Application Note DK9222-0909-0005

XFC technology oversampling

Keywords
XFC
oversampling
Distributed Clocks
EtherCAT
EL1262
EL2262
EL3632
EL3702
EL3742
EL4712
EL4732

Oversampling

Oversampling is a special type of signal sampling that is used for refining the time resolution of a signal. Detection of the signal curve is refined according to the set oversample factor, so that high resolutions of up to 1 µs (digital EL12xx input terminals) and 10 µs (analog EL37xx input terminals) are possible.

Technical background

Oversampling means that a signal is scanned with a higher frequency within the terminal than would be required for the signal transfer. The time window of the signal variation is narrower than the duration of a communication cycle, since sampling takes place several times within a communication cycle. In order to maintain the chronology of the events, a whole set of process data is transferred to the controller during the next communication cycle.

Achieving shorter cycle times via high-performance fieldbus technology and high-performance processors is one technique for improving the time resolution of the signal curve in the field. Alternatively, the higher precision can be achieved through high-precision input and output terminals, rather than during data transfer. This technical approach for finer time resolution of the data requires a reliable time relationship between all system devices to be generated.

Application Note DK9222-0909-0005

XFC technology oversampling

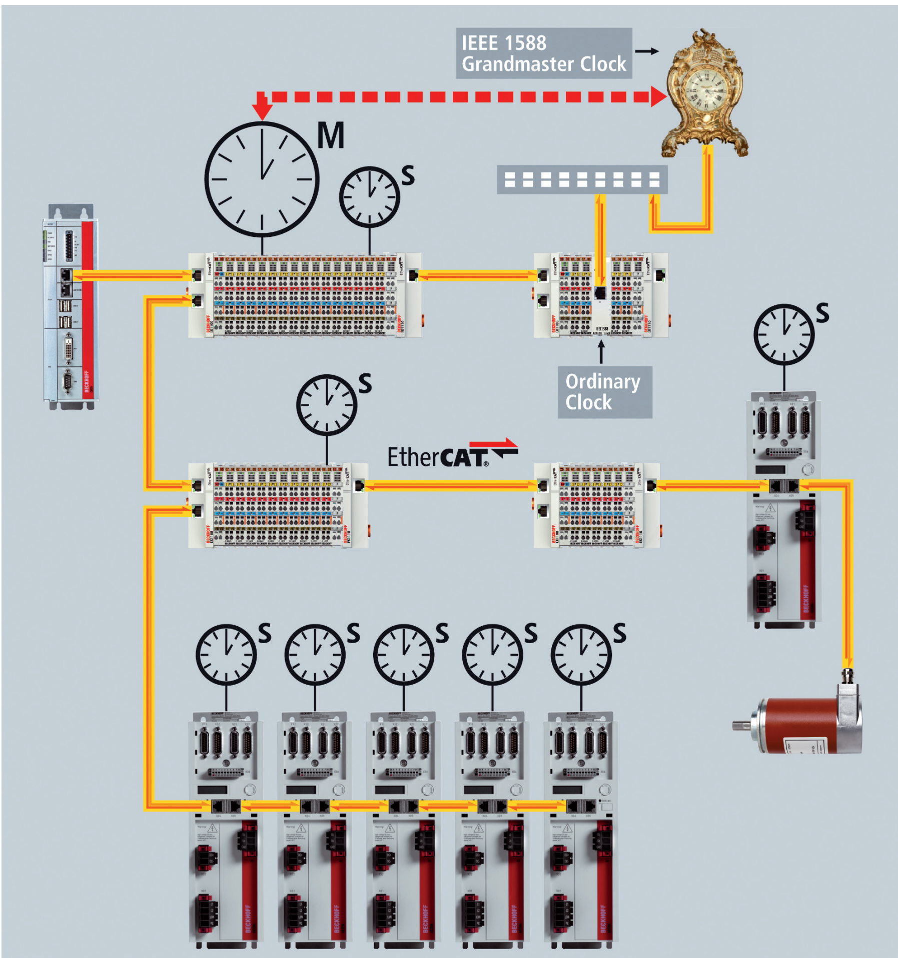

Fig. 1 Local clock generators in the field

This is possible through the distributed clock function under EtherCAT (see Fig. 1): The local clock generators in the EtherCAT slaves provide a uniform system time. The differences in internal protocol run-times of the bus between slaves are calculated, and these micro-delays are compensated after synchronisation of the clocks in the EtherCAT slaves. The now unified system time in the bus system allows reliable chronological relationships between different events within the system. For distributed clock function see distributed clocks system description, available under https://www.beckhoff.com/xfc.

The precision of the signal acquisition at I/Os is achieved through oversampling of the signal. This means that the signal is not queried once per communication cycle as usual, but several times with a defined frequency within the cycle. The sampled data are sent to the controller as a process data packet with the next communication cycle and analysed. For the user this has the advantage that a finer subdivision can be achieved through oversampling with a typical motion application communication cycle of 1 ms, without having to modify the cycle time. With an oversample frequency of 10 kHz and a cycle time of 1 ms the

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communication cycle is divided into 10 intervals. The change of state at the input or output is determined with a precision of 100 µs.

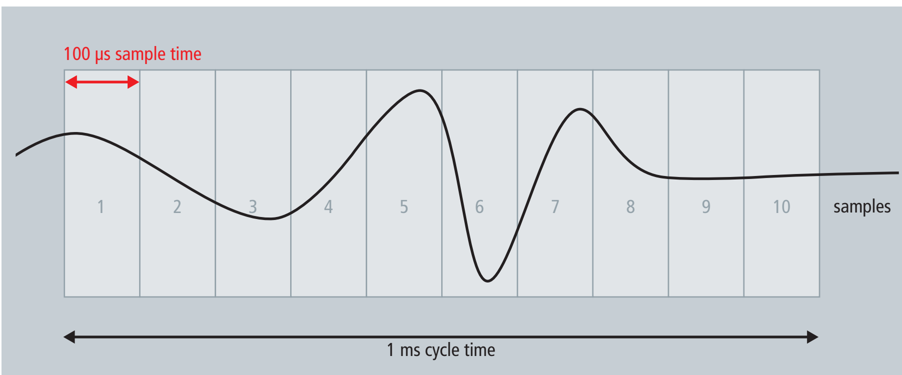

Fig. 2: Cycle time vs. sample time

Different oversample frequencies can be set depending on the terminal. As a rule, the configurable frequency does not depend on the bus speed, but on the signal processing within the terminal. Digital input and output terminals currently enable resolutions of up to 1 µs, with analog signals the smallest possible interval is 10 µs. Even for moderate communication cycles with only 1 ms, digital signal acquisition is possible with a 1000th of the time, analog with a 100th.

Application Note DK9222-0909-0005

XFC technology oversampling

Practical applications: vibration analysis

Sampling of an analog input signal with the EL3632 IEPE terminal

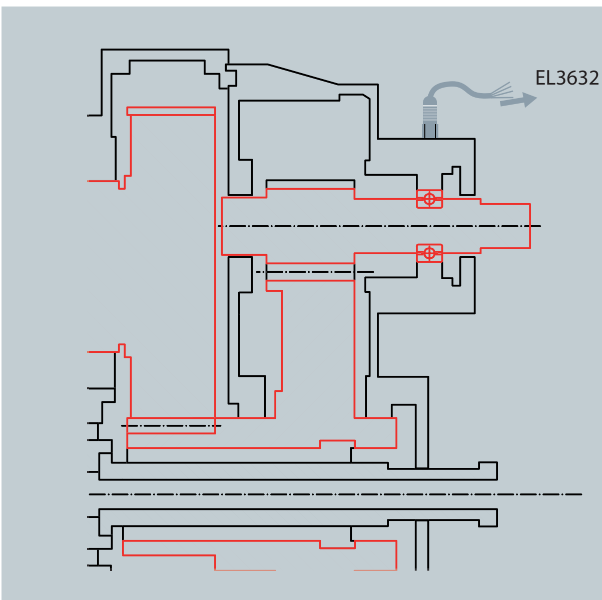

Fig. 3 Gear unit with sensor at the ball bearing

For the quality evaluation of a gear unit the built-in radial ball bearings are checked for faulty balls. Since faulty balls show up in a vibration analysis, the bearing is run in a test rig with a vibration sensor. The sensor signal indicates the vibration curve according to the IEPE standard and shows any vibrations. (The acronym IEPE stands for Integrated Electronics Piezo-Electric and describes an industrial standard for piezoelectric sensors with built-in impedance transformer electronics. Other manufacturer names for the same principle are ICP®, CCLD, Isotron®, Deltatron®, Piezotron®, etc.) For communication with a higher-level analysis unit, e.g. a control PC, the values are transferred cyclically via a bus system. A more detailed temporal resolution of the vibration can be achieved through reduction of the bus cycle time or through oversampling with a constant cycle time. With a moderate bus cycle of 1 ms and high-resolution oversampling, even finely graded vibration amplitudes can be represented, resulting in a computing time surplus that can be used for mathematical analyses.

Application Note DK9222-0909-0005

XFC technology oversampling

Practical applications: torque analysis

A corresponding application scenario would be an EL3702 (±10 V input terminal, max. oversample factor 10 µs) at a fast torque sensor with matching analog signal output. This can be used for measuring the synchronously smooth operation of a gear specimen, for example. The incoming signals have to be suitably filtered in the higher-level control system in order to eliminate noise as necessary. Through oversampling with a frequency of 100 kHz the vibration curve is scaled more finely with a timebase of 10 µs, so that small torque fluctuation are reproduced sufficiently. The vibration curve can therefore also be mapped in relation to the exact axis position, e.g. through application of a high-resolution incremental encoder.

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± 5 V analog input terminal with oversampling (IEPE) **www.beckhoff.com/EL3632**
± 10 V analog input terminal with oversampling **www.beckhoff.com/EL3702**
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