Accuracy of absolute linear encoder systems

This document describes the accuracy of absolute linear encoders and the factors that influence it. Factors that contribute to the inaccuracy of the absolute magnetic scale include slope error, magnetisation error, crosstalk error and sub divisional error (SDE). The most important factors contributing to inaccuracy are magnetisation and crosstalk errors. The SDE error is considered negligible.

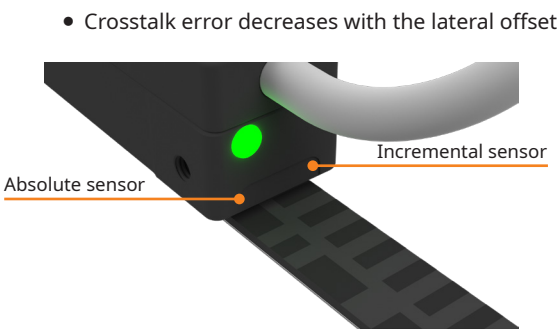
Crosstalk - how absolute track magnetisation affects incremental track sensing

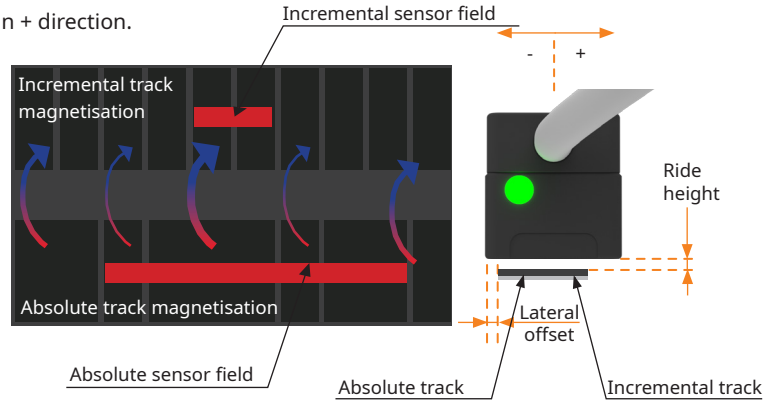
Crosstalk is a disturbance caused by the magnetic field of an absolute track that affects the sensor reading of an incremental track.

The readhead has incremental and absolute sensing surfaces. The closer the incremental sensor is to the absolute track in the lateral axis, the stronger the crosstalk effect becomes. Ride height (distance between the readhead and the scale) also influences the intensity of the crosstalk error. As the ride height increases, the ratio between the incremental sensor distance and the absolute track shifts in favour of the absolute track.

We recommend installing the readhead in the centre of the scale. However, it is best if the readhead is slightly shifted laterally towards the incremental track, but is still within the specification for the lateral offset. In the General accuracy chapter, you can find the accuracy as a function of ride height and lateral offset.

- Crosstalk error increases with the ride height.
- Crosstalk error decreases with the lateral offset in + direction.



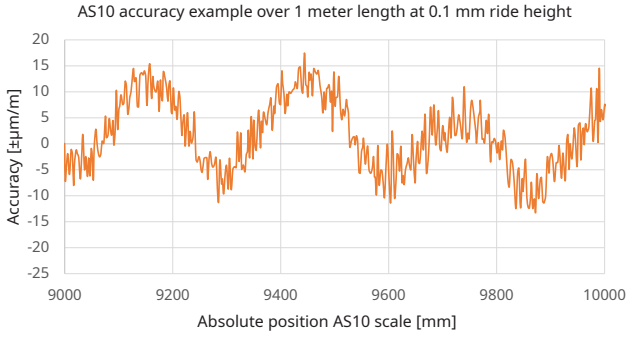


Magnetisation error

The magnetisation error is caused by imperfections in the elasto-ferrite material and possible deviations in the magnetisation process. The magnetisation error is also an aftereffect of the handling during production and the method of final packaging. When the scale is rolled onto a reel, each layer of the scale touches the adjacent layer and with its magnetic field (~50 mT) impairs the magnetisation of the next layer. The effect works in both directions. The deterioration in the magnetic properties of the scale is then reflected in the accuracy as an undulation (see diagram below). The SAS10 and DS19 (up to 2 m) magnetic scales are not affected by this phenomenon since they are not rolled up on a reel, and therefore have better overall accuracy.

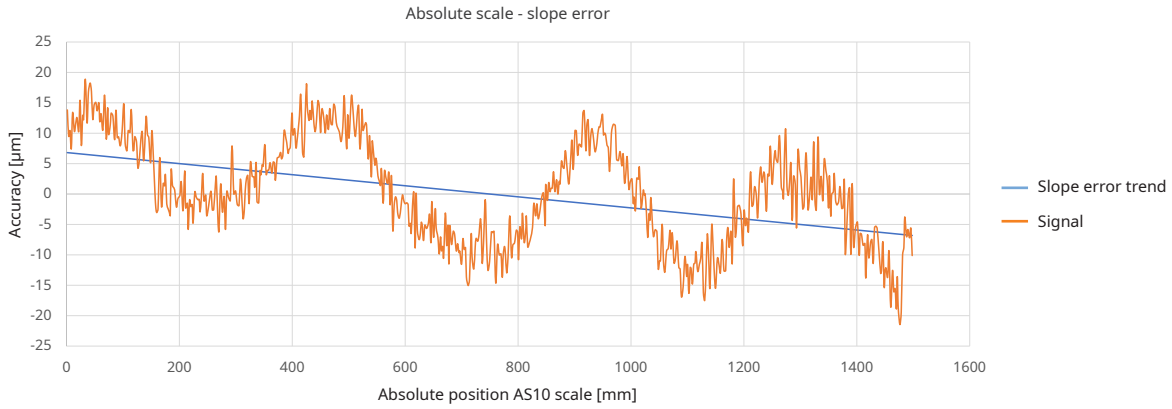
Factors influencing the magnetisation error:

- Magnetic inhomogeneity of the elasto-ferrite layer
- Deviations in the elasto-ferrite thickness
- Handling method during production
- Type of packaging



Slope error

Slope error is a non-periodic error that occurs on longer scales. The slope error is caused by the thermal expansion or contraction of the scale. The AS10 and SAS10 scales are magnetised at a very controlled environmental temperature (21°C). Any deviation from the “production” temperature will result in a slope error.



Sub-divisional-error (SDE) or interpolation error

The sub-divisional or interpolation error is a periodic accuracy error. The period of the SDE is a magnetic pole (in our case 2 mm).

It is influenced by the following factors:

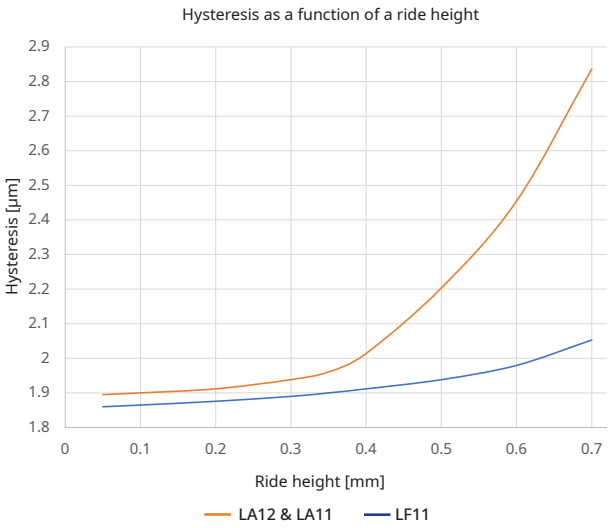
- Homogeneity and cycle definition of the magnetic poles
- Sensing distance (ride height) between scale and readhead
- Quality of the signal processing
- Characteristics of the internal AMR sensor

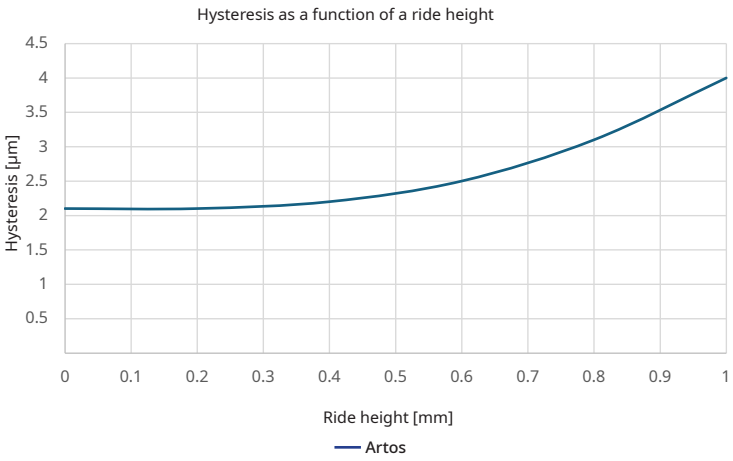
The SDE leads to speed ripples in applications in which the encoder is used as speed feedback, e.g. in speed control loops.

Hysteresis

Hysteresis is the difference in the result of measuring the same point when approached from different directions.
Ferromagnetic materials are known to maintain their magnetised state in response to external fields and attempt to change direction.

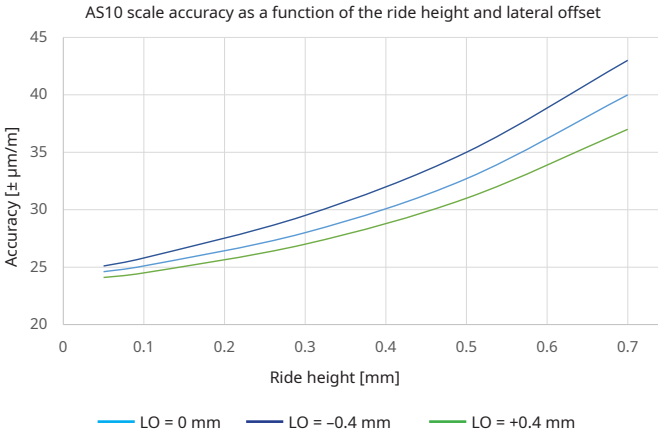
The hysteresis in encoder systems depends on the strength of the magnetic field. A stronger magnetic field will result in lower hysteresis and vice versa. Therefore, the hysteresis is strongly influenced by the ride height at which the readhead is installed.

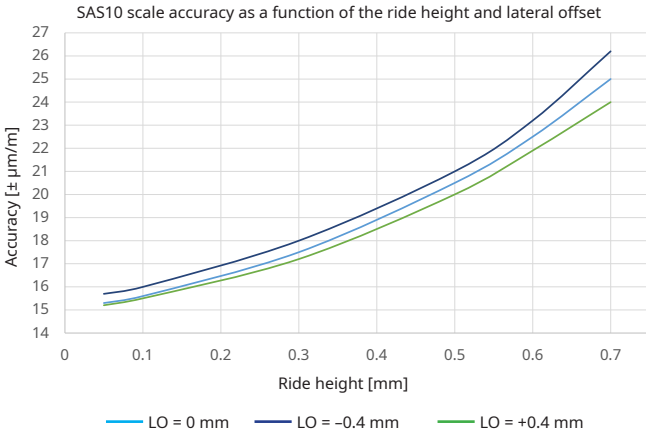


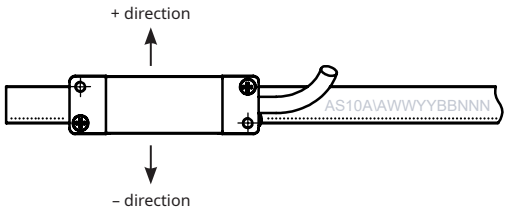


General accuracy

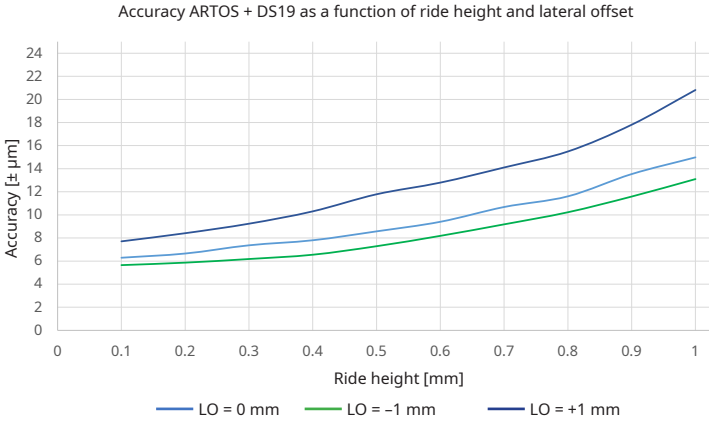
The following diagrams show the accuracy of the AS10 and SAS10 scales as a function of the ride height and lateral offset. Valid for all readheads (LA11, LA12 and LF11).

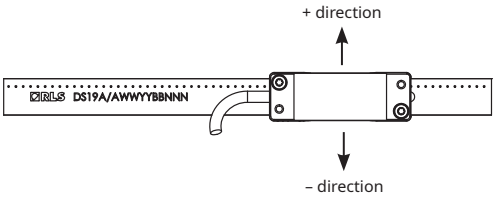


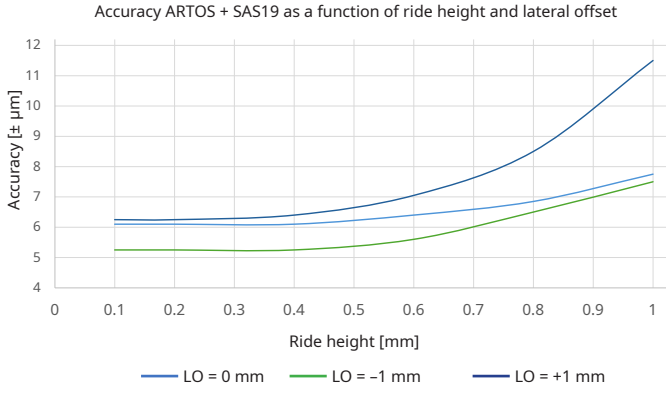


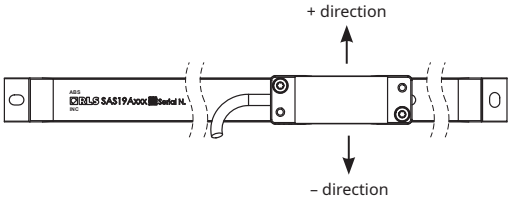


The following diagrams show the accuracy of the DS19/SAS19 scale as a function of ride height and lateral offset. The orientation of the absolute and incremental track on the DS19 scale is opposite to the AS10 magnetic scale, hence the directions ("+" and "–") are reversed. They are valid for Artos readhead (DHL and DBL) and for DS19 scales up to 2 m long.









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Document issues

Issue	Date	Page	Description
1	11. 3. 2022	General	New document
2	14. 5. 2024	3	DS19 information added
3	16. 4. 2025	2	Hysteresis diagram amended
		3	SAS19 information added