Application Note DK9222-0909-0003

XFC technology microincrements

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Microincrements

The microincrement function of the EL5101 and EL5151 EtherCAT Terminals can be used to maximise the physical resolution of an incremental encoder. The number of counted encoder segments can be output more detailed by a width of 8 bit, i.e. 256 times.

Technical background

The incremental encoder is the main link between the mechanical system and the control system for monitoring mechanical movements. Incremental encoders convert linear or rotary movements into signals that can be analysed electrically. For rotary movements, a certain number of light/dark segments applied to a pulse disc are scanned with a light beam. A scannable scale arranged in the direction of motion is used for capturing linear movements. The accuracy of the returned position is limited by the encoder resolution. For rotary movements, the resolution corresponds to the quotient of revolution (360°) and number of segments. It indicates the smallest possible measurable difference between two positions. The more segments, the higher the resolution and the more precise the position information. A standard encoder has 1000 lines, resulting in an accuracy of 360° / 1000 = 0.36°. This means a rotary movement can be monitored with a precision of ±0.36°. In many cases, this is adequate for simple positioning tasks, although a finer resolution is required in order to monitor axis synchronism in addition to the position.

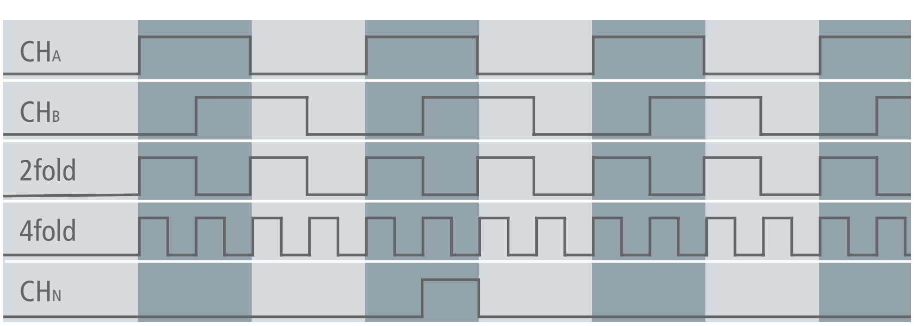

Fig. 1 Encoder signals with different resolutions

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Physical improvement of the resolution through maximisation of the encoder segments is only feasible to a certain degree, since manufacturing tolerances and operating conditions increase the costs of the encoder. A simple and effective way of maximising the resolution is to use a second detection point. With two signals that are offset by 90°, three additional edges are available for detection. They can be used to detect the direction of rotation in addition to the position, and an additional reference signal for zeroing is output once per revolution. Analysis of these additional edges can refine the resolution by a factor of 4 (360° / 4 * 1000 = 0.09°), which is why this principle is referred to as quadrature encoder.

Axis synchronism monitoring

Axis synchronism is monitored through cyclic position polling and interpolation of these values within the PLC. The timebase for the interpolation is provided by the strict cycle-linked processing of the instructions in the PLC. With a cycle time of 1 ms, which is common for motion applications, the positions are scanned with a timebase of 1 ms. However, the real encoder scanning intervals are not as rigid as those of the PLC and vary. The reason for the irregularity is inherent to the functional principle variation of the fieldbus transfer times (jitter) and the encoder inaccuracy with ±½ edge. Since the PLC does not take this discontinuity of the polling intervals into account and assumes a constant interval duration, the position representation in the process image of the PLC may be unsteady even if the axis is in fact synchronous. This only virtual deviation can have three different effects:

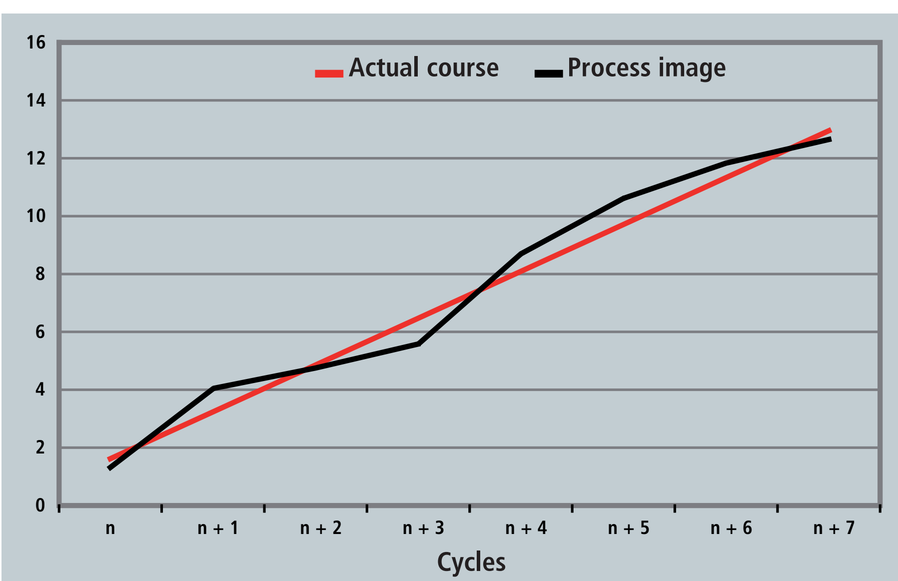

Diagram 1 Asynchronism according to process image

1st case:

Although in reality the axis runs absolutely uniformly, the process image shows a non-uniform movement (see Diagram 1)

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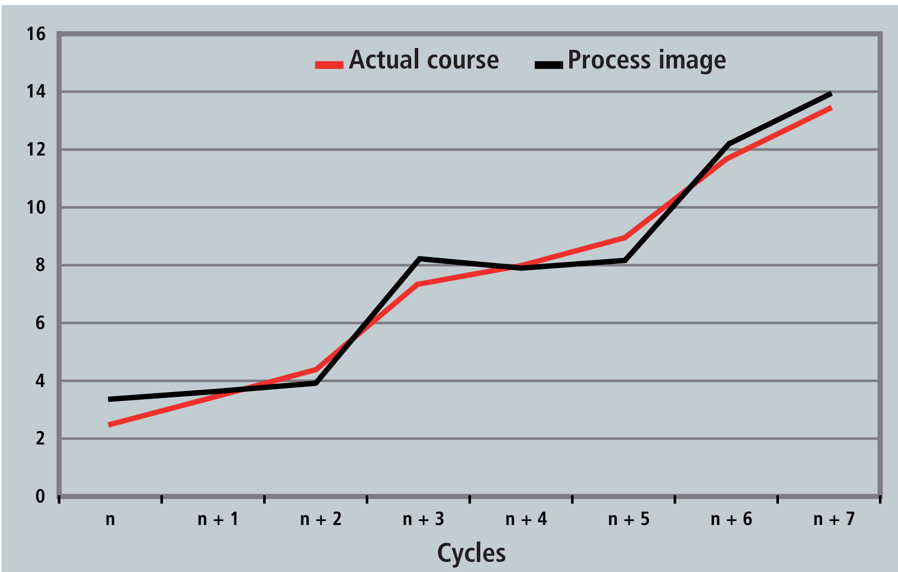

Diagram 2 Amplified asynchronism according to process image

2nd case:

While the axis only runs slightly unevenly, the effect is amplified in the process image (see Diagram 2)

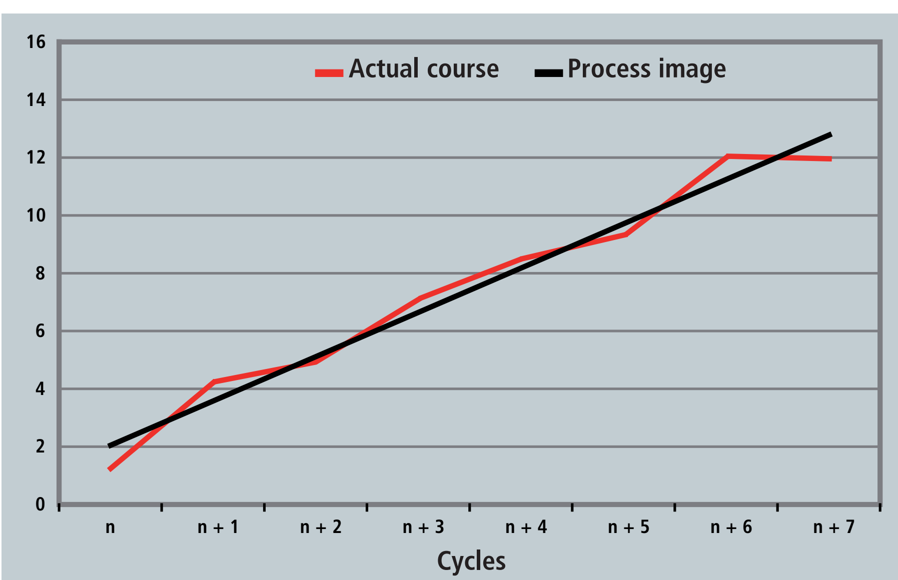

Diagram 3 Equalising asynchronism according to the process image

3rd case:

The axis runs unevenly, the process image equalises the non-uniform movement (see Diagram 3)

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Synchronisation of the strictly cyclical polling through the distributed clock function

High uniformity of the polling intervals can be achieved by using a local clock generator in the EtherCAT slaves, for example the distributed clock function under EtherCAT (see Fig. 2). This principle is based on measuring the protocol run times within the bus and adjustment of the clock generator clocks in the individual fieldbus slaves. With DC, any run-time difference is known exactly and can be compensated. The polling intervals of the EtherCAT slaves are thus adapted to the strictly cyclic operation mode of the PLC. For distributed clock function see distributed clocks system description, available from the download area under http://www.beckhoff.com/english/download/ethercat.htm .

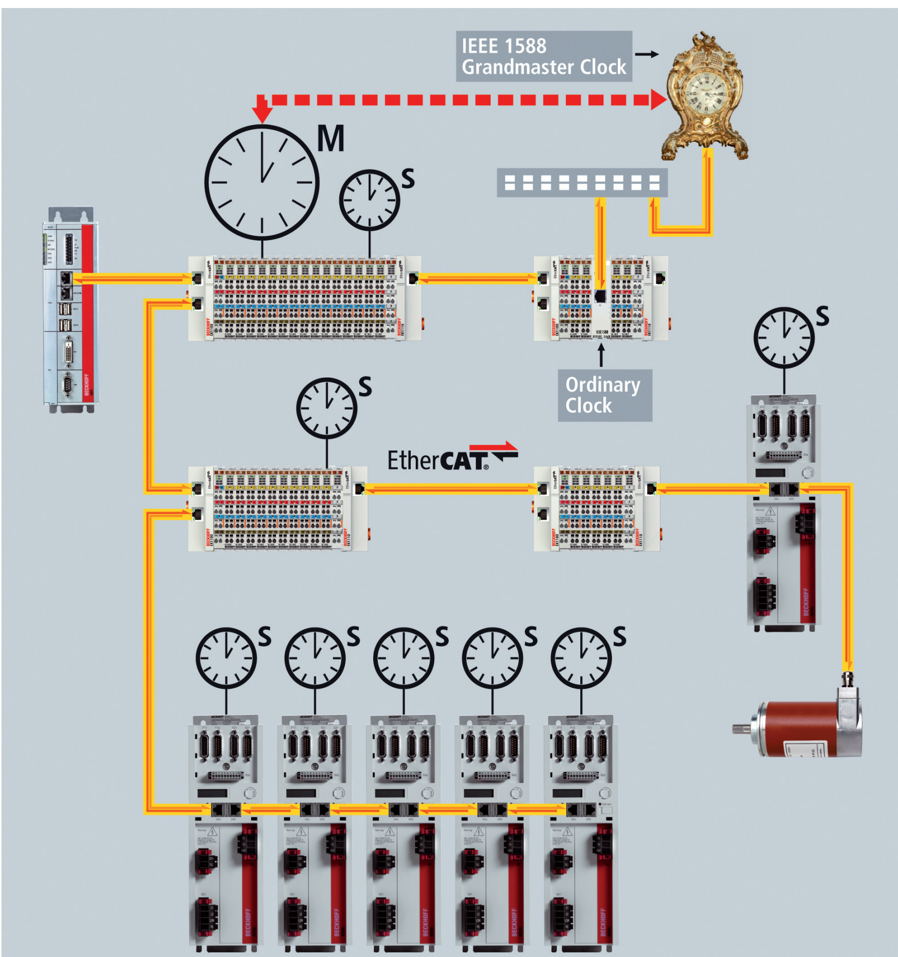

Fig. 2 Local clock generators in the field

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Virtual maximisation of the physical encoder resolution through microincrements

The semi-edge inaccuracy of the encoder is eliminated by using the microincrement mode of the EL51x1 encoder interface terminal. In this mode, the terminal automatically interpolates the position scans to be transferred over a width of 8 bit. This mode therefore offers a 256 times higher resolution than the encoder is able to provide physically. The microincrement mode is only suitable for motion analyses, because for interpolation within the terminal the position is sampled with a significantly higher resolution than is passed on to the fieldbus in interpolated form. The principle of interpolation in the terminal requires a minimum speed, i.e. microincrements cannot be analysed at (near) standstill.

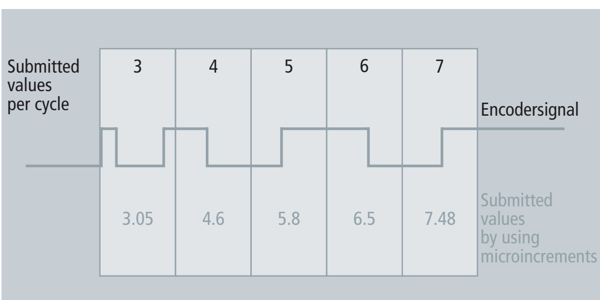

Fig. 3 Different encoder signals resolutions (with and without microincrements)

Control architecture for highest performance **www.beckhoff.com/XFC**

EtherCAT **www.beckhoff.com/EtherCAT**

Encoder interface terminal **www.beckhoff.com/EL5151**

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