Improving the accuracy of the FlexIN system
with the DSi interface

Abstract: This application note demonstrates how using two LM10 readheads positioned 180° apart and connected via the DSi interface improves the accuracy of the FlexIN magnetic encoder system. The method reduces eccentricity-related errors and significantly enhances overall system performance. Experimental results confirm a substantial reduction in peak-to-peak error.

The **FlexIN** system is a rubber-supported scale with a built-in tensioning mechanism designed for installation on large shafts. It can be used in combination with the LM10 and LM15 incremental readheads.
The **DSi system** is an interface that combines signals from two separate incremental readheads to improve angular accuracy in rotary applications.
Renishaw offers the **DSi system** as a high-precision solution for use with their optical encoders. We have explored its potential using our LM10 incremental magnetic encoder with the FlexIN scale system.

Related products

FlexIN magnetic scale system for large diameters

LM10 incremental magnetic encoder

DSi dual readhead angle encoder system

DSi dual news release

Description

Accuracy is one of the most critical parameters of a system. When an application demands very high accuracy, optical encoders are often considered; however, they are not always optimal. Optical solutions can be sensitive to environmental influences, can be challenging to install due to tight tolerances on large shafts, and can present cost constraints.

Magnetic encoders provide an effective alternative. They are generally more cost-effective, allow for significantly larger installation tolerances, and are not affected by contamination such as dirt on the scale. While magnetic systems do not inherently achieve the same level of accuracy as optical encoders, appropriate design and installation measures can yield satisfactory performance.

As described in the FlexIN datasheet, several factors contribute to overall system inaccuracy. One of the most significant is total installation runout, or eccentricity. System accuracy is strongly influenced by the degree to which the scale, wrapped around the shaft, deviates from a uniform circumference. To mitigate this effect, a process known as “scale kneading” may be applied during installation. In this process, the operator uses a dedicated roller to smooth peaks and valleys around the circumference after the FlexIN scale has been mounted. This step improves accuracy and ensures that the distance between the readhead and the FlexIN scale remains within the specified installation tolerances. Excessive eccentricity may otherwise result in an excessive air gap, leading to signal loss at the readhead (see the FlexIN installation video for further details).

Explainer video: FlexIN installation

Eccentricity is also influenced by the quality of the shaft bearings and the manufacturing accuracy of the shaft itself. For higher-accuracy applications, high-quality bearings are essential, and the shaft must be manufactured within defined tolerances.

Considering the effects described above, system accuracy can be further improved by using two readheads positioned 180° apart. External electronics can then combine the signals from both readheads to compensate for and reduce the remaining eccentricity errors.

In our evaluation, we successfully integrated two LM10 readheads, installed 180° apart on the FlexIN scale, achieving stable operation and demonstrating compatibility with the DSi system. This combination significantly improved angular accuracy, demonstrating the potential of combining cost-effective magnetic encoders with advanced signal-processing solutions.

Experimental setup and methodology

To evaluate the performance improvement achieved by combining two **LM10IC magnetic encoders** with the **DSi system**, a controlled test setup was used. The setup was designed to replicate typical operating conditions while allowing precise measurement of position accuracy.

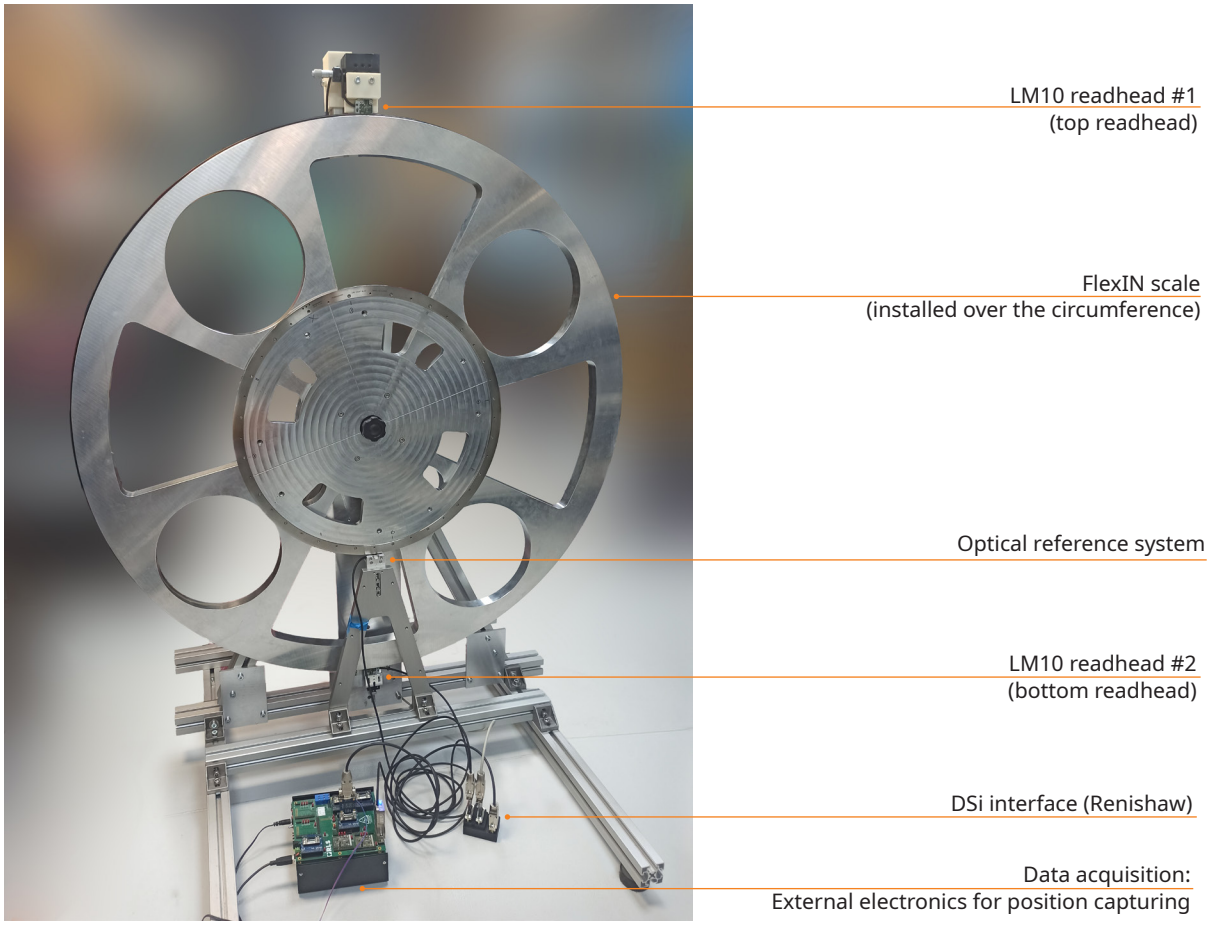

Figure 1: Setup

Equipment and configuration of the experimental setup

- **Magnetic encoder (2x):** LM10IC13BAA10D07
- **Scale type:** FlexIN FI2000A1584A0792A100
- **Large shaft:** OD = 1124.2 mm
- **Signal processing:** DSi system (dual incremental input) from Renishaw
- **Data acquisition:** A system was used to record position outputs for analysis (RLS proprietary system).
- **Mounting:** Encoder readhead and FlexIN scale were mounted to minimise mechanical play and vibration.

Products used

Part numbers	Quantity	Description
LM10IC13BAA10D07	2	• Incremental magnetic encoder with RS422 line driver ABZ • 5 V power supply • Interpolation x8192 • Minimum edge separation 0.12 us (8 MHz) • With reference • 1.00 m cable length • 15 pin D type plug • Additional alarm channel (_07 special option) – (DSi specifies the alarm)
FI2000A1584A0792A100	1	• FlexIN system • Compatible with LM10 readhead (2 mm pole pitch) • For shaft OD 1124.2 mm • With a reference mark at 180° location
DSi-QTR20	1	• DSi interface • Quadrature inputs (2 readheads) • Remote – line-driven alarm • Sampling frequency 20 MHz

When using alternative readhead configurations with the DSi system, input compatibility must be verified. Particular attention should be given to the encoder output signal characteristics, especially the frequency of the ABZ quadrature signals.

Procedure

1. The magnetic encoders were aligned and installed according to standard manufacturer guidelines. Refer to the **MSD01** and **LM10** datasheets for installation details.

   Explainer video: FlexIN installation

2. Both LM10 readheads were connected to the DSi system to process incremental signals and generate the compensated position output.
3. Repeated position readings were taken under controlled rotational motion profiles.
4. Measurements were compared to reference standards (optical encoder) to determine overall positioning accuracy.
5. The data were analysed to quantify improvements in resolution, repeatability, and error reduction relative to baseline measurements without the DSi system.

This methodology enabled a clear evaluation of the accuracy improvements achievable by integrating the LM10IC13BAA10D07 encoder with the advanced signal processing provided by the Renishaw DSi system.

Results and discussion

The integration of the LM10IC13BAA10D07 magnetic encoder with the DSi system produced a noticeable improvement in positioning accuracy compared to a single readhead output measurement.

Plot 1 explanation

The red line on the plot below depicts the accuracy of the readhead installed at the bottom of the setup (Picture 1). The blue line depicts the accuracy of the readhead installed at the top.
The purple line shows the combined red and blue accuracy for the DSi system.

Observation

- The red and blue lines have a prominent first-order error (eccentricity). This is a result of the eccentric installation of the FlexIN scale, along with minor contributions due to the axis mechanical properties (bearings, shaft of the axis).
- The spike in accuracy (joint error) is observed every 360° for each readhead. This results from the readhead passing the joint on the FlexIN system. The joint error is caused by the phase mismatch and damage to the magnetic pattern during the scale cutting process. The phase mismatch is the physical gap between both ends of the scale.
- The purple line shows a significant improvement when using the DSi system. The eccentricity is significantly reduced and thus improves overall system accuracy.

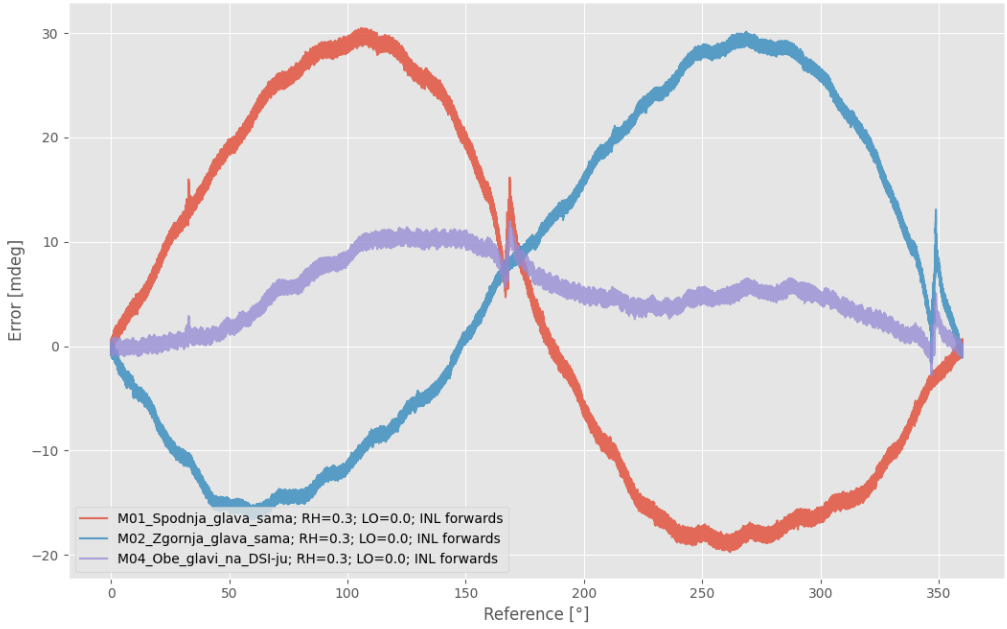

Figure 2: Plot 1 – Overall accuracy (top and bottom readheads and accuracy after DSi compensation)

Plot 2 and 3 explanation

The red line on the plots below depicts the accuracy of the readhead installed at the bottom and top of the setup (Plots 2 and 3). The blue line shows the improved accuracy after the DSi system.

Observation

- The red lines (Plots 2 and 3) have a prominent joint error.
- The blue line shows the accuracy after the DSi system compensation of both readheads. The improvement in accuracy on the joint is not marginal.

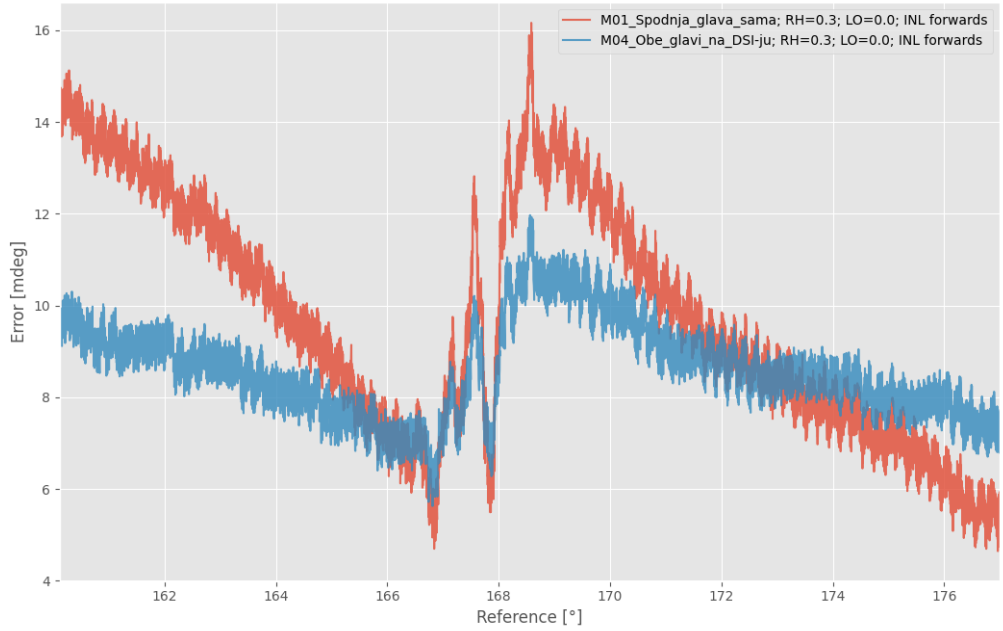

Figure 3: Plot 2 – Joint error (bottom readhead, red line). The blue line – accuracy after DSi compensation.

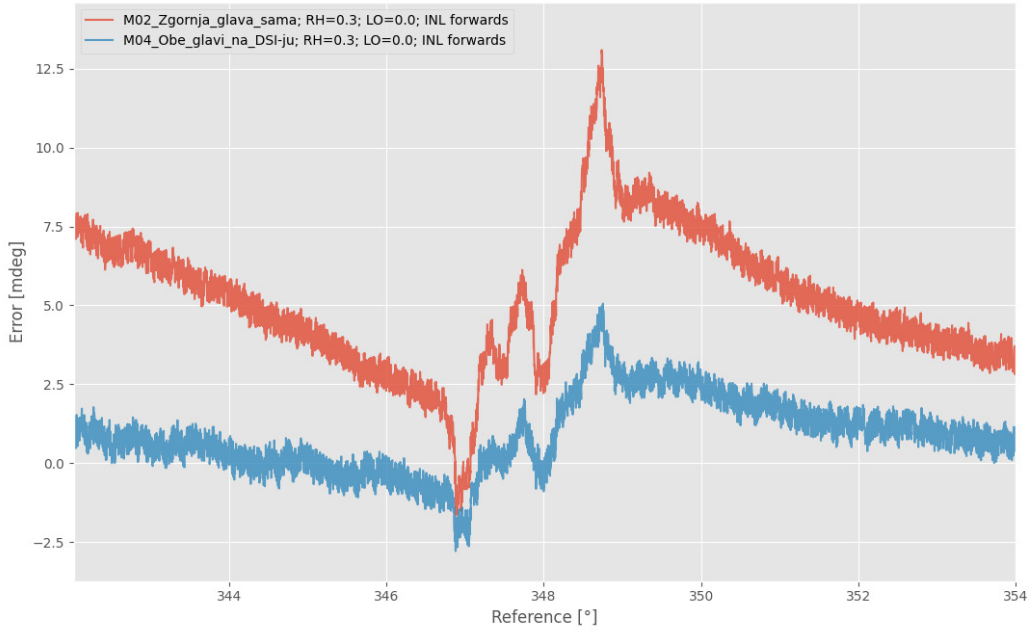

Figure 4: Joint error (top readhead, red line). The blue line – accuracy after DSi compensation.

Key observations

1. Accuracy improvement: The processed signals from the DSi system allowed the magnetic encoder to achieve better accuracy by reducing first-order error (eccentricity), compared to a single readhead output (LM10 readhead). The accuracy is improved from p2p 50 mdeg to p2p 10 mdeg.
2. Joint error improvement: The error at the scale joint is marginally improved, although a residual spike remains. The accuracy is improved from p2p 21 mdeg to p2p 6 mdeg.

These results illustrate the potential of combining high-quality magnetic encoders with advanced signal-processing systems. While the LM10IC13BAA10D07 provides reliable position sensing, adding the DSi system via FlexIN significantly enhances accuracy, repeatability, and signal stability. This approach is particularly advantageous in precision motion applications where optical encoder alternatives are either impractical or cost-prohibitive.

Recommendations

- For applications requiring high-accuracy motion control, integrating the LM10IC13BAA10D07 with the DSi system via FlexIN is strongly recommended.
- Further optimisation of encoder alignment and mounting can further reduce initial errors from a single readhead.
- When using alternative readhead configurations with the DSi system, input compatibility of the DSi system must be verified. Particular attention shall be given to the encoder output signal characteristics, especially the frequency of the ABZ quadrature signals.

Head office

RLS Merilna tehnika d. o. o.

Poslovna cona Žeje pri Komendi
Pod vrbami 2
SI-1218 Komenda
Slovenia

T +386 1 5272100
E mail@rls.si

www.rls.si

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Document issues

Issue	Date	Page	Description
1	14. 4. 2026	–	New document