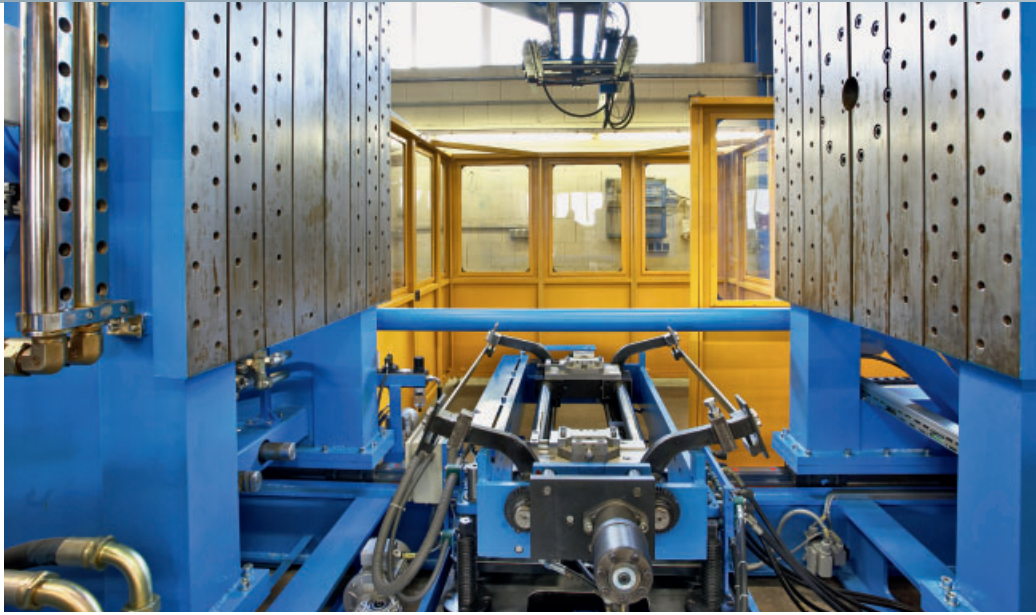


EtherCAT: High-performance control requires high-performance communication

The first PC-based controller in 1986 was already high-performance because, thanks to fast PC processors, it was already significantly more powerful and faster than the so-called hardware controllers at that time. Even then it was a challenge to bring this computing power “down to the ground,” i.e. to the sensors and actuators of the plant to be controlled. Although plug-in I/O cards were a solution, they coupled the maximum number of inputs and outputs to the number of free card slots and led by nature to the multi-wire, inflexible wiring of all peripheral devices up to the PC in the central control cabinet. As a result, a serial fieldbus was required – and there was still no convincing system at the close of the 1980s: Interbus, SERCOS and co. were still in their infancy and initially supported either I/Os or drives. PROFIBUS DP and CANopen hadn't even been invented yet. Beckhoff made a virtue out of necessity and developed the Lightbus protocol that was the basis for the current real-time Ethernet fieldbus: EtherCAT.



The operational principle of Lightbus of telegram processing on the fly, coupled with priority-controlled, logical communication channels, had already led in 1989 to impressive performance figures: While over 1000 distributed I/Os were addressed every millisecond, some fast drive controllers could be updated at the same time every 100 μ s with the Lightbus. Lightbus was thus even more powerful than the fast PC CPUs of the time, laying the foundations for a long life of this fiber-optic-based fieldbus technology.

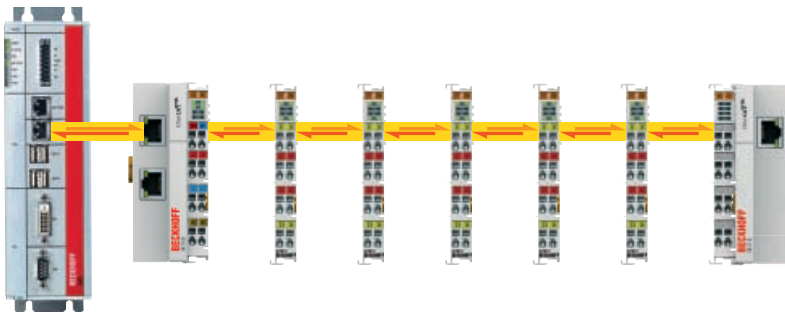
Over 20 years after its development, the Lightbus system is still faster than practically all other fieldbuses and also faster than the vast majority of the Industrial Ethernet variants, which represent the latest fieldbus generation. But even the Lightbus is no longer fast enough to completely map the computing power of today's PC CPUs in the plant peripherals. Therefore, Beckhoff developed EtherCAT, in a manner of speaking the next Lightbus generation. EtherCAT also uses the principle of processing on the fly and supports an arbitrary number of logical communication channels – but on a medium that is 40 times faster, on 100 Mbit/s Fast Ethernet. EtherCAT can communicate, for example, with 100 servo axes every 100 μ s. However, even the fastest Industrial PC cannot calculate the control algorithms of this number of axes every 100 μ s. So Beckhoff

has once again developed a bus system that is “future-proof” and will not represent a bottleneck in the control system in the foreseeable future.

Fieldbus becomes the bottleneck for PC-based control

Classic fieldbuses cannot match the performance of PC-based control. Therefore, despite a high-performance controller, additional local special controllers and regulators are frequently used for local pre-processing of the data when a slower fieldbus or Industrial Ethernet system is chosen. These controllers must be programmed and configured separately. Examples of this are special hydraulic controllers, integrated drive positioning controllers or even the mass flow controllers in semiconductor manufacturing plants. The variety of hardware and tools required for this forces up the costs of acquisition, engineering and maintenance. Distributed local controllers may be a tried-and-tested means in modular machines, but in many applications they are quite simply a necessity born of the communication bottleneck.

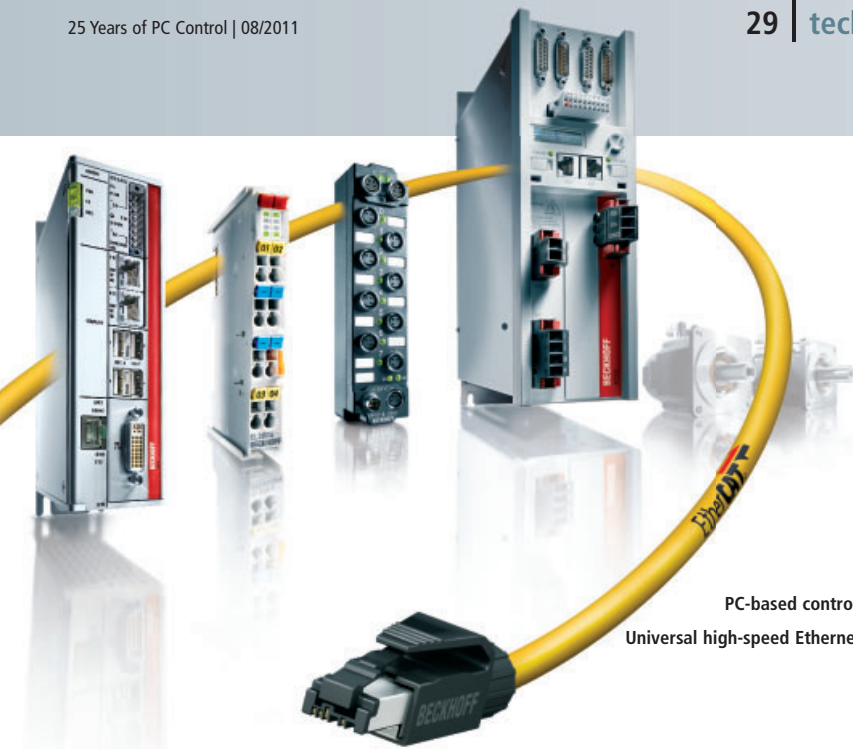
Using EtherCAT and TwinCAT, very fast control loops can also be closed over the bus: complex special controllers and their proprietary programming tools become redundant and can be replaced by fast I/O terminals and a TwinCAT controller function block. That is not only less expensive; it also opens the “black box” of the special controller: if necessary, the machine manufacturer or system integrator can optimize the controller software for its application or even replace it entirely using proprietary control algorithms, with which it sets itself apart from the competition. With TwinCAT 3, users can also elegantly develop these control algorithms and debug them online with Matlab®/Simulink® or C/C++.



Ethernet down to the terminal: Full duplex Ethernet in the ring, one telegram for many devices, connection directly at the standard Ethernet port

EtherCAT architecture makes compact IPC designs possible

The extraordinary performance of EtherCAT leads not only to simplified control architectures, but also to simplified hardware structures in the IPC itself: Fieldbus interfaces – which are still necessary in many plants for



PC-based control:
Universal high-speed Ethernet



Martin Rostan, Head of Technology
Marketing, Beckhoff Automation

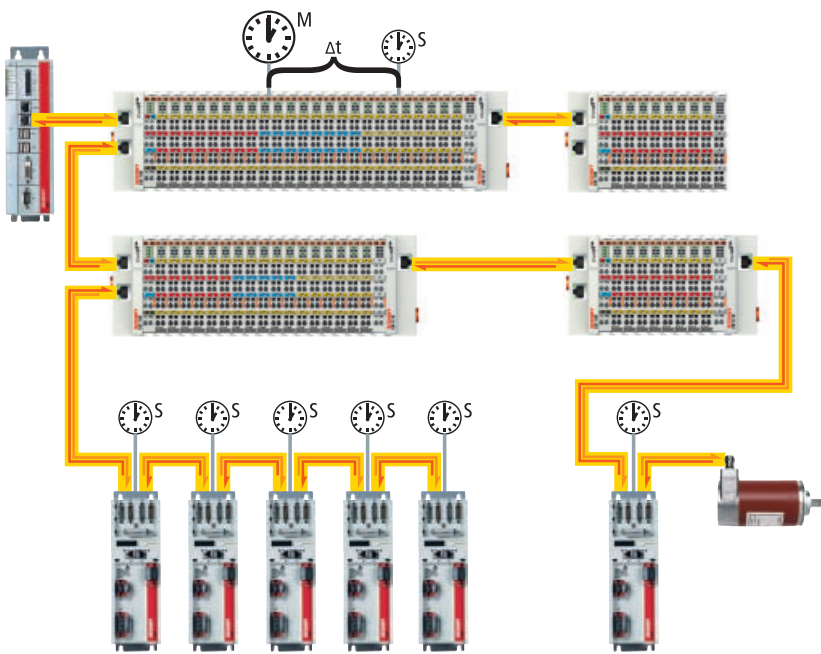
reasons of investment protection and the elegant migration to EtherCAT or for connectivity to neighboring systems – can be implemented as EtherCAT terminals and thus connected locally. The number of card slots on the local PC bus no longer determines the shape and the expandability of the system. IPCs become more compact. Fieldbus cables become shorter and thus make higher baud rates possible – a further gain in performance.

However, it is not only applications with closed control loops that benefit from the combination of a high-performance controller and high-perfor-

mance communication: all applications with event-dependent control are also accelerated. Very frequently the next work step is dependent on the occurrence of an event. It continues as soon as the work piece has arrived, the pneumatic cylinder has reached its target position, the part to be mounted is actually in the gripper or the desired pressure is available. To this end, sensors are continuously and cyclically scanned, wherein the time taken to respond to the occurrence of the event is directly dependent on the scanning frequency and the communication efficiency. With an ultrafast bus such as EtherCAT, fast I/O modules, TwinCAT and the PC controller, these small waiting periods are shortened significantly. The result is a noticeable increase in the efficiency of the plant compared to conventional control technology. In the case of an assembly plant with, for example, two such events per second, just converting from “a PLC with a traditional fieldbus” to “a software PLC with EtherCAT” can achieve approx. 3% more throughput.

EtherCAT – fast, flexible, inexpensive

EtherCAT is the fastest fieldbus and is therefore often reduced to “high-performance.” That, however, is putting it too briefly – just as “PC-based” with TwinCAT means not only ultrafast, but also scalable, flexible, highly integrated, user-friendly and inexpensive. Many users implement EtherCAT even though they do not need the performance advantages at all. What counts for them is the inexpensive costs, the flexible topology without active infrastructure components, the simple configuration, thanks to automatic address assignment, the excellent diagnostic characteristics with fault location or the global acceptance and large selection of EtherCAT devices. Or simply the advantage that the EtherCAT master makes do entirely without auxiliary hardware; the Ethernet interface, which is present on the PC anyway, is enough. That alone makes EtherCAT the natural partner of PC-based control technology – and both technologies are indeed “high-performance” in any case.



Distributed clocks: Local absolute system synchronization
for CPU, I/O and drive units

EtherCAT www.beckhoff.com/EtherCAT