Accuracy of ring encoder systems

The accuracy of the ring encoder measurement is influenced by **encoder-specific errors** and i**nstallation-dependent error**. In order to evaluate the total accuracy, each of the significant errors must be considered. Image 1 shows a typical accuracy error plot with marked particular influences.

1. Encoder-specific error

Magnetisation error

The magnetisation error is caused by imperfections in the elastoferrite materials used and possible deviations resulting from the magnetisation process. The following factors influence the result:

- the magnetic nonhomogeneity of the elastoferrite layer,
- the ring installation tolerances during the magnetisation process,
- the accuracy of used measuring system during the magnetisation process,
- the quality of the magnetisation system.

The magnetisation accuracy can be calculated by the following formula:

$$A_M = \pm \frac{4.6}{D}$$

where:

A_M ... Magnetisation accuracy (°)

D ... Outer ring diameter (mm)

D (mm)	Magnetisation accuracy
20	±0.229°
40	±0.115°
60	±0.076°

Sub divisional error (SDE) or interpolation error

The sub divisional error or interpolation error is a periodical accuracy error, caused by imperfections in the length of poles. It is influenced by the following factors:

- the length of poles,
- the homogeneity and cycle definition of magnetic poles,
- the sensing distance (ride height) of the installed readhead,
- the quality of signal processing,
- the characteristics of internal AMR sensor.

The SDE leads to speed ripples in applications where encoder is used as speed feedback, eg. in speed control loops.

The SDE can be calculated by the following formula:

$$SDE = \pm \frac{0.58}{D}$$

where:

SDE ... Sub divisional error (°)

D ... Outer ring diameter (mm)

D (mm)	SDE
20	±0.029°
40	±0.014°
60	±0.009°

For radial rings, SDE is strongly influenced by sensing distance (ride height) which is illustrated on Image 2. For axial rings, radial offset of readheads has a bigger influence on SDE than axial offset (see Images 3 and 4).

Image 1: Typical accuracy error plot

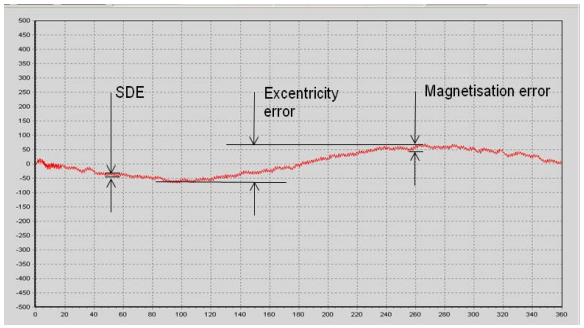


Image 2: Example of SDE error vs. radial offset for radial ring MR075E

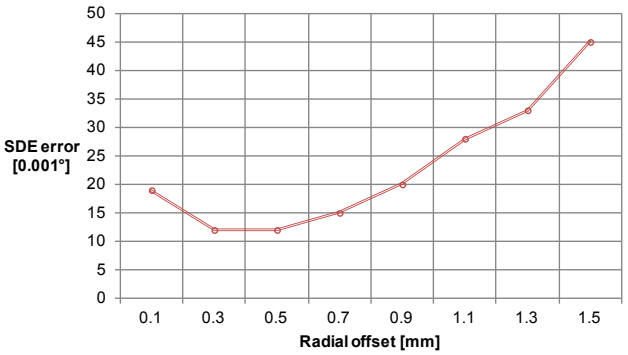


Image 3: Example of SDE error vs. axial offset for axial ring MR061C

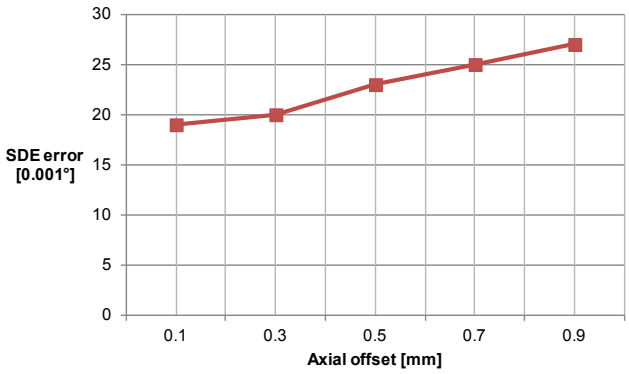
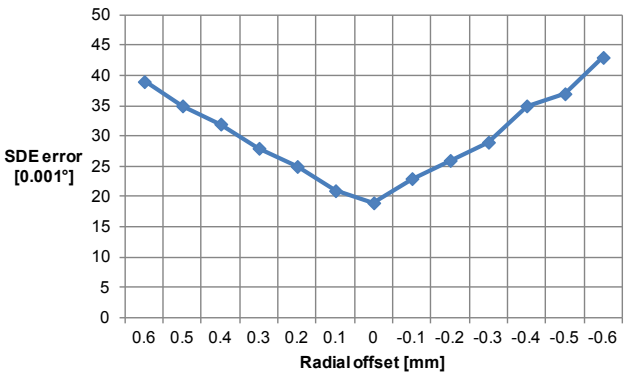


Image 4: Example of radial offset vs. SDE error for axial ring MR061C



Accuracy of ring encoder systems continued

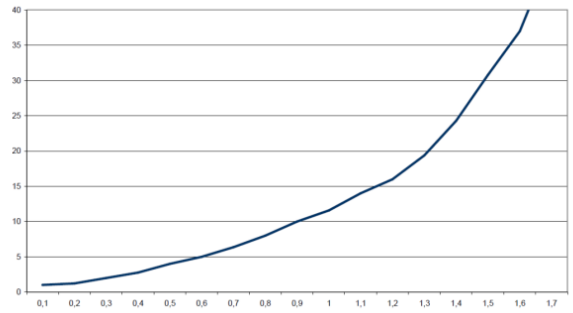
Hysteresis

Hysteresis is the difference in result of measurement of the same point approaching it from different directions.

The ferromagnetic materials are known to maintain their magnetised state in response to external fields, trying to change their direction.

Hysteresis in encoder systems depends on the strength of the magnetic field. Increasing the magnetic field leads to decreasing the hysteresis and vice versa. Therefore, hysteresis is strongly influenced by the sensing distance at which the readhead is installed (Image 2).

Image 5: Hysteresis vs. ride height
(for encoder systems with 2 mm pole length)



2. Installation-dependent error

Installation and adjustment of the ring and the readhead, in addition to the given encoder-specific error, normally have a significant effect on the system's overall accuracy. Of particular importance are the installation eccentricity and the effect of deformations resulting from the ring installation.

Installation eccentricity

Eccentricity can be caused by the misalignment of the ring's center towards the rotational axis.

The error caused by eccentricity can be calculated by the following formula:

$$E_{accuracy} = \pm 0.114 \frac{e}{D}$$

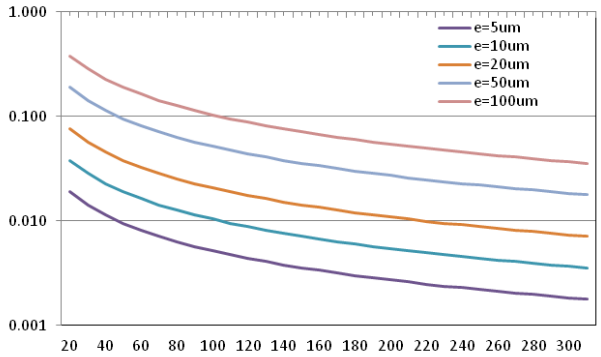
where:

$E_{accuracy}$ ... Eccentricity error (°)

e ... Misalignment of ring's center towards the rotational axis (µm)

D ... Outer ring diameter (mm)

Image 6: Eccentricity influence on accuracy error



Deformations of the ring during installation

By installing a ring to a not-ideally circular shaft, possible deformations can occur. These can have a significant influence on the system accuracy error.