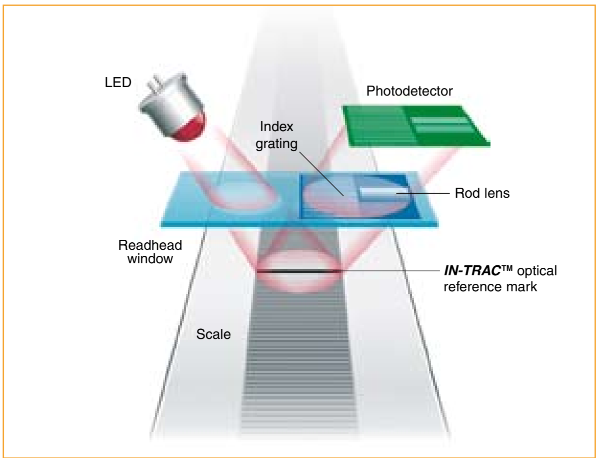
SiGNUM™ RELM technical information

RELM Invar scale

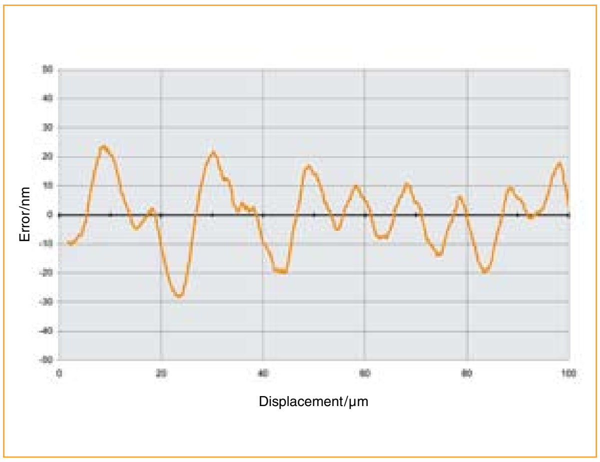
The SiGNUM™ RELM system comprises the SiGNUM™ SR readhead, Si interface and RELM spar scale.

RELM scale is manufactured from Invar, a low expansion nickel/iron alloy. The scale is available in a range of defined lengths up to 980 mm with custom lengths available on request. RELM has a coefficient of expansion of ≈0.6 µm/m/°C (0 °C to 30 °C) and is individually certified to ±1 µm accuracy, providing extremely high precision feedback. The robustness of the Invar spar permits a much smaller cross-section than typical glass scales, yet allows easier handling and installation, without risk of breakage.

RELM scale incorporates Renishaw's ***IN-TRAC*™** auto-phase optical reference mark at the scale mid-point, or 20 mm from the scale end (RELE). The ***IN-TRAC*™** reference mark provides a bi-directionally repeatable datum across the speed and temperature ranges specified, without increasing overall system width. Dual optical limit outputs are also available, using customer positioned markers, to give on-scale end of travel indication. System designers can choose between mechanical mounting, using clips and a datum clamp, or adhesive mounting using a specially formulated backing tape and epoxy earth point, to suit their specific requirements.



SiGNUM™ optical scheme



SDE graph showing a reduction through SiGNUM™'s dynamic signal processing

SiGNUM™ SR readhead and Si interface

The 'scale' component of RELM is essentially a plane reflective metal grating of 20 µm period. While uniform graduation is critical to good encoder metrology, the unique optics do not require the scale to be a good diffraction grating, just strongly periodic. This property of the readhead optics results from the way fringes at the detector are derived from the scale. A transmissive phase grating produces an 'image' of the scale with non-periodic features, such as dirt, filtered out. The nominally square-wave scale pattern is also filtered to leave a pure sinusoidal fringe field at the detector. Here, a multiple finger structure is employed, fine enough to produce photocurrents in the form of four symmetrically phased signals. These are combined to remove DC components and produce sine and cosine signal outputs with high spectral purity and low offset, while maintaining bandwidth to beyond 500 kHz.

The balance and level control of these signals is further enhanced by active adjustment of individual channel gains, offsets and also control of the LED light source within the SiGNUM™ readhead. As a result, the inherent cyclic error (sub-divisional error - SDE) is ±30 nm, i.e. 0.15% of scale period. Interpolation is by CORDIC algorithm within the SiGNUM™ interface and is available to 5 nm.

The ***IN-TRAC*™** reference mark is embedded in the incremental scale in the form of a dark line. This feature is rejected by the filtering incremental optics, but detected by a split photodetector within the readhead. With appropriate level sensing and gating circuitry this yields a reference mark output that is bi-directionally repeatable to unit of resolution at all speeds. Calibration of phase with respect to the analogue channel is performed automatically on installation by the logic within the interface, which also provides comprehensive system monitoring and set-up assistance.

SiGNUM™ RELM high accuracy linear encoder range

Scale

- Accuracy: Individually certified to ±1 µm, calibrated against International Standards
- Low coefficient of expansion: Invar, ≈0.6 µm/m/°C (0 °C to 30 °C)
- Mounted using datum clamp and clips or specially formulated adhesive backing tape
- ***IN-TRAC™*** auto-phase optical reference mark
- RELM: reference mark at mid-point of scale
- RELE: reference mark 20 mm from end of scale
- On-scale dual optical limit outputs
- Available in a range of defined lengths up to 980 mm
- Spar cross-section: 1.5 mm x 15 mm

SiGNUM™ SR readhead and Si interface

- Dynamic signal processing gives cyclic error (sub-divisional error - SDE) of ±30 nm, offering 'fine pitch' encoder performance
- Speeds up to 12.5 m/s
- Operating temperatures up to 85 °C
- Multilingual **SiGNUM™** software simplifies installation and provides system diagnostics via USB connection to PC
- Integral LEDs on head and interface for optimum setup and system diagnostics
- User selectable AGC maintains 1 V_{pp} analogue signal amplitude
- Readhead rated to IP64, interface rated to IP30
- Analogue output with 20 µm signal period
- Digital resolutions from 5 µm to 5 nm
- 3-state or differential line driven alarm signals are available on all units
- Warnings and limits can be selected as active-high or active-low
- Readhead: 14.8 mm x 36.0 mm x 16.5 mm (H x L x W)
- High flex, UL-approved cable – up to 10 m between readhead and interface and new IP68 in-line connector option

SiGNUM™ RELM applications

Direct linear encoders are now the default choice for motion control in a huge range of applications. The new SiGNUM™ RELM encoder system offers system designers the perfect balance between high performance and ease of use, finding uses in many applications previously only suitable for fragile fine pitch encoders.

Wafer handling and dicing

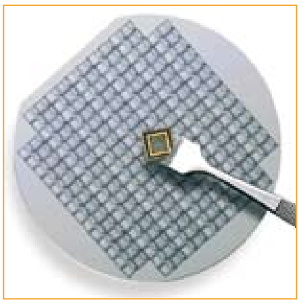
As wafer size increases, wafer processing machines need to be faster, more accurate, capable of reliable handling yet sufficiently compact to make efficient use of clean-room floor space.

That's a lot of requirements to meet, but to stay ahead of the field, equipment manufacturers are constantly searching for new technologies to give their future designs the edge.

High performance motion components, such as air bearings, linear motors and ceramic guides can improve performance, but the choice of position feedback encoder is critical. With class leading accuracy, repeatability, reliability and speed, you can depend on RELM to give your machine the edge.

Semiconductor inspection

As feature sizes shrink, manufacturers face the challenge of detecting ever smaller 'killer' defects. Automated optical inspection (AOI) is a key part of this process and requires high performance encoders for precise position feedback. Low coefficient of expansion, high accuracy scales are critical for many high performance optical inspection machines.



Scientific instruments

With recent advances in nanotechnology, the requirement for precision motion feedback for scientific instruments is growing. High accuracy, high resolution, and 'super smooth' velocity control are crucial to cutting edge research.

Wire/die bonding

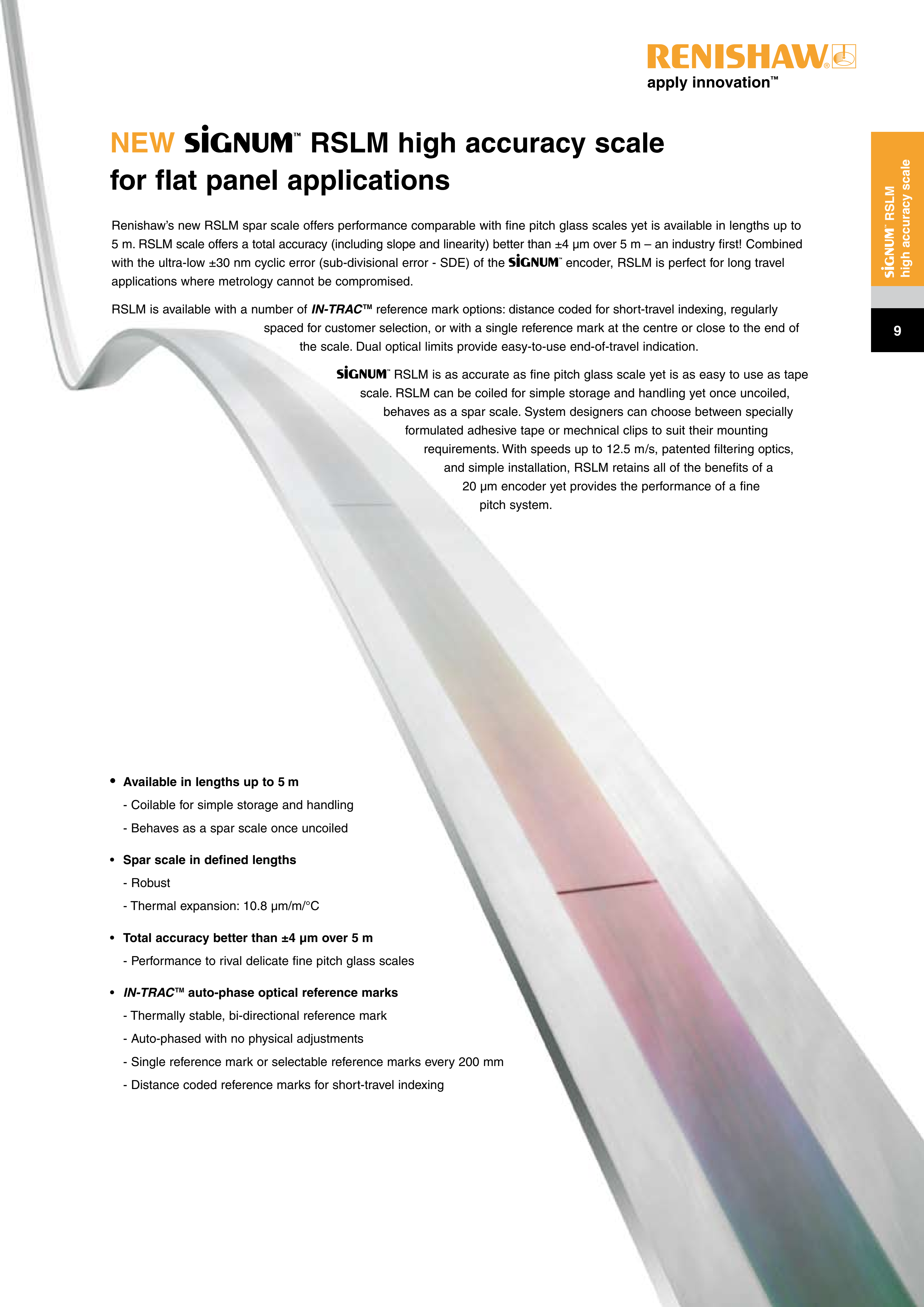
As manufacturers strive to improve the specification of their future generation machines, many look to the position feedback system to provide much of the increased performance. Wire bonders demand low CTE, repeatability and speed – just three of the many areas where SiGNUM™ RELM excels.

NEW SiGNUM™ RSLM high accuracy scale for flat panel applications

Renishaw's new RSLM spar scale offers performance comparable with fine pitch glass scales yet is available in lengths up to 5 m. RSLM scale offers a total accuracy (including slope and linearity) better than ±4 µm over 5 m – an industry first! Combined with the ultra-low ±30 nm cyclic error (sub-divisional error - SDE) of the SiGNUM™ encoder, RSLM is perfect for long travel applications where metrology cannot be compromised.

RSLM is available with a number of ***IN-TRAC*™** reference mark options: distance coded for short-travel indexing, regularly spaced for customer selection, or with a single reference mark at the centre or close to the end of the scale. Dual optical limits provide easy-to-use end-of-travel indication.

SiGNUM™ RSLM is as accurate as fine pitch glass scale yet is as easy to use as tape scale. RSLM can be coiled for simple storage and handling yet once uncoiled, behaves as a spar scale. System designers can choose between specially formulated adhesive tape or mechnical clips to suit their mounting requirements. With speeds up to 12.5 m/s, patented filtering optics, and simple installation, RSLM retains all of the benefits of a 20 µm encoder yet provides the performance of a fine pitch system.



- **Available in lengths up to 5 m**
  - Coilable for simple storage and handling
  - Behaves as a spar scale once uncoiled
- **Spar scale in defined lengths**
  - Robust
  - Thermal expansion: 10.8 µm/m/°C
- **Total accuracy better than ±4 µm over 5 m**
  - Performance to rival delicate fine pitch glass scales
- ***IN-TRAC*™ auto-phase optical reference marks**
  - Thermally stable, bi-directional reference mark
  - Auto-phased with no physical adjustments
  - Single reference mark or selectable reference marks every 200 mm
  - Distance coded reference marks for short-travel indexing

RG2 20 µm and RG4 40 µm optical linear encoders

Precision control of machines and motion systems requires high performance rotary or linear encoders. If the application demands ultimate positioning, combined with precision and reliability, a non-contact optical encoder is ideal. Renishaw's RG2 and RG4 linear encoders offer a durable scale with excellent metrology that can be cut to any user-defined length. RG2 and RG4 scales require none of the careful handling and cleaning most traditional scales need. The unique optical arrangement maintains signal strength, purity and accuracy in conditions considered unsuitable for most open optical encoders.

The drive towards higher accuracy and throughput has increased the use of linear motors throughout industry and for many applications the lead screw and rotary encoder have been replaced with high speed non-contact linear encoders.

Why RG2 and RG4?

- **High speed, non-contact** operation – perfect for the high speeds required of automation today
- **Zero friction and zero mechanical wear** for long term reliable operation
- **Open optical design** guarantees high performance whilst withstanding levels of contamination found in most factories
- Flexible scale on a reel (up to 70 m) for **'cut-to-measure' convenience** eliminates the need to stock multiple scale lengths
- Patented scale applicator tool enables **fast and accurate scale installation**
- **Integral set-up LED** lights green to indicate correct set-up; no need for oscilloscopes or dedicated set-up equipment
- **Dual limit** switches offer unique end of axis travel indication
- A range of **compact readheads** with interpolation give digital resolutions from 10 µm to 10 nm as well as 12 µA and 1 V_{pp} analogue outputs
- Unique **thermal-matching** of scale to substrate simplifies thermal compensation of the system

The RG2 and RG4 encoder systems combine these user-friendly features with exceptional measurement performance. The world's leading manufacturers of high accuracy co-ordinate measuring machines rely on RG2 and RG4 – the familiar gold stripe is visible on many of their machines.

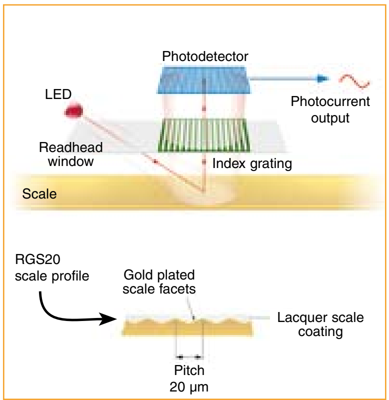
Automated circuit board tester – Proteus

RG2 20 µm and RG4 40 µm technical information

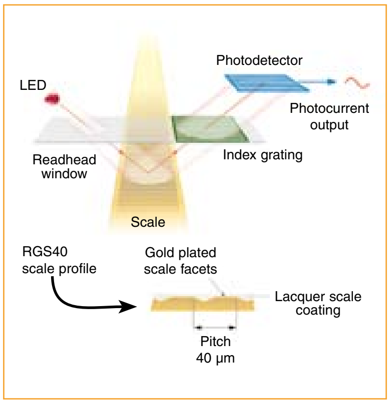
The RG2 and RG4 are open, non-contact optical systems, eliminating friction and wear whilst permitting reliable high speed, high resolution operation. The unique 20 µm pitch filtering optics of the RG2 system ensure excellent signal stability even when used in workshop environments.

Using similar optics, the RG4 40 µm pitch system retains the beneficial features of the RG2 system but with a number of obvious differences which give the RG4 additional benefits. The greater scale pitch of RG4 allows higher speed, more generous set-up tolerances, and the orientation of the optical elements enable it to read a wider variety of scale types.

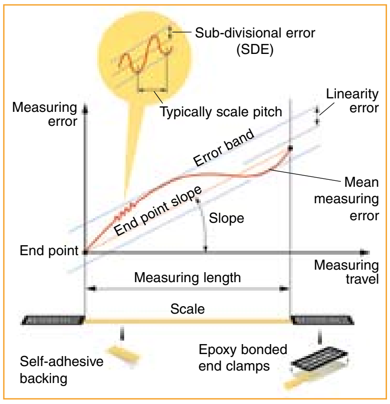
All readhead types come with industry standard analogue or square wave outputs, with analogue signal period equalling scale pitch and digital resolutions from 10 µm to 10 nm. All systems incorporate a unique, integral set-up LED, which lights green when optimum installation has been achieved. Reference mark and/or limit switch outputs are available on all models of readhead. The reference mark provides a repeatable home or zero position, whilst the limit is used as an end of travel indicator.



RG2 optical scheme



RG4 optical scheme



RGS scale metrology

An infra-red LED emits light onto the scale facets, which reflects back into the readhead through a transmissive phase grating. This produces sinusoidal interference fringes at the detection plane within the readhead.

The optical scheme averages the contributions from many scale facets and effectively filters out signals not matching the scale period. This ensures signal stability even when the scale is contaminated or slightly damaged.

Thermal characteristics often play a significant role in determining overall measurement accuracy. The RGS tape scale is rigidly restrained at its ends and is therefore forced to match the thermal behaviour of the substrate, removing the need to compensate for yet another coefficient of expansion.

Low short-term errors are assured by the unique optical design, typically giving less than ±0.15 µm (RG2) cyclic error (sub-divisional error - SDE) or ±0.25 µm (RG4). This is included within the linearity specification of ±0.75 µm (RG2) or ±1 µm (RG4) in 60 mm or ±3 µm in any metre length.

The RGS gold plated scale is lacquer coated for handling protection and easy maintenance. A self-adhesive backing enables quick and easy installation with minimum axis preparation. Continuous lengths are supplied on reels and can be cut to length at the point of installation.

Scale installation is quick and easy using dedicated application tooling which utilises the motion of the machine axis to ensure correct alignment.

To complete the installation, reference mark, limit switch actuators and end clamps are simply glued into place, eliminating the need to produce holes or threads in the substrate.

RGS20-S 20 µm tape scale is read by RGH22, RGH24, RGH25 and RGH26 readheads, whilst RG4 readheads (RGH34, RGH40 and RGH41) can read combinations of RGS40-S 40 µm tape scale, RGS40-G glass scale, 40 µm RESR angle encoders and other reflective etched scale for specialist OEM applications.

RG2 20 µm range

RGH22

- Compact and robust housing
- Integral interpolation and set-up LED
- Resolutions available 5 µm, 1 µm, 0.5 µm, 0.1 µm and 50 nm
- Reference mark and dual limit switch sensors
- 16.0 mm x 44.0 mm x 27.0 mm (H x L x W)

RGH24

- Super-compact and robust housing
- Integral interpolation and set-up LED
- Resolutions available 5 µm, 1 µm, 0.5 µm, 0.2 µm, 0.1 µm, 50 nm, 20 nm and 10 nm
- Reference mark or single limit switch sensor
- 14.8 mm x 36.0 mm x 13.5 mm (H x L x W)

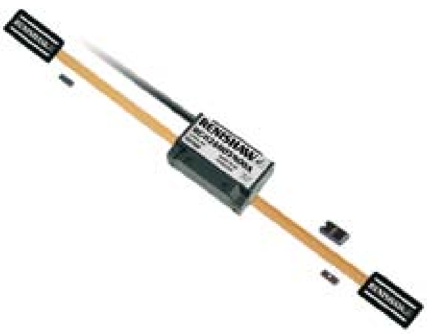
RGH25

- Ultra-compact and robust housing
- External interpolation with set-up LED
- Resolutions available 5 µm, 1 µm, 0.5 µm, 0.1 µm and 50 nm
- Reference mark or single limit switch sensor
- 10.5 mm x 36.0 mm x 13.5 mm (H x L x W)
- Ultra high vacuum version available – see page 15

RGH25F

- Ultra high resolution
- Resolutions available 0.2 µm, 0.1 µm, 50 nm, 20 nm and 10 nm
- Reference mark
- Self tuning adaptive electronics give low cyclic error (SDE)
- Automatic gain control and automatic offset control
- 10.5 mm x 36.0 mm x 13.5 mm (H x L x W)
- Ultra high vacuum version available – see page 15

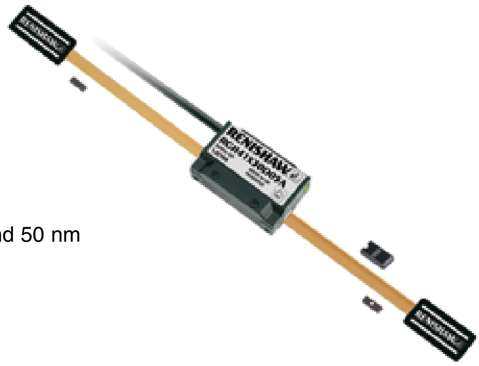
RGH26



- Mitsubishi MELSERVO® serial comms compatible readhead
- Compact and robust housing
- Integral interpolation and serial conversion
- Resolutions available 5 µm, 1 µm, 0.5 µm (Mitsubishi serial outputs)
- Reference mark and dual limit switch sensors
- 16.0 mm x 44.0 mm x 27.0 mm (H x L x W)

RG4 40 µm range

RGH41



- Reads RGS40-S tape scale
- Compact and robust housing
- Generous set-up tolerances
- Integral interpolation and set-up LED
- Resolutions available 10 µm, 5 µm, 2 µm, 1 µm, 0.4 µm, 0.2 µm, 0.1 µm and 50 nm
- Reference mark and dual limit switch sensors
- 17.0 mm x 44.0 mm x 27.0 mm (H x L x W)

RGH34

- Reads RGS40-S tape scale and other reflective 40 µm scales
- Compatible with 40 µm RESR angle encoder
- Ultra-compact component readhead
- Generous set-up tolerances
- Low mass <2 grams
- Resolutions available 10 µm, 5 µm, 2 µm, 1 µm, 0.4 µm 0.2 µm and 0.1 µm
- FPC cable
- Reference mark or single limit switch sensor
- 9.5 mm x 15.0 mm x 15.0 mm (H x L x W) readhead only
- Physically identical 20 µm pitch variant also available (RGH35) for rotary applications

RGH40

- Reads RGS40-G glass scale and 40 µm RESR angle encoder
- Compact and robust housing
- Generous set-up tolerances
- Integral interpolation and set-up LED
- Resolutions available 10 µm, 5 µm, 2 µm, 1 µm, 0.4 µm, 0.2 µm, 0.1 µm and 50 nm
- Reference mark and dual limit switch sensors
- 17.0 mm x 44.0 mm x 27.0 mm (H x L x W)

RGS40-G

- 40 µm pitch chrome on glass scale
- Available in a range of measuring lengths from 120 mm to 1 m
- Coefficient of thermal expansion ≈ 8.5 µm/m/°C
- Accuracy <±5 µm/m
- Datum clamp with metal clips or alternative adhesive mounting options
- For use with the RGH34 and RGH40 readheads

RG2 20 µm and RG4 40 µm applications

Direct linear encoders are the preferred choice for many of today's automation systems. To maintain high yield, speed, accuracy, repeatability and reliability, designers need the very best motion components available.

Semiconductor handling, electronics assembly, specialist machines, laser cutting, optical inspection, PCB probe testing, printing, scanning and scientific instruments are just a few of the systems where RG2 and RG4 linear encoders are enhancing performance.

PCB inspection and test

The increasing complexity, density and value of PCBs requires quick, reliable, in-line fault detection and correction throughout the assembly process. Automated optical inspection (AOI) and flying probe testers play a vital part in this process with fast, accurate and reliable linear encoders providing the performance needed.

Wafer handling and dicing

Throughput, yields, reliability and performance relentlessly rise. To keep pace, equipment manufacturers continually advance the performance of their machines. New technology air bearings, linear motors and ceramic guides contribute significantly to performance improvements, but without high quality position feedback these advances would not be possible.

Flat bed computer-to-plate (CTP)

To simplify machine design and reduce costs, some manufacturers of rotary CTP machines have introduced flat bed format machines. Unlike rotary machines, the flat bed format uses high speed linear motors to drive the scanning head in both X and Y. Clarity of the image is essential and manufacturers rely on high performance linear encoders to control the linear motors. RG2 and RG4 offer the speed, reliability and low cyclic error (sub-divisional error - SDE) required by these applications.

Flat Panel Display

To increase volume production of TFT screens to meet global demand, FPD process machines (from CVD to inspect and repair) are being designed to process ever larger panels. Machine size may grow, but as screen resolution is increasing too, accuracy, speed, stability and repeatability cannot be compromised. The RG2 and RG4 meet many of these requirements and are extensively used throughout the FPD manufacturing process.

Proteus probe tester

Exitech laser cutting machine

Airbus A380 wing-panel assembly machine

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RG2 20 µm UHV range

Renishaw's vacuum range is based on the established RG2 linear and RESR angle encoder systems. Specially constructed from clean UHV compatible materials and adhesives to give low outgassing rates and a clean RGA, these readheads also feature reduced current consumption to minimise heat dissipation.

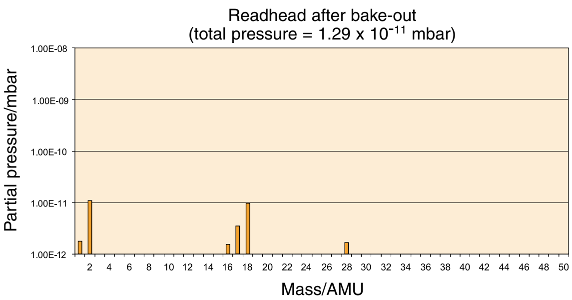
The RG2 vacuum range is suitable for a wide range of applications including wafer handling/testing, scientific instruments, spectroscopy, vacuum inspection equipment and many more...

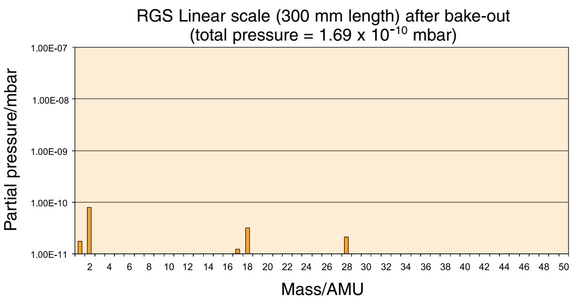
Why RG2 UHV?

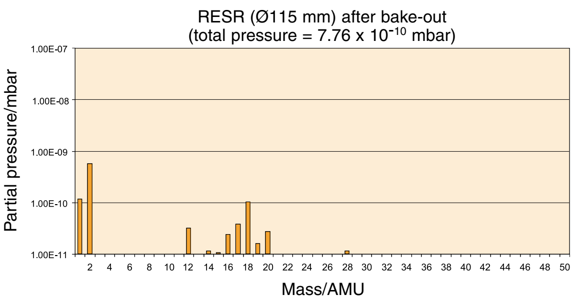
- **Clean RGA**
- **Low outgassing** rates
- Bake-out temperature of **120 °C**
- **Non-contact** open optical system
- Digital resolutions from **5 µm to 10 nm**
- Automatic Offset Control (AOC) minimises **cyclic error** (sub-divisional error - SDE) **(<±0.1 µm)**
- Self-tuning adaptive electronics for high accuracy and **long-term reliability**
- Integral set-up LED enables quick and **easy installation**
- **RFI screened** UHV compatible cable as standard

RG2 UHV range

Thermo Vacuum Generators – vacuum chamber







Residual gas analysis (RGA)

The RGA (residual gas analysis) indicates what gases are emitted. The results of this analysis are presented in graphical form (see opposite) showing the quantity of molecules of specific atomic mass units (AMU) present in the chamber after a 48 hour bake-out at 120 °C.

RGH25U, RGH25F and RGH20F UHV readheads all give a very clean RGA with no significant levels of hydrocarbon contamination. The outgassing products are those normally occurring in UHV systems (H_2, H_2O, CO, CO_2).

The UHV range

Renishaw vacuum systems are available for both rotary and linear applications. Check the table below for the correct combination of readhead, interface and scale.

	Readhead	Interface	Scale
Linear (med-res)	RGH25U	RGB25	RGS20-S
Linear (hi-res)	RGH25F	RGF	RGS20-S
Rotary	RGH20F	RGF	RESR 20 µm

SiGNUM™ RESM and the RESR optical angle encoder

Years of assisting our customers with high-performance rotary installations have provided the inspiration for our unique design of angle encoders that satisfies the many requirements of angular positioning applications.

Renishaw's angle encoders feature a highly accurate scale graduated axially onto the periphery of the stainless-steel ring – the unique process achieving a graduation accuracy of better than ±0.5 arc second (Ø417 mm ring).

Available in a range of 20 diameters, all Renishaw angle encoders have a very low section and a large internal diameter giving the designer freedom to position the encoder around large internal rotors, payloads or services. These slender proportions also give the rings a low moment of inertia, ensuring that whatever the installation, the system can be positioned with minimal torque and maximum speed.

The patented taper mount corrects for eccentricity of the rotor/shaft and ensures excellent accuracy, offering easy and robust fine adjustment of the ring's form and all installation tolerances.

Combined with the readhead and interface, which feature advanced signal processing, cyclic error (sub-divisional error - SDE) is only ±30 nm (±0.06 arc second on a Ø206 mm ring) to offer truly impressive system performance.

Why Renishaw angle encoders?

- **High speed, non-contact** optical performance
- **Zero backlash**
- ***IN-TRAC*™ optical reference mark** remains phased and bi-directionally repeatable up to **85 °C and over 4,500 rev/min**
- Graduation **accuracy to ±0.5 arc second** (Ø417 mm ring)
- Angular **resolution to 0.004 arc second**
- Wide range of diameters and line counts provide compatibility with industry standard controllers **(Ø52 mm to Ø550 mm with line counts from 4,096 to 86,400)**
- One-piece stainless steel ring withstands **vibration, mechanical** and **thermal shock** and **thermal overload**
- **Patented taper mount minimises errors** and simplifies integration
- **Low mass** and **moment of inertia**
- **UHV compatible** (RESR and RGH20F)
- **SDE** of **±30 nm** for exceptional velocity stability
- **Integral LEDs** for **optimum set-up** and system diagnostics
- Multilingual **SiGNUM™** software enables easy installation and **real-time diagnostics**
- SR readhead sealed to **IP64** for 'wipe-clean' recovery

SiGNUM™ RESM system

Föhrenbach RESM application

Optical angle encoder performance

The sources of error associated with angular motion systems can be categorised simply as either repeatable or non-repeatable.

Repeatable errors

For non-contact angle encoders like SiGNUM™ RESM or the RESR, repeatable errors consist of:

- Errors inherent with the angle encoder
- Errors due to the installation of the product

In these respects, SiGNUM™ RESM and the RESR offer excellent performance. The graduation process that produces the scale combined with Renishaw's renowned filtering readheads, give exceptional system accuracy.

Renishaw's patented taper mount minimises installation errors, simplifies the integration and reduces set-up time.

Non-repeatable errors

Non-repeatable errors are of particular concern in an angular motion system, because they cannot be compensated for. Enclosed encoders with integral bearings typically suffer from the following non-repeatable errors:

- Coupling backlash
- Shaft wind-up (torsion)
- Coupling and angular errors (departure from true 'constant velocity')
- Mechanical hysteresis

The RESM and RESR, as non-contact systems, do not exhibit these errors and provide system repeatabilities unmatched by any sealed encoder.

The repeatability of Renishaw's angle encoders provides;

- Repeatability for your machine
- Precise angular incremental moves
- Improved metrology of the machine

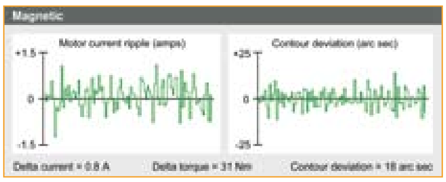
The repeatability of SiGNUM™ RESM and the RESR enables system errors to be mapped to enhance accuracy – the use of multiple readheads on one ring can improve accuracy further by compensating for eccentricity and the effect of bearing wander (See DSi, page 21).

Dynamic performance is also essential for precision rotary axes; an area where RESR and in particular, SiGNUM™ RESM excel. Fundamental scale pitch, not resolution, is critical for an encoder. SiGNUM™'s fine scale pitch and signal processing enable precise motion control. If the scale pitch is coarse (as with inductive and magnetic encoders), the noise on a reported position (jitter) and cyclic error (sub-divisional error - SDE) will be very high. Correspondingly, positional stability and velocity ripple will be many times worse. Consequently, the dynamic response of SiGNUM™ RESM is perfectly suited to precision rotary axes, as illustrated by test results below.

These results, taken by a customer, show a direct-drive motion system exhibiting less current ripple, less torque ripple and closer adherence to a perfect contour when SiGNUM™ is used. The result is less heat generation and better surface finish.

SiGNUM™:
Delta current = 0.0926 A
Delta torque = 3.51 Nm
Contour deviation = 0.0006 deg

Enclosed optical:
Delta of current = 0.601 A
Delta torque = 22.86 Nm
Contour deviation = 0.004 deg



Magnetic:
Delta of current = 0.820 A
Delta torque = 31.16 Nm
Contour deviation = 0.005 deg

DDR motor application

Modular non-contact encoders

Optical angle encoders technical information

Patented taper mount reduces errors

Renishaw's angle encoders feature a unique taper mount, to give an unmatched combination of accuracy, ease of installation and dynamic performance.

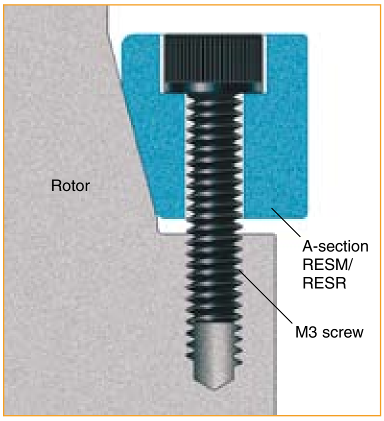
A tapered seating is the only geometry that guarantees mating parts a perfect radial location despite tolerances in their diameters. The machine tool taper nose is testimony to this.

Additionally, a **short** taper still achieves perfect location but can also accommodate slight **axial** run-out (swash), automatically creating a corresponding component of radial displacement.

Renishaw angle encoders combine the short taper seat with a ring of axial fixings to exploit this geometric effect and allow eccentricity to be easily and reliably adjusted on installation. A Ø200 mm ring, mounted on a seat with 10 µm eccentricity, needs only 0.01° swash to produce a perfect installation.

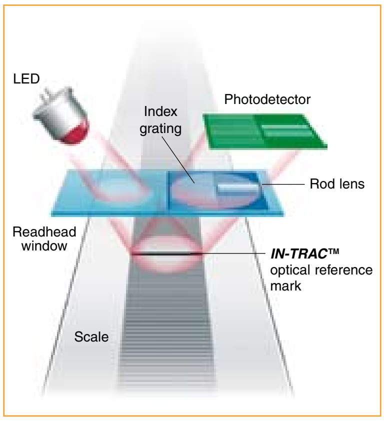
The result is a unique combination of advantages:

- Elimination of close tolerances on customers' parts
- Small cross-section that can be placed wherever best with maximum diameter through-hole
- A solid seating, immune to shock, vibration or temperature swings, even with different CTE seating material
- Easy adjustment for run-out on installation – only a dial gauge is needed – including compensation for eccentric and out-of-round seating faces
- Low mass and moment of inertia
- Quick and easy installation and disassembly; the taper is self freeing
- Axial graduations on the encoder periphery: nothing to clash if the rotor moves longitudinally, easing installation and maintenance access.



Patented taper mount – cross-section

Patented taper mount assembly



SiGNUM™ optical scheme

Principles of operation – SR, RESM and *IN-TRAC*™

The 'scale' component of RESM is essentially a plane reflective metal grating of 20 µm period. While uniform graduation is critical to good encoder metrology, the unique **SiGNUM**™ optics do not require the scale to be a good diffraction grating, just strongly periodic. This property of the readhead optics results from the way fringes at the detector are derived from the scale. A transmissive phase grating produces an 'image' of the scale with non-periodic features, such as dirt, filtered out. The nominally square-wave scale pattern is also filtered to leave a pure sinusoidal fringe field at the detector. Here, a multiple finger structure is employed, fine enough to produce photocurrents in the form of four symmetrically phased signals. These are combined to remove DC components and produce sine and cosine signal outputs with high spectral purity and low offset, while maintaining bandwidth to beyond 500 kHz.

The balance and level control of these signals is further enhanced by active adjustment of individual channel gains, offsets and also control of the LED light source within the **SiGNUM**™ readhead. As a result, the inherent cyclic error (sub-divisional error - SDE) achievable is ±30 nm, i.e. 0.15% of scale period. Interpolation is by CORDIC algorithm within the **SiGNUM**™ interface and is available down to 5 nm.

The ***IN-TRAC***™ reference mark is embedded in the incremental scale in the form of a dark line. This feature is rejected by the filtering incremental optics, but detected by a split photodetector within the readhead. With appropriate level sensing and gating circuitry this yields a reference mark output that is bi-directionally repeatable to unit of resolution at all speeds. Calibration of phase with respect to the analogue channel is performed automatically on installation by the logic within the interface, which also provides comprehensive system monitoring and set-up assistance.

Optical angle encoder range

SiGNUM™ RESM 20 µm

- Graduation accuracy to ±0.38 arc second
- Resolution to 0.004 arc second
- Repeatability to 0.006 arc second
- Range of diameters and line counts from Ø52 mm to Ø550 mm
- ***IN-TRAC*™** auto-phase optical reference mark
- Patented taper mount minimises installation errors and simplifies integration
- 10 mm x 10 mm small cross-section ring
- Extra-low inertia (B-section) rings available
- Compatible with **SiGNUM**™ SR readheads
- Readhead sealed to **IP64** for 'wipe-clean' recovery
- Cyclic error (sub-divisional error - SDE): ±30 nm
- Operating temperatures up to 85 °C and over 4,500 rev/min
- Multilingual **SiGNUM**™ software simplifies installation and provides real-time diagnostics

RESR 20 µm and 40 µm

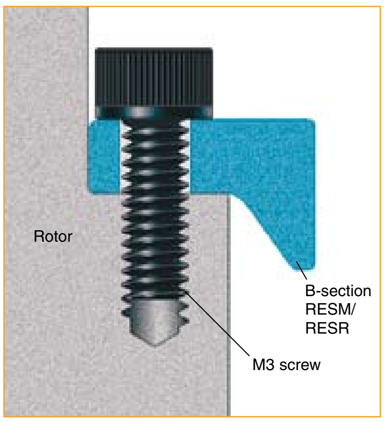
- Graduation accuracy to ±0.5 arc second
- Resolution to 0.01 arc second
- Repeatability to 0.01 arc second
- Range of diameters and line counts from Ø52 mm to Ø550 mm
- UHV compatible (RESR and RGH20F)
- Patented taper mount minimises installation errors and simplifies integration
- 10 mm x 10 mm small cross-section ring
- Extra-low inertia (B-section) rings available
- Compatible with RGH20, RGH35, RGH34 and RGH40 readheads

A-Section and B-Section rings

RESM and RESR are both available with two standard cross-sections; the A-Section or the extra-low inertia B-Section. A-section rings with the patented taper mount offer higher accuracy and easiest adjustment. However, for applications demanding the highest dynamic response, the B-Section is recommended.

B-Section rings reduce mass and inertia by 50%, enabling a well-designed angular motion system to achieve even higher acceleration, deceleration and shorter settling times. B-Section rings are installed with an interference fit directly to the rotor. They are available in 5 standard outside diameters from 75 mm to 200 mm with maximum speeds corresponding with the A-Section sizes.

Outside diameter	75 mm	100 mm	115 mm	150 mm	200 mm
A-Section mass (kg)	0.15	0.2	0.25	0.3	0.4
B-Section mass (kg)	0.07	0.1	0.12	0.15	0.2
A-Section inertia (kgmm^2)	160	420	640	1600	3800
B-Section inertia (kgmm^2)	78	200	310	720	1800



B-section mount – cross-section

Optical angle encoder specifications

RESM/RESR maximum speeds and accuracy

Nominal outside diameter (mm)	Maximum speed (rev / min)		System accuracy (arc second)	
	RGH20D	SiGNUM™	RGH20D	SiGNUM™
52	2938	4591	5.6	4.28
57	2680	4188	5.1	3.91
75	2037	3183	3.9	2.97
100	1527	2387	2.9	2.23
101	1512	2363	2.9	2.21
103	1483	2317	2.8	2.16
104	1469	2295	2.8	2.14
115	1328	2075	2.5	1.94
150	1018	1591	1.9	1.49
200	763	1193	1.4	1.11

Nominal outside diameter (mm)	Maximum speed (rev / min)		System accuracy (arc second)	
	RGH20D	SiGNUM™	RGH20D	SiGNUM™
206	741	1158	1.4	1.08
209	731	1142	1.4	1.07
229	667	1042	1.3	0.97
255	599	936	1.1	0.87
300	509	795	1.0	0.74
350	436	682	0.8	0.64
413	370	578	0.7	0.54
417	366	572	0.7	0.53
489	312	488	0.6	0.46
550	278	434	0.5	0.41

Note: SiGNUM™ speeds based on resolutions up to 0.5 µm.
Note: System error is graduation error plus sub-divisional error (SDE).
Effects such as eccentricity influence installed performance; for application advice please contact Renishaw.

NEW SiGNUM™ Si-FN with FANUC serial communications

The non-contact format and large through-hole of the RESM ring, combined with high accuracy and a rugged IP64 sealed readhead make **SiGNUM™** encoders perfect for machine tool rotary axes. The new **Si-FN** interface adds **FANUC** serial communications…

Ideal for use in gear-driven and direct-drive rotary axes, **Si-FN** provides **FANUC** serial communications direct from the encoder for higher performance and easier connectivity.

Si-FN interfaces are available with three resolution options:

- **Normal:** 20 bit (0.0003°) up to 4,500 rev/min
- **High Type A**: 23 bit (0.000043°), up to 1,200 rev/min
- **High Type B**: 26 bit (0.0000054° or 0.02 arc second), up to 600 rev/min

As with the rest of the **SiGNUM™** range, the intelligent **Si-FN** interface features advanced signal processing such as Automatic Gain Control, Balance Control and Offset Control, to output reliable signals of high fidelity. The result is the best cyclic error (sub-divisional error - SDE) in its class; the SDE of the Ø209 mm **Si-FN** system is only ±0.06 arc seconds… five times better than competitor optical encoders and more than ten times better than magnetic and inductive encoders.

As well as providing finer resolutions, 'High Type A' and 'High Type B' **Si-FN** versions feature advanced filtering electronics for the purest signals to improve position stability and velocity ripple by a factor of 2.

Si-FN interfaces with **FANUC** serial communications can be used with standard **SiGNUM™ SR** readheads and standard **RESM** rings of 52 mm, 104 mm, 209 mm or 417 mm diameters. This allows the machine or rotary axis builder to easily select **Si-FN** as a 'last minute' upgrade option.

All position processing occurs in the **Si-FN** interface so high resolution and high speed combinations are possible that would require unfeasibly high frequency signals if used with traditional digital quadrature.
Serial communications also provide exceptional reliability in noisy environments, especially when combined with **SiGNUM™**'s double-shielded UL-approved cable.

The **Si-FN** adds a fully-functional DRO (digital readout) to **SiGNUM™** software for further diagnostics via a PC's USB port.

SiGNUM™ Si-FN encoder

SiGNUM™ software DRO function

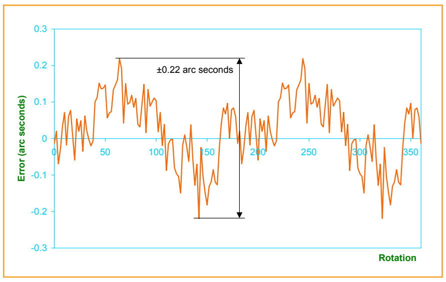
NEW DSi and REXM ultra-high accuracy encoder

Renishaw's new **DSi** combines two **SiGNUM™ SR** readheads on a **RESM** ring and outputs a customer located, angularly repeatable ***propoZ*™** reference (index) position, which is completely unaffected by bearing wander or power cycling.

Precision rotary axes often demand very high accuracy without calibration or error-map. The **DSi** allows the addition of a second readhead to eliminate odd error harmonics including eccentricity and compensate for the effect of both static and dynamic bearing wander. The result is total installed error of typically ±2.0 arc second (Ø209 mm **RESM**). The combined incremental signals of the two readheads simply appear, at the DSi output, as a single very high accuracy encoder.

DSi provides the ***propoZ*™** reference (index) output, which is completely unaffected by bearing wander or power cycling. The customer selects the desired ***propoZ*™** reference position by driving the axis to the chosen angle and simply pressing a button. This feature makes alignment of the encoder's reference position (to the T-slots on a machine tool rotary table, for example), faster and more precise. The selected angle is then stored in the **DSi**'s memory so the patented ***propoZ*™** reference (index) is locked to that angle, ensuring perfect angular repeatability… even if the centre of rotation of the axis moves whilst the **DSi** is switched off.

For applications that require the highest angular accuracy, the **REXM** angle encoder offers new levels of angular metrology - better than ±1.0 arc second total installed accuracy.



The total installed accuracy of a sample 183 mm REXM system is ±0.22 arc second, determined by analysis of sequentially rotated installations.

Like the **RESM**, the **REXM** stainless steel ring has graduations marked axially onto the periphery. However, it features a thicker cross-section designed to minimise all installation errors except eccentricity.

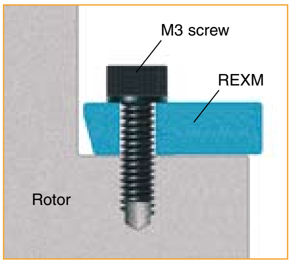
The remaining eccentricity is easily corrected using the **DSi** to combine the output of two readheads. Once the **DSi** has eliminated eccentricity, the only errors remaining are graduation and cyclic error (sub-divisional error - SDE) both of which are exceedingly small.

When **REXM** is used with the **DSi**, it is possible to achieve a total installed accuracy of better than ±1.0 arc second. Tests on a 183 mm **REXM** ring have achieved an impressive total installed accuracy of ±0.22 arc seconds (see graph, bottom left of page).

Furthermore, as a non-contact encoder that locks to the rotor without flexible couplings, **DSi** and **REXM** maintain the dynamic performance advantages of **SiGNUM™** encoders, as well as eliminating coupling losses and 'reversal errors' that are critical in applications that demand the ultimate metrology.

Dual SiGNUM™ readheads

Dual SiGNUM™ interface



REXM mount – cross-section

REXM

Optical angle encoder applications

DDR (torque) motors

In high-accuracy applications, transmission systems reduce system bandwidth, introduce audible noise and ultimately, increase maintenance costs. Direct-drive rotary motors develop high torque, provide rapid acceleration, offer smoother constant velocity and enable precise servo control. Because the load is rigidly fixed to the motor, direct-drive systems are mechanically rigid.

Direct-drive motors offer significant benefits, but place greater demands on the motion control system and in particular, the encoder. Non-contact optical encoders complement DDRs perfectly. Fine scale pitch gives significantly better position stability and SiGNUM™'s exceptionally low cyclic error (sub-divisional error - SDE) enables smoother velocity control.

Because Renishaw's angle encoders are taper-locked directly to the rotor, the system does not suffer from servo 'hunting', oscillation, backlash, nor any other mechanical hysteresis errors that plague traditional enclosed encoders with a flexible coupling.

Direct encoder feedback on gear-driven axes

By fitting direct encoder feedback to the rotor of a gear driven axis, accumulated transmission errors and backlash can be eliminated. The direct non-contact feedback of Renishaw's angle encoders eliminates mechanical hysteresis to improve repeatability, enabling precise small incremental movements.

SiGNUM™ RESM and the RESR offer short axial lengths and easy integration, simplifying performance upgrades on rotary tables and other axes. Such upgrades can be simple modular options on otherwise standard axes and, thanks to the encoder's large internal diameter, the through-hole of the rotor is retained.

Machine tool rotary axes

Precision rotary axes on machine tools require reliable and accurate encoders for position feedback. Renishaw's low profile, non-contact angle encoders offer exceptional accuracy in an easy-to-install format with a large internal diameter. SiGNUM™ RESM and the RESR are open non-contact systems, so they do not suffer from mechanical hysteresis or seal and bearing friction. In addition, the direct mounting of the ring, close to the rotary table, ensures compact design and optimum servo control.

Vibration and mechanical shock may damage some enclosed encoders, but RESM and RESR are rugged by design. Unlike frameless glass rotaries with hub mounting, radial screws etc, the one-piece stainless steel rings won't crack or shatter. Also there are no bearings, seals or couplings to break when the machine is pushed to the limit.

No wonder Renishaw angle encoders are so widely used on machine tool axes…

- Direct encoder feedback on gear-driven rotary tables (single and 2-axis)
- Direct-drive rotary tables
- 4th and 5th axes of vertical and horizontal machining centres
- C axes of vertical machining centres, including triple-function machines (turning, milling, grinding)
- C axes of lathes for indexing/positioning operations
- B axis of multi-function lathes
- Single and dual axis rotating spindle heads
- High accuracy rotary axes on gear hobbing machines, EDM machines and diamond turning machines

FPT Dino high speed milling machine

Optical encoder accessories and custom solutions

Scale applicator kits and applicators ensure the easiest, most precise installation for all readhead types.

Magnetic reference mark actuators are required to produce a repeatable home position for all RG2/4 readheads. Limit switch actuators (end-of-travel output) are available in various lengths and types.

Various end clamps for RGS scale.

The RGH22 ribbon cable variant features an integral connector for standard ribbon cable.

3 axis digital readout for resolutions to 0.1 µm and maximum input frequency of 10 MHz.

The magnetic track system is designed for use with longer axes on which the scale requires occasional re-installation. Standard RGS scale is held magnetically in an aluminium extrusion.

Assembled extension cables, bulk cable and connectors to suit all system combination.

Very long axes present some unique challenges, often requiring a method of maintaining readhead installation tolerance or the ability to read across gaps in the scale. The sprung wheeled guide and dual readhead interface offer practical solutions.

Swipe blocks enable a functional test of readheads without having to install a complete axis.

Not all application needs can be met with standard products. Often a custom solution is necessary, so talk to us about your requirements; anything from a special connector to a purpose designed angle encoder ring.

To provide complete solutions for optical linear and angle encoders a full range of accessories is available, from reference mark actuators to digital readouts. Renishaw is committed to providing position feedback solutions to satisfy customer specific requirements, such as custom angle encoder diameters and cross sections. Please contact Renishaw for further information on how we can meet your specific requirements.

Magnetic rotary encoders

Renishaw now offers a range of frictionless miniature magnetic encoders with resolutions from 8-bit (256 counts per revolution) to 13-bit (8,192 counts per revolution).

The novel non-contact design provides reliable long-term operation by eliminating the need for seals or bearings, whilst operational speeds of over 60,000 rpm can be achieved with measurement accuracy to 0.3°. For harsh environments, compact versions are also available with sealing to IP68.

The new range of rotary magnetic encoders is easy to integrate, with a range of formats offered, including component, modular and packaged versions. Output signal types include industry standard absolute, incremental, analogue, linear voltage and linear current.

With such a flexible and robust design, many applications are already benefiting from these new encoders. These can be found within the marine, automotive, aviation, motor control and automation industry sectors.

Motor sport

Salakazi Racing has equipped its KTM dragster with an automatic clutch. Fitted to it is the RM22 encoder with the ability to monitor position at up to 30,000 rpm. One device monitors the position of the crankshaft in the engine, while the other measures the clutch speed. By comparing these values, clutch slippage, traction and road conditions can be determined with high precision which allows technicians to properly adjust the first stage counterweights in the clutch before each race. This provides maximum speed and acceleration with minimal wheel spin during the first few fractions of a second.

CCTV camera – Overview Ltd, UK

Security cameras

CCTV cameras require excellent reliability and high repeatability in absolute positioning, but at low cost. The pan and tilt position of the camera is easily controlled with an encoder IC integrated within the camera mechanism and with no parts to wear, long term reliability is guaranteed!

Why magnetic rotary?

- Non-contact / frictionless design for **reliable long term operation**
- Industry-standard absolute, incremental, sinusoidal analogue and linear outputs
- Binary and decimal options to **13-bit absolute** (8,192 counts per revolution incremental)
- High speed operation to **60,000 rpm** depending on resolution with low inertia moving parts
- Excellent dirt immunity to **IP68** for use in harsh environments
- **Low cost** robust design that is easy to install
- **Compact design** with packaged encoders from just 22 mm diameter
- Shock resistant and **low inertia**
- Extended operational temperature range **-40 °C to +125 °C**

The KTM dragster built by Salakazi Racing

RENISHAW
apply innovation™

Magnetic rotary encoders technical information

Each magnetic encoder contains an integrated circuit that senses the angular position of a permanent magnet placed above it. The permanent magnet is cylindrical and diametrically polarized.

Hall sensor technology detects the magnetic flux density distribution at the surface of the silicon. Hall sensors placed in a circular array around the centre of the IC deliver a voltage representation of magnetic field distribution.

The sine and cosine voltage outputs from the sensor array vary with magnet position. These signals are then converted to absolute angle position with a fast flash interpolator.

This basic sensing technology can then be combined with further electronics to produce a wide range of output formats. Resolutions of up to 13-bit absolute (8,192 counts per revolution incremental) are achieved with internal interpolation.

The ability of the encoder system to operate with a gap between the magnetic actuator and the encoder chip allows its incorporation into designs that need isolation of the moving elements.

The magnetic encoder range is designed and manufactured by RLS d.o.o (www.rls.si) in Slovenia, Renishaw's partner in encoder technology.

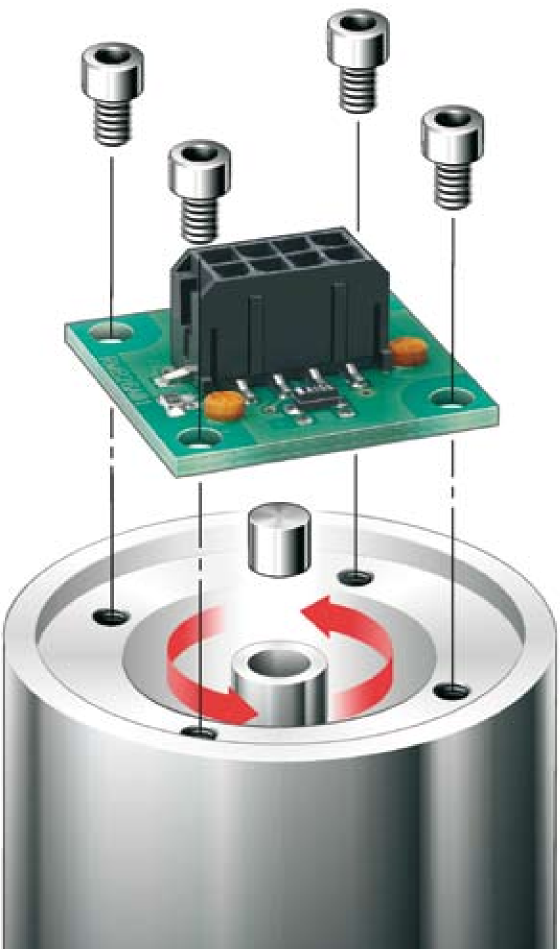
made in Slovenia by RLS

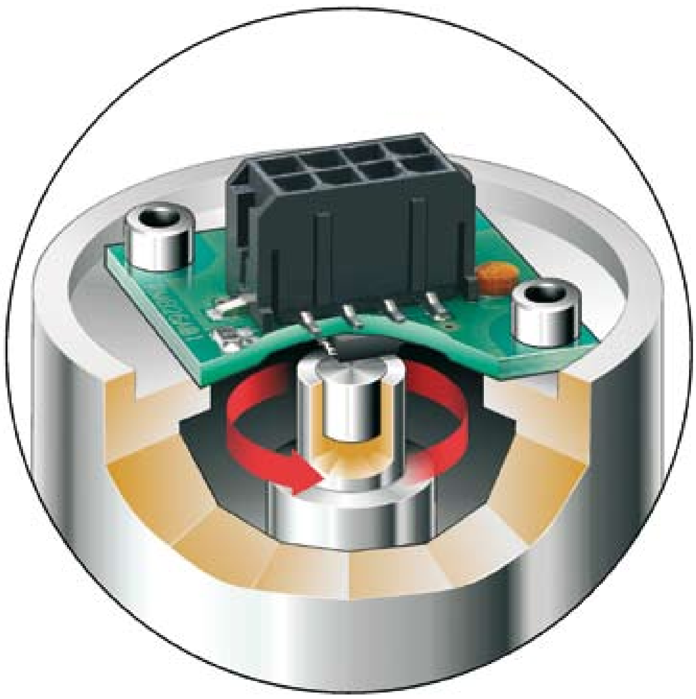
Magnetic encoders in motors

Major brushless DC motor manufacturers are now taking advantage of the small size and high accuracy of the AM256 sensor chip used within the new range of magnetic kit encoders. By simple addition of a magnet into the end of the motor shaft and the location of a small PCB module just clear of the shaft, high purity sine and cosine signals are produced at one cycle per turn. Absolute shaft position can then be determined, to high resolution, for feedback and commutation control. The system is highly immune to stray magnetic fields in the motor as the AM256 sensor uses a self-compensating array of Hall sensors and analogue processing techniques. The encoder kit is sufficiently robust to handle the high temperatures of stall and overload conditions in the motors. Equally smooth control in both directions is achieved within operational temperatures of up to 125 °C.

The new range of kit encoders are:

- **Compact** – occupies an axial length of only 7 mm with a diameter down to 20 mm
- **Robust** – resistant to high shock and vibration over wide temperature ranges. Continuous operation at up to 125 °C
- **Reliable** – non-contact, no-wear design combined with a high reliability silicon process yields industry leading reliability figures even at elevated temperatures.
- **Flexible** – absolute, incremental and analogue outputs are offered in a range of industry standard formats, with resolutions from 6-bit to 13-bit (5.6° to 0.04°)
- **Accurate** – the use of a large array of Hall effect sensors in the chip, coupled with very accurate conditioning of the signal outputs, ensures high purity signals and accuracy
- **High speed** – rotational speeds of up to 60,000 rpm





Magnetic rotary range

Angular magnetic encoder ICs

- Non-contact angular position encoding over 360°
- High speed operation up to 60,000 rpm
- Industry standard absolute, incremental, sinusoidal analogue and linear output formats
- AM256 – 8 bit resolution or 256 counts per revolution incremental
  - Low voltage and compact package options available
  - Dual absolute variant offering redundant functionality
- AM512B – 9 bit resolution or 512 counts per revolution incremental
- AM8192 – up to 13 bit resolution or 8,192 counts per revolution incremental

OnAxis™ magnetic encoder module

- Low cost encoder modules for OEM integration
- Industry standard absolute, incremental and analogue output formats
- Standard PCB and fully sealed modules available
- PCB modules (RMB range) are ideal for high volume applications where the board can be integrated within an external housing
- RB44 and RM44 are fully sealed modules that can be installed easily on a non protected surface since each encoder is sealed within a solid die cast housing with immunity to IP68

Magnetic rotary encoders

- Range of fully sealed encoders for easy integration to existing designs
- High speed operation to 30,000 rpm
- Industry standard absolute, incremental, sinusoidal analogue and linear output formats
- Non-contact, frictionless design (RM22 and RM36) and traditional bearing/shaft version (RE22 and RE36)
- Resolution – 9 bit to 13 bit absolute or 512 to 8,192 counts per revolution incremental
- Excellent dirt immunity to IP68
- Stainless steel body option (RM36 only)

Interferometric feedback solutions

The RLE system is a unique, advanced homodyne laser interferometer system, specifically designed for position feedback applications.

Simple system architecture reduces hardware requirements to an RLU laser unit, one or two RLD10 detector heads and measurement optics.

Optical configurations within the range of RLD10 detector heads enable linear, planar (X-Y) and differential measurements to be performed.

The fully compatible range of user selectable system components enables a unique configuration to match a specific application, and provides sub-nanometre resolution capability at velocities to 2 m/s for axis lengths up to 4 m.

The RLU laser unit, containing the HeNe laser tube, the majority of system electronics and the fibre optic launch mechanism, forms the heart of the RLE system.

Fibre optic launch capability allows the laser unit to be mounted remotely from the measurement axis, thereby eliminating a potential heat source without increasing the demands on alignment stability.

Two models of RLU are available – RLU10 and RLU20. Each model is available in either single or dual axis configuration, with the main difference between the two models being the frequency stability specification: ±50 ppb (parts per billion) over one hour for the RLU10 and ±2 ppb over one hour for the RLU20. The choice of RLU laser unit determines the designation of the complete system: a system incorporating an RLU10 laser unit is referred to as an RLE10, a system incorporating an RLU20 laser unit is referred to as an RLE20 system.

Position output signals from the RLU are directly available in differential digital RS422 format and/or 1 V_{pp} analogue sine / cosine formats. From the digital output, resolutions to 10 nm are available. The signal period for the analogue output is 158 nm when using a double pass plane mirror or differential interferometer, and 316 nm for a single pass retroreflector based system. Optionally, an RGE interpolator or RPI20 parallel interface can be used in combination with the analogue output to provide resolutions to 0.39 nanometres or 38.6 picometres respectively.

RLE10 laser system

RLU10 laser unit

X-Y stage application – Anorad – Rockwell Automation

RLE laser interferometer systems

RLD detector units

Most RLD10 detector units contain the fringe detection scheme, interferometer optic and integrated laser beam steerer(s). Six different RLD detector heads are available based on four variants.

- **Single pass interferometer** – Uses an external retroreflector target optic for linear applications with axis lengths up to 4 m. Available with 0° or 90° beam launch orientation. 316 nm signal period enables resolutions to 20 nm, or 77.2 picometres when used with the optional RPI20 parallel interface.
- **Double pass interferometer** – Requires an external plane mirror target optic for X-Y applications with axis lengths up to 1 m. Available with 0° or 90° beam launch orientation. 158 nm signal period enables resolutions to 10 nm, or 38.6 picometres when used with the optional RPI20 parallel interface.
- **No internal interferometer** – The absence of interferometer optics within this head enables the RLE system to be configured with external optics that allow linear, angle and straightness measurements to be made. 0° beam launch orientation only.
- **Double pass differential interferometer (column reference)** – Requires external plane mirror targets for both reference and measurement arms for X-Y applications with axis lengths to 1 m. 158 nm signal period enables resolutions to 10 nm, or 38.6 picometres when used with the optional RPI20 parallel interface.

  As the measurement and reference beam paths have an element of commonality, this detector head offers a number of benefits.

  - Measures stage versus column or workpiece versus tool for a true differential measurement.
  - Removal of errors due to thermal translation of the interferometer mounting position.
  - Minimisation of the effects of laser frequency instability as the differential path length (between measurement and reference paths) is reduced.
  - Common mode environmental effects enable the detector head to be mounted outside the process chamber with minimal affect on positioning accuracy.

RLE system benefits

The unique fibre optic launch based architecture provides interferometer system performance with the ease of use normally associated with glass or tape scale based encoder systems.

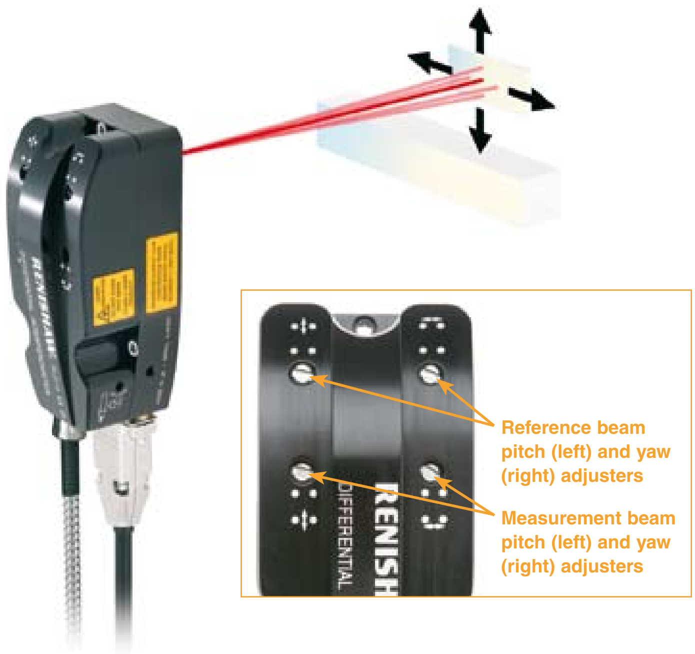
These architectural advantages are achieved through a combination of the following features:

- **Fibre optic laser launch** – Enables the laser light to be taken directly to where the axis position needs to be measured, eliminating the requirement for remote beam benders, splitters and associated mounts.
- **Integrated laser beam steerers** – Incorporated in all RLD10 detector heads to further reduce alignment complexity.
- **Integrated interferometer optics** – Most RLD detector heads include prealigned interferometer optics and fringe detection system, making installation simple: align the RLD10 with the external optic on the moving element.
- **Removal of potential heat error source** – Fibre optic launch enables the RLU laser head to be mounted in a location that is insensitive to dissipated heat without affecting alignment or stability.

RLD10 single pass interferometer

RLD10 double pass interferometer

RLD10 differential interferometer



RLE system accessories

RCU10 compensation system

When using any laser interferometer system in a non-vacuum environment, some form of refractive index compensation is required to maintain accuracy under varying environmental conditions. This is because the fundamental fringe spacing (unit of count) is a function of the wavelength of the laser light which varies fractionally depending on the refractive index of the air through which it travels.

To counter these refractive index changes, Renishaw offers the RCU10 real-time quadrature compensation system, providing the following features and benefits:

- ±1 ppm positioning over a broad range of environmental conditions.
- Simultaneous implementation of multiple error correction algorithms.
- Individual air temperature sensors for each axis.
- RCU10-CS configuration software enables the RCU10 system to be configured to match the specific requirements of the application.
- One to six axis capability: multi-axis systems can formed using a number of individual RCU10 compensators connected via a high-speed serial link.

RPI20 parallel interface

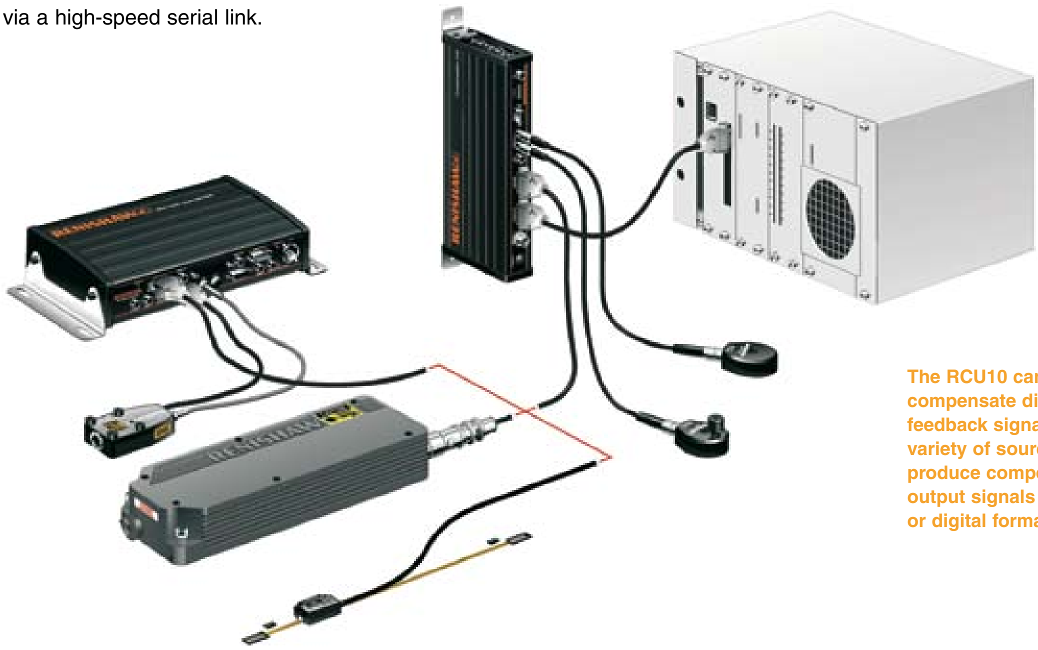
Renishaw's RLE laser interferometer systems directly produce 1 V_{pp} sine / cosine signals with periods of 316 nm and 158 nm from single and double pass interferometers respectively. These sinusoidal signals can be interpolated to provide ultra-high resolution positional feedback.

Although sine / cosine interpolation is available within a number of proprietary control systems, the analogue bandwidth of these systems is often designed for tape and glass scale based encoders. These scale systems produce relatively coarse signal periods and the sinusoidal frequencies for any given velocity are considerably lower than those produced by an interferometer. This bandwidth limitation means that laser interferometer feedback systems can only be used in low velocity motion applications.

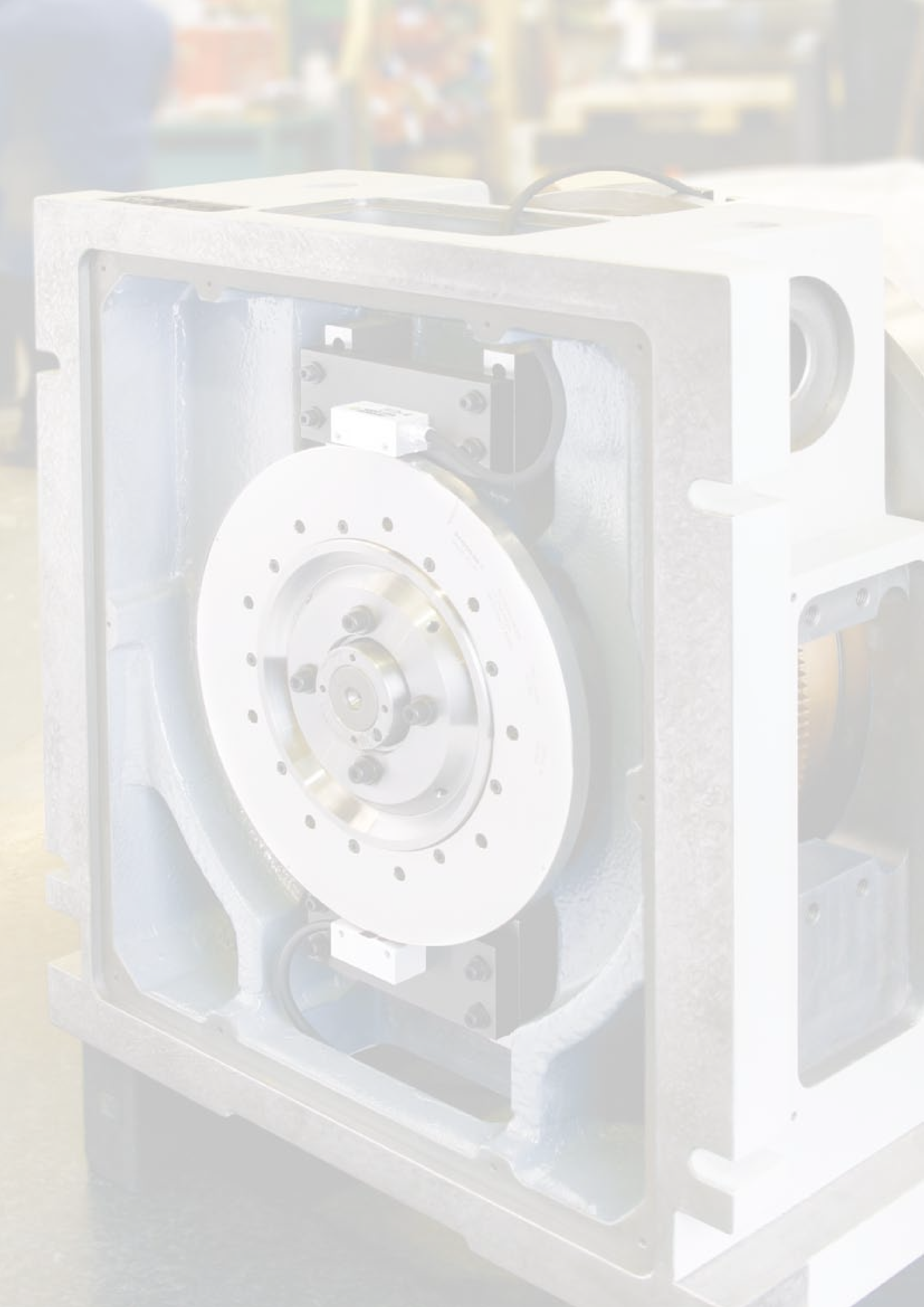
The Renishaw RPI20 parallel interface has been specifically designed to overcome this limitation by providing ultra-high resolution parallel format output at high-speed. The RPI20 interpolates by 4096, produces resolutions of up to 38.6 picometres and has an analogue input bandwith of <6.5 MHz, enabling the interferometer system to be used in applications that have velocity requirements of up to 1 m/s.

RCU10 compensator and sensors

RPI20 parallel interface



The RCU10 can be used to compensate digital position feedback signals from a variety of sources and can produce compensated output signals in analogue or digital format.



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- **Spectroscopy systems for non-destructive material analysis in laboratory and process environments.**
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