

Introducing the RESOLUTE™ FS encoder

The RESOLUTE Functional Safety (RESOLUTE FS) optical absolute encoder is based on the design of the award winning RESOLUTE series with elements redesigned to meet FS safety standards. RESOLUTE FS encoder systems are certified as:

- A Category 3 PLd rated part against ISO 13849:2015
- Being suitable for use in a SIL2 application against IEC 61508:2010 and IEC 61800-5-2:2007

RESOLUTE FS encoders also achieve the higher level of FS EMC performance defined by IEC 61326-3-1:2008 and meet the same general environmental performance limits as the standard RESOLUTE series. Much of the redesign enhances monitoring and diagnostic coverage. The original design of the RESOLUTE series included a position integrity check which greatly simplified the process of developing a full FS derivative.

RESOLUTE overview

The RESOLUTE FS encoder is a true absolute encoder system designed to provide position feedback for the motion control of linear and rotary axes. It consists of three elements: a precision graduated scale, an electro-optical readhead and a compatible interface. The RESOLUTE FS readhead is available with RELA ZeroMet™ high-accuracy spar scale, RSLA stainless-steel spar scale, RTL tape scale, RESA rotary scale or REXA high-accuracy rotary scale. The REXA ring can also be used with a dual input version of Renishaw's Drive-CLiQ interface, designed for use with two RESOLUTE readheads, to compensate for the effect of bearing wander by elimination of all 'odd' error harmonics including eccentricity.



Possible medical robotic applications, for example, the *neuromate*® stereotactic robot



The new RESOLUTE FS encoder system

RESOLUTE series encoders capture a 1-dimensional image of a barcode-like pattern on the scale and perform a type of image processing in order to extract position data. The position calculated by the RESOLUTE FS encoder is divided into two parts: a coarse position and a fine position in-between the scale period ($\leq 30 \mu\text{m}$). First, the encoder determines these values based on the scale data alone. A secondary coarse position is then determined independently by a position checking algorithm*, wherein the two most recent good readings are extrapolated in time to find the current position. If the measured coarse reading and the extrapolated values differ by more than half the scale period, then an error counter is incremented. Once the error counter reaches five, an error flag is sent to the controller which stops the machine. The RESOLUTE FS encoder variant also double checks the above process and includes a position validation check in order to satisfy IEC 61508. Position data is sent from the readhead via a custom output protocol and the position validation check confirms that the data arriving at the interface agrees with the values that have been internally generated in the readhead.

RESOLUTE FS scales have also been designed to minimise positional disturbance during operation. As a result, linear scales are applied to machine substrates with adhesive and rotary scales are installed in strict compliance with the installation instructions in the RESOLUTE FS installation guide and safety manual (L-9796-9134). Mounting instructions for the encoder readhead also specify the recommended screw type and a thread locking compound. These measures combine to ensure the correct reporting of position at all times.

Primary applications

Power drive system (PDS) use as defined by IEC 61800-5-2:2007

Encoders are essential for the correct operation of many obligatory safety functions in CNC machine tool and other heavy machinery. RESOLUTE FS encoders can be integrated into the safety control systems of adjustable-speed Power Drive Systems (Safety Related) – PDS (SR)s – to support the following safety functions:

Safety function

- Safe stop 1 (SS1)
- Safe stop 2 (SS2)
- Safe operating stop (SOS)
- Safe limited acceleration (SLA)
- Safe acceleration range (SAR)
- Safe limited speed (SLS)
- Safe speed range (SSR)
- Safely limited position (SLP)
- Safely limited increment (SLI)
- Safe direction (SDI)
- Safe brake control (SBC)
- Safe cam (SCA)
- Safe speed monitor (SSM)

In addition to enhanced safety, end-users also benefit from increased machine productivity and availability as they will no longer need to power down machinery whenever there is direct human interaction.

Robot control safety systems that require ISO 13849:2015

RESOLUTE FS encoders can also be integrated into PLd rated safety control systems of the robot types defined by the following standards:

• Personal care robots against ISO 13482:2014

Robots that perform basic household tasks, personal assistance and transportation.



Possible applications with robotic arms in industry



Possible applications with semiconductor wafer handling robots

• Industrial robots against ISO 10218-1:2011

Robots that operate in an industrial environment, for example robotic arms in automotive manufacturing.

• Service robots against ISO 18646-1:2016

Robots that perform useful tasks for humans or equipment excluding industrial automation applications.

• Medical robots – Please contact your local Renishaw salesman to discuss

Robots that are applied in the medical sciences. They include, but are not limited to, surgical robots such as Renishaw's *neuromate* stereotactic robot.

FS data for use by safety system designers

RESOLUTE FS encoder compliance is as follows:

ISO 13849:2015

- PL = d
- Category = 3
- Mean-Time to Dangerous Failure (MTTFd)
 - ▶ Siemens DRIVE CLiQ system = 87 years
 - ▶ BiSS Safety system = 132 years
- Diagnostic Coverage (DC) = 90% / Medium

IEC 61508:2010 and IEC 61800-5-2:2007

- SIL = 2
- Probability of Dangerous Failure per Hour (PFH)
 - ▶ Siemens DRIVE CLiQ system = 1.33E-07
 - ▶ BiSS Safety system = 8.75E-08
- Demand mode = continuous
- Lifetime = 20 years

Summary

RESOLUTE FS encoder systems offer customers the outstanding metrology performance of the RESOLUTE series but with the added peace-of-mind that comes from compliance with the world's most stringent functional safety standards. New applications for the RESOLUTE family of encoders now include the latest collaborative robotic and industrial manufacturing technologies.

For further information on RESOLUTE FS systems, please visit www.renishaw.com/resolutefs

*To read the Whitepaper: *Safety first - the position determination and checking algorithms of the RESOLUTE™ true-absolute optical encoder*; please visit www.renishaw.com/whitepapers



RESOLUTE FS with RELA linear scale

About Renishaw

Renishaw is an established world leader in engineering technologies, with a strong history of innovation in product development and manufacturing. Since its formation in 1973, the company has supplied leading-edge products that increase process productivity, improve product quality and deliver cost-effective automation solutions.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

Products include:

- Additive manufacturing and vacuum casting technologies for design, prototyping, and production applications
- Dental CAD/CAM scanning systems and supply of dental structures
- Encoder systems for high-accuracy linear, angle and rotary position feedback
- Fixturing for CMMs (co-ordinate measuring machines) and gauging systems
- Gauging systems for comparative measurement of machined parts
- High-speed laser measurement and surveying systems for use in extreme environments
- Laser and ballbar systems for performance measurement and calibration of machines
- Medical devices for neurosurgical applications
- Probe systems and software for job set-up, tool setting and inspection on CNC machine tools
- Raman spectroscopy systems for non-destructive material analysis
- Sensor systems and software for measurement on CMMs
- Styli for CMM and machine tool probe applications

For worldwide contact details, visit www.renishaw.com/contact



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