Automotive electronics: EtherCAT oversampling terminals ensure interoperability with SENT sensors

High-precision signal acquisition at resolutions up to 1 µs

Digital EtherCAT I/O Terminals with oversampling functionality enable exceptionally precise signal acquisition at higher timing resolutions than overlying bus cycle times. This capability not only offers important benefits such as for logging data from high-speed processes or fault analysis, it also allows the frames in serial protocols to be read and evaluated directly. Such protocols are used for communication with sensors like SENT devices in automotive electronics, for instance. With the EL1262-0050 EtherCAT Terminals, sensors of this kind can be directly integrated into EtherCAT systems.

Digital sensors return a discrete value of 0 or 1 to a controller. The controller, usually connected to I/O systems over a fieldbus, reads out the bus system data in a set cycle, commonly clocked in the millisecond range. Important to note here is that the bus system needs a degree of determinism and the controller must run in synchronization with it, even if bus cycles are sometimes longer or shorter. With Beckhoff hardware and software, the synchronization between controller and bus system are assured, as are the deterministic features of the ultra-fast EtherCAT communication system. This means that PC-based control provides the ideal foundation on which to implement oversampling technology.

Bus cycle subdivision with oversampling
Oversampling involves polling signals at a configurable multiple of the bus cycle time (i.e. in micro cycles) and writing the results to a temporary buffer. The set of process data collected is then transferred during the next bus cycle.

Oversampling functionality can avoid situations like the following during signal polling: If, for example, a sensor is queried every 10 ms, only the data available at the precise time of the query is actually acquired. The controller is effectively blind from one query to the next, so details of any changes in the sensor's state occurring between PLC queries are not recorded. For instance, a sensor's state might switch from 0 to 1 and stay there for 9.9 ms. If it then reverts to 0, the sensor signal – from the perspective of the controller reading it out – will appear not to have changed at all over the 10 ms cycle.

Situations like this can be detected by using an EtherCAT oversampling input terminal such as the EL1262 to connect the sensor. This EtherCAT Terminal is able to subdivide the bus cycle into as many as 1,000 micro cycles. In the case of a 10 ms bus cycle, an oversampling factor of 1,000 translates into a sampling interval of 10 µs. In a 1 ms bus cycle, a sampling interval of just 1 µs can
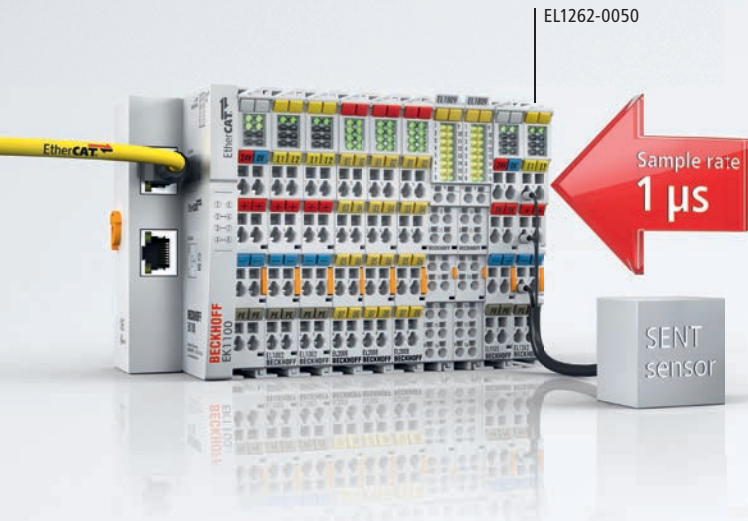
The EL1262-0050 EtherCAT Terminal with oversampling functionality and 5 V inputs allows the direct connection of SENT sensors.

Protocol structure in SENT data communication: A SENT data signal trace showing a series of SENT messages at the top and a 32-bit SENT message comprising 4 bits of status/communication information, plus 24 bits of signal data and a 4-bit CRC checksum at the bottom.

be achieved, which is the shortest that EtherCAT oversampling terminals can currently support. This technology is ideal for reading out SENT sensors.

The pulse width encoding protocol: SENT

Single Edge Nibble Transmission (SENT) is a simple, unidirectional, asynchronous protocol that encodes sensor data based on the time between falling edges in a digital signal. The pulse length describes the signal value transmitted. A single bit in the SENT protocol generally corresponds to 3 µs, which meets the minimum requirement in terms of sampling precision. The signal level is 5 V. The EL1262-0050 oversampling terminal meets both requirements in that it supports precise data acquisition down to 1 µs and is capable of processing the signal level directly. It can sample each bit of the SENT signal three times – more than enough to reliably read the data transmitted in a signal pulse.

The data sets acquired are then processed in a ready-made function block, which evaluates the pulse lengths recorded, calculates the checksums and then marks the value either as valid or invalid.

The SENT protocol is mainly used for communication between sensors and electronic control units in vehicle electronics. Due to the simplicity of the protocol, the microcontrollers in ECUs are capable of evaluating it. SENT protocol receivers are not available for use in constructing measurement and test benches, but the open Beckhoff control system offers an alternative: The EL9505 power supply terminal can serve as the required 5 V power source, and the EL1262-0050 variant of the EtherCAT digital input terminal can be used to capture the sensor signal. In this way, SENT sensors can be directly and easily connected to the open and modular control platform from Beckhoff. This means that test benches equipped with Beckhoff technology can be used to conduct quality inspections on, say, throttle valve or steering torque sensors and make any necessary adjustments before the sensors are fitted to a vehicle.
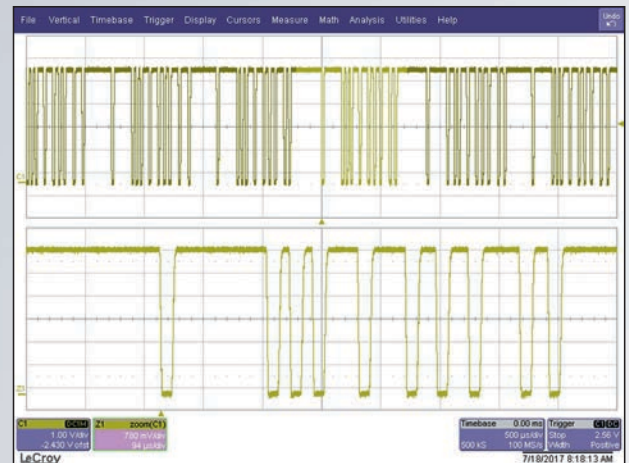
Oversampling: Part of the XFC technology toolbox

In the case of SENT, oversampling is ideal for evaluating the protocol on the controller side using IEC 61131 commands. It also makes it possible to react quickly to changes, additions or new protocols.

XFC technology offers the right tools, even for more complex protocol evaluations. The EtherCAT distributed clocks functionality, which allows an EL1262 oversampling terminal to synchronise its timebase with other EtherCAT hosts highly precisely, is one example. With the distributed clocks, not only can signals be captured in up to 1 µs, they are also time-stamped with an accuracy of up to 10 ns.

The time stamp/multi-time stamp technology thus allows additional, much more accurate timing information to be provided on each process datum, which can be valuable when more extensive signal evaluation or analysis is required.

XFC (eXtreme Fast Control) offers the automotive sector a control solution with exceptionally high performance. It is based on an optimized control and communication architecture that consists of an advanced Industrial PC, ultra-fast I/O terminals with enhanced real-time characteristics, the high-speed EtherCAT industrial Ethernet system and TwinCAT automation software. With XFC, I/O response times of less than 100 µs are possible.

Further information:
www.beckhoff.com/EL1262-0050
www.beckhoff.com/XFC