HEIDENHAIN

Technical Information

Resulting Linear Error after Multipoint Linear Error Compensation with the LIDA 400

The measuring accuracy specified for incremental linear encoders from HEIDENHAIN typically applies for a range of one meter. Many applications, such as on measuring machines, require shorter distances, for example 50 mm or 100 mm.

By calibrating the machine and compensating the error in the subsequent electronics it is possible to significantly increase the machine accuracy. This process is particularly well established in coordinate measurement technology and plays a key role in ensuring high machining accuracy over large measuring lengths. Modern controls allow ten and more compensation values per meter traverse.

To calculate the expected measuring uncertainty of the machine, the machine manufacturer needs data on the maximum error to be expected between the compensation points. Because nonlinear error components occur in incremental encoders and cause relevant error even over short ranges, the usual specification of measuring accuracy is insufficient.

HEIDENHAIN therefore determines the expected residual error after sectional (multipoint) linear compensation for the encoders of the LIDA 400 series. Here the high accuracy and good signal quality of this encoder becames apparent.

Multipoint Linear Error Compensation

The accuracy of incremental linear encoders is comprised mainly of the position error over larger distance intervals and the position error within one signal period.

With the LIDA 400, the **position error over the measuring length** is measured in a comparative measurement with a calibrated reference measuring device. The measurement is recorded with a measuring interval of one millimeter. An example of the position error over the measuring length is shown in Figure 1.

Finding the residual error
HEIDENHAIN ascertains the position error after multipoint linear error compensation (residual error) at compensation point intervals A of 50 mm and 100 mm. The following example uses the distance A of 50 mm (see Figure 2). The compensation values are determined at n x 50, i.e. at 0, 50, 100, 150 etc. The values between these points are then interpolated. The following multipoint linear compensation eliminates the error at the respective compensation points. The curve in Figure 3 shows the residual error after multipoint linear compensation.

The maximum residual error
Of course, the residual error determined in this way greatly depends on the position of the compensation points. To find the actual maximum residual error, the compensation points are each shifted by one millimeter and the compensation values for the positions 1, 51, 101, etc. to 49, 99, 149 etc. are recorded. As in the above example, for these points as well the residual error is recorded and the maximum residual error is calculated from the large number of error curves. This method ensures that the specified maximum error after multipoint linear error compensation is independent of the position of the compensation points.
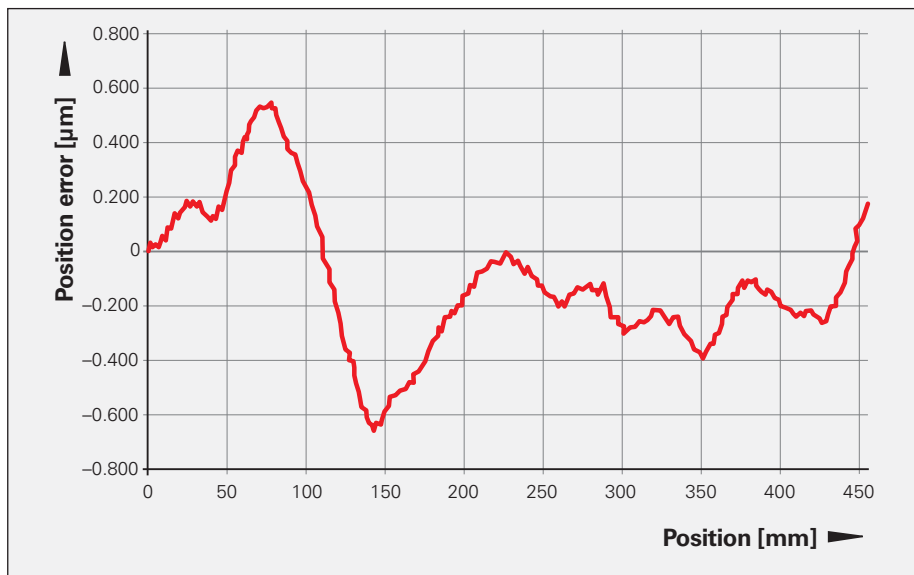

Figure 1:   Typical position error over measuring length

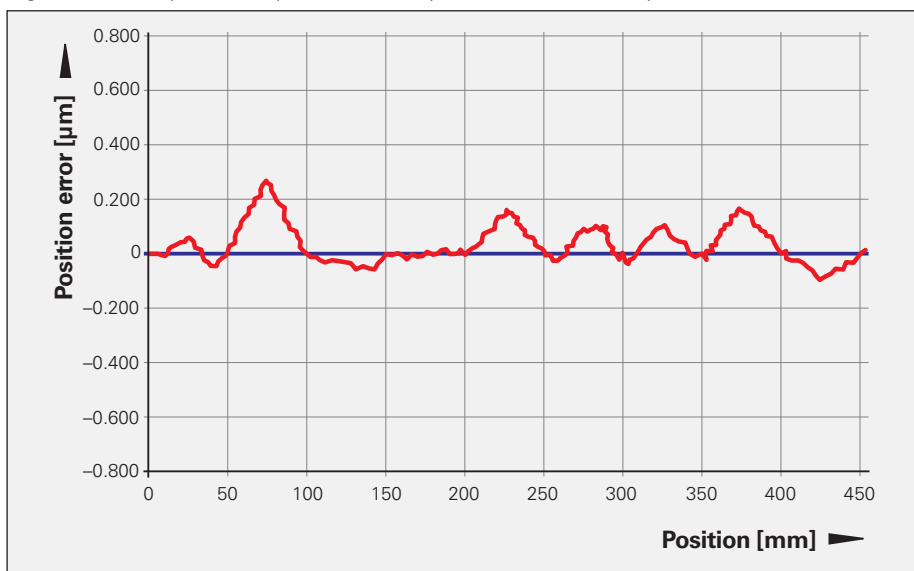Figure 2:   Compensation points for multipoint linear error compensation

Figure 3:   Residual error after multipoint linear error compensation

Position error u within one signal period

Accuracy evaluation of the entire encoder must also include the position error within one signal period.

This error is determined by the quality of the measuring standard and the scanning as well as the signal period of the encoder. On the LIDA 400, when mounted according to the Mounting Instructions, it is typically ±1% of the signal period. For a signal period of 20 µm the position error within one signal period is calculated at ± 0.2 µm. The range of error, here 0.4 µm, is used for further calculation.

Resulting position error

The resulting error F_{total} after multipoint linear compensation therefore consists of
- the maximum residual error over large length intervals $F_{residual}$ (depending on the compensation point interval) and
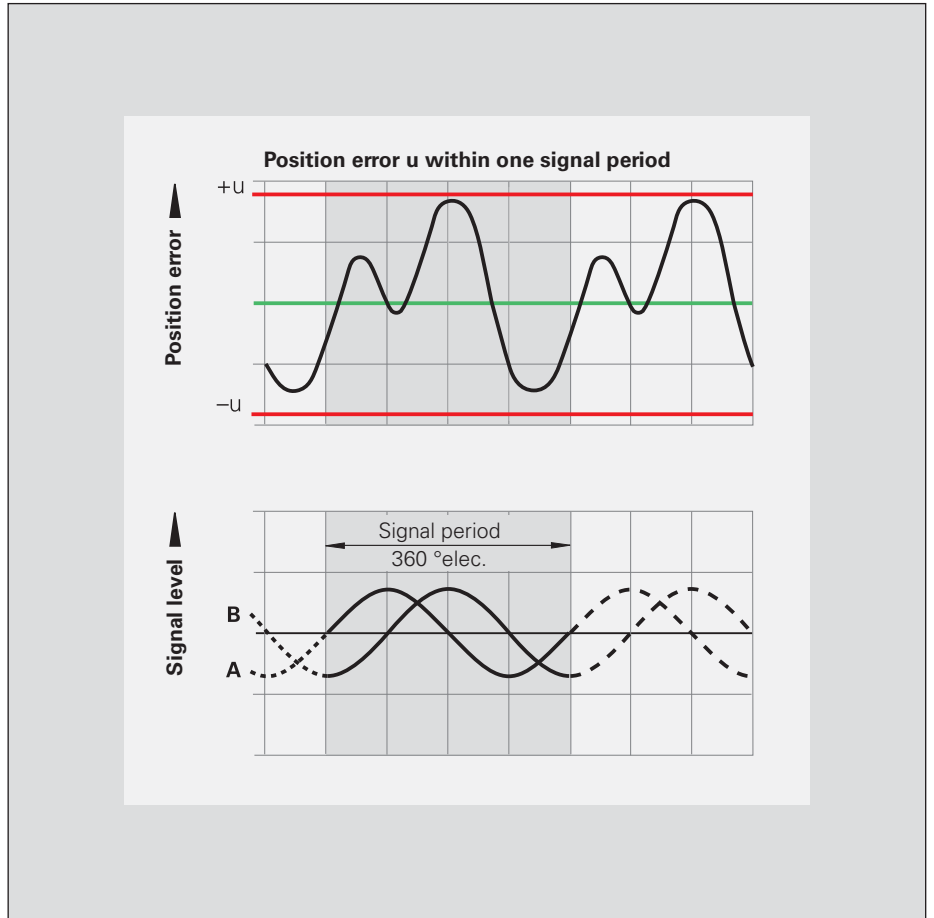- the position errors u within one signal period

$$F_{total} = F_{residual} + u$$

For the LIDA 400 in this example, the following typical values were calculated:

- At a compensation point interval A of 50 mm:
  F_{total} = 0.8 µm + 0.4 µm
  F_{total} = 1.2 µm

- At a compensation point interval A of 100 mm:
  F_{total} = 1 µm + 0.4 µm
  F_{total} = 1.4 µm

Conclusion

With its specification of the resulting length error after multipoint linear error compensation, HEIDENHAIN provides the machine tool builder with an important index.

It allows him to prepare a good assessment of the measuring uncertainty to be expected, and at the same time indicates the high accuracy of the linear encoder from the LIDA 400 series.
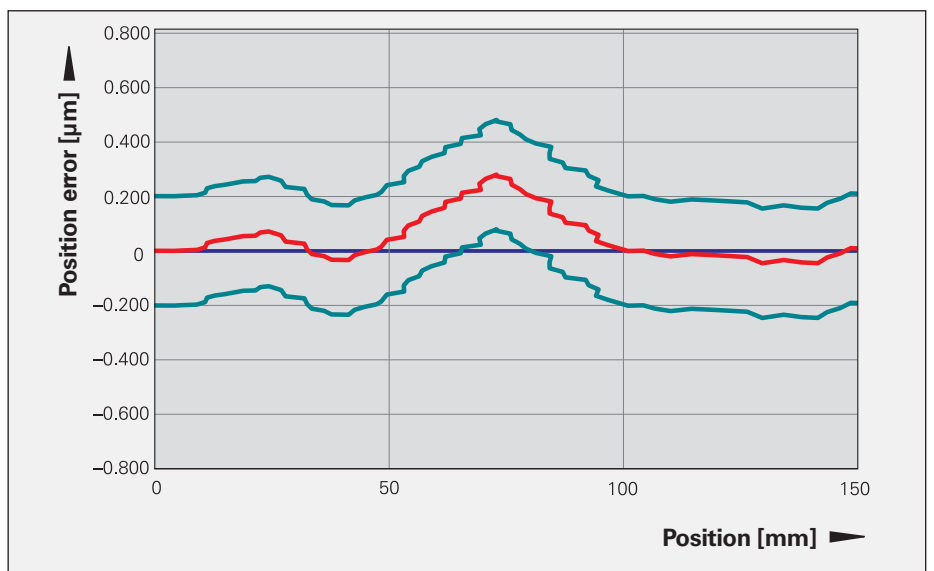

Figure 4:   Position error u within one signal period

Figure 5:   Total error after multipoint linear error compensation under consideration of the position error u within one signal period

Measuring the Machine

Modern subsequent electronics are capable not only of linear error compensation over the entire measuring range, they can also compensate error at specified points. This makes it possible to provide good compensation down to a relatively small residual error even for nonlinear error curves. For both methods, the actual error curve of the complete axis must be exactly measured over the path whose error is to be compensated. Mechanical influences of the axis, such as guideway error, sag at the end positions, tolerances of the bearing surface and similar factors, but also less-than-optimal mounting (Abbe error) always have an effect. It is therefore not enough to evaluate encoder error solely on the basis of the deviations documented in a calibration chart.

To measure the resulting deviations, HEIDENHAIN offers the VM 182 comparator system for measuring lengths up to 1 520 mm. Measuring machines with correspondingly high accuracy or laser interferometers are also suitable.

VM 182 comparator system

The VM 182 comparator system serves for acceptance testing, inspection and calibration of linear axes on machine tools and measuring equipment with traverse ranges up to 1 520 mm. The VM 182 makes it possible to measure the linear and nonlinear error curves as well as the reversal error of machine axes according to DIN ISO 230-2. At the same time as it finds the position error, it also measures the guideway error orthogonal to the traverse direction of the machine axis. The compensation values can be used in the subsequent electronics for electronic error compensation.

The VM 182 is connected through an **IK 220** counter card to a PC with the **ACCOM** software, which evaluates the measured values according to DIN ISO 230-2, ISO 230-3 or the VDI/DQO directive 3441.

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For more information
• Brochure: *Exposed Linear Encoders*
• Brochure: *Measuring Systems for Machine Tool Inspection and Acceptance Testing*