"EtherCAT helps deliver the processing power of advanced PC technology"

XTS – revolutionary Drive Technology enabled by EtherCAT

It is a widely accepted fact that EtherCAT is the fastest Industrial Ethernet technology currently available. EtherCAT acts as an Ethernet fieldbus, i.e. it offers the benefits of Ethernet with the simplicity of a conventional fieldbus. This too is widely known by now. But what does this mean for automation technology? Using the EtherCAT-based XTS system as an example, we demonstrate that the use of EtherCAT not only means "higher, faster, further," but also enables totally novel solution approaches: Without EtherCAT, XTS would be unthinkable.

The new XTS drive system (eXtended Transport System) combines the benefits of tried and tested rotational and linear drive systems. This results in a drive system that is an evolution of existing linear motor principles: XTS is a linear motor that moves in a circle. The motor is fully integrated in a unit, together with power electronics and displacement measurement. One or more wireless movers can be moved highly dynamically at up to 4 m/s on an almost arbitrary, modular and flexible path. The compact XTS revolutionizes drive technology by enabling totally new, space-saving machine concepts and new freedom for mechanical engineering.

The control and communication challenge of the XTS technology is that the drive control loops cannot be closed locally in the distributed drive modules, since the movers are moved with the aid of sequential solenoid coils. The drive amplifiers in the modules control several solenoid coils and have to deal with a continuously changing number of movers. Since the dynamic properties of the movers are to be carried beyond the module boundary, the control has to take place centrally. After all, the aim is to move the movers smoothly and seamlessly from one module to the next.

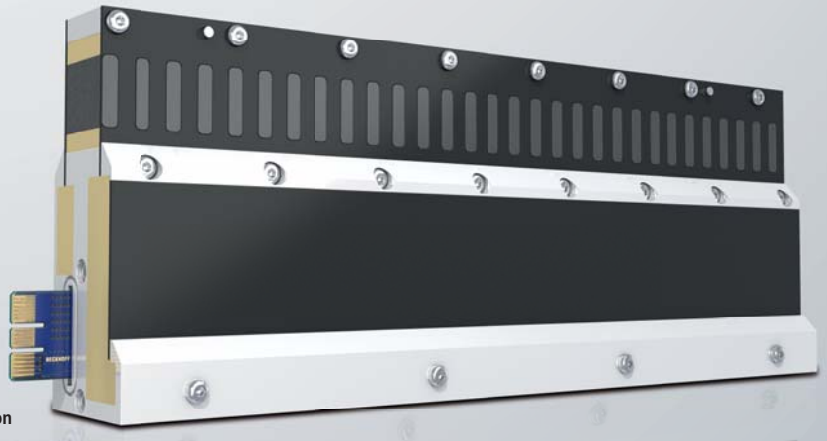
High process data communication: 80 Mbit/s per 3-meter distance

The challenge is not made any easier by the large number of position sensors and coils. Every 30 mm there is a position sensor, which has to be queried in a precise 250 µs cycle. The distributed coils are also controlled based on this cycle. This results in tremendous demands on the communication system: for every 3 meters of XTS distance, around 80 Mbit/s of process data must be transported to and from the distributed modules! Since XTS is an extremely precise drive system, the process data naturally must be sampled and output largely jitter-free. High-precision synchronization of the devices is therefore necessary – for longer distances over several EtherCAT segments. And it goes without saying that the whole system should be robust, simple to wire, and last but not least, cost-effective.

Dynamic data processing

EtherCAT meets these XTS requirements thanks to its special operating principle of processing on the fly. Each network device picks the data intended for it from the common data frames or writes its data into these frames – without first receiving, processing and dispatching the frames again, as it is usually the case. The frames are processed in the EtherCAT slave controllers during the transfer, practically without delay. Almost all advantageous features of EtherCAT are derived from this unique principle of operation developed by Beckhoff:

– The net usable data rate of EtherCAT reaches more than 95 % of the bit rate, since the Ethernet frame overhead does not occur per device and direction, but only once per approx. 1500 bytes of process data, which may be distributed to any number of devices. The required 80 Mbit/s are therefore exceeded, even with 100 Mbit/s Ethernet.



Supply: internal connection of control voltage, power supply and EtherCAT beyond modules

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- Since the same frame is used for input and output data, the bandwidth is available in full duplex mode. In other words, a bandwidth of 100 Mbit/s gross will essentially become 200 Mbit/s.
- The EtherCAT slave controllers process the frames in hardware and therefore make the process data available to the local application immediately after the frames have passed through: Protocol stack cycle times are irrelevant for EtherCAT.
- The high-precision clocks in the slave controllers are synchronized precisely and generate a common system clock, whose accuracy is independent of the frame sending jitter of the master. This not only enables EtherCAT to achieve synchronization accuracy on the distributed devices in the two-digit nanosecond range (!), it also means that no special hardware is required in the master.
- Since the frames are transferred without software influence in the chip, EtherCAT offers minimum (and constant) pass-through delay. This means that the delay can quite easily be computationally eliminated during synchronization of the distributed clocks in the devices: The simultaneity of the sampling matches the synchronization accuracy.
- Physically, EtherCAT is always a point-to-point connection. Any EMC influences therefore disappear after the next device, i.e. unlike in conventional fieldbuses where they are distributed across the whole system. Notwithstanding the high data rate, EtherCAT is therefore unusually robust.
- In the unlikely event that a fault leads to a bit error, it can be reliably detected and localized thanks to CRC checks. Each frame is always checked by all devices, regardless if they participate in the current communication or not.
- The EtherCAT slave controllers provide up to 4 EtherCAT ports. This means that every topology combination is supported, without the need for active infrastructure components such as switches or hubs. With the XTS system it makes sense to simply daisy-chain the modules.
- Notwithstanding its exceptional performance and the ultra-precise synchronization, EtherCAT only has minimum hardware requirements in the master: a standard Ethernet port is sufficient. Unlike in conventional fieldbuses or other Industrial Ethernet systems, no special bus master chips or communication coprocessors are required. This not only reduces costs, but makes EtherCAT a natural partner for PC-based control technology. EtherCAT helps deliver the processing power of advanced PC technology, without being resource-intensive. High processing power certainly comes in handy for the XTS system – after all, many demanding control tasks must be handled in a 250 µs cycle. Thanks to EtherCAT and optimum utilization of the CPU performance on the part of TwinCAT software, usually only a single control computer is required, even for longer XTS distances. Several synchronized EtherCAT segments can be connected, if required.

EtherCAT – The basis for high-speed Drive Technology

Three technologies were basic prerequisites for the development of the XTS system: the high-performance PC architecture to make the required processing power available in a cost-effective manner, TwinCAT to implement this processing power in an easily configurable control system and of course EtherCAT to manage the demanding communication requirements in a robust way.

XTS is a clear example of an EtherCAT-based system approach that would have been unthinkable with conventional bus systems. In this case the crucial factor was performance; there are other examples for which the virtually unlimited number of nodes per system, the flexible topology features or simply the low system costs were crucial. It goes without saying that the EtherCAT features are also advantageous for all applications that would have been solvable with conventional bus systems. After all, EtherCAT has established itself as the Industrial Ethernet solution with the largest number of device vendors.

Further Information:
www.beckhoff.com/XTS
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