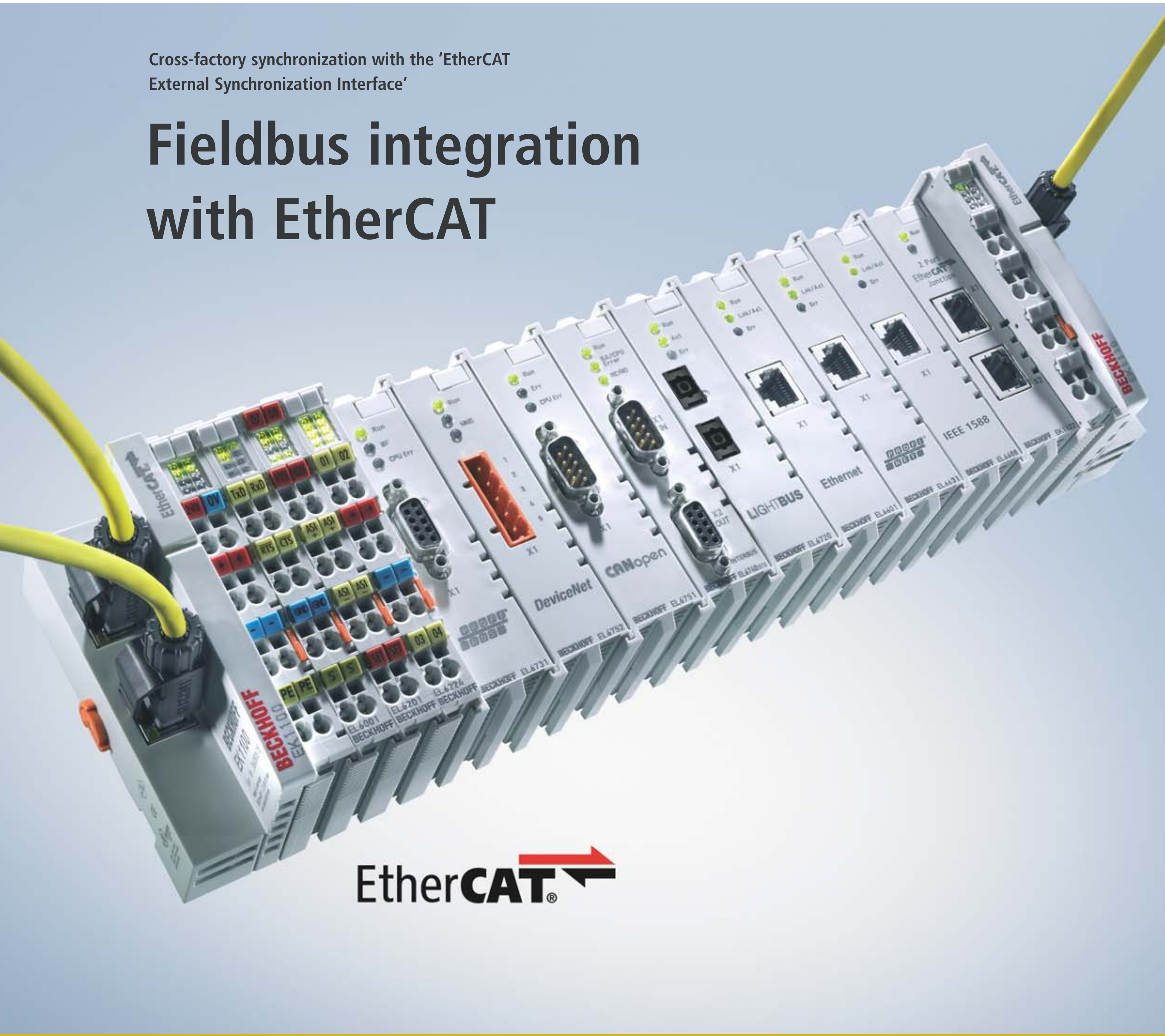
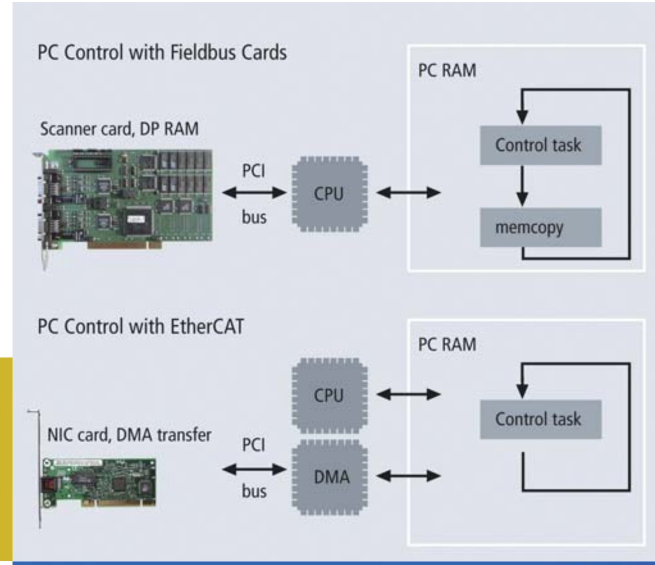
Cross-factory synchronization with the 'EtherCAT External Synchronization Interface'

Fieldbus integration with EtherCAT



The high transmission rate of fast Ethernet and the high protocol efficiency of EtherCAT enable the operation of several subordinated fieldbuses. Classic fieldbus interfaces provided in the Industrial PC are sourced out to intelligent interface terminals in the EtherCAT I/O system. Besides the local I/Os, axes and operating devices, complex systems such as fieldbus masters, serial interfaces, gateways and other communication interfaces can also be addressed via the PC's Ethernet port. This solution additionally offers high protection of investment: existing fieldbus devices can be integrated seamlessly in the EtherCAT system.



EtherCAT improves system performance without changing the CPU e.g. by shifting the mapping task from the PC to EtherCAT. Pre-sorted data are transferred to the RAM via Direct Memory Access (DMA).

EtherCAT instead of PCI

Classic PC controllers often have the problem that a large portion of the computing power is lost through the PCI bus accessing the PCI fieldbus cards. In applications with 50 PROFIdrive axes that are controlled via PROFIBUS DP with a cycle time of 2 ms, more than 25 % of computing power is required just for accessing the PCI cards.

This loss of computing power results from the fact that PCI cards usually work like a PCI slave, i.e. the PC accesses a dual-port RAM via the 33 MHz PCI bus. In the write direction, this access can still be decoupled via intelligent PCI drivers if need be, but during the reading access, the PC must wait until the data has actually been read. A 33 MHz access represents a considerable restriction for a 2 GHz processor.

When EtherCAT is used, access takes place via an Ethernet controller in the PC, which is normally connected to the PC controller using high-performance DMA access. The transmission of the fieldbus data runs in parallel to the PC's other tasks so that the PC has the complete computing power at its disposal. The EtherCAT/fieldbus gateways, which replace the conventional PCI cards, use the advantages of the extremely flexible topology of EtherCAT networks, in which they can be wired peripherally to the machine.

The EtherCAT modular device profile describes the EtherCAT interface of the various EtherCAT/fieldbus gateways. Thanks to this uniform interface definition, the integration of the various gateways is not restricted to TwinCAT systems, in which all EtherCAT/fieldbus gateways are comfortably integrated. This solution is also attractive for other control systems since very few new functions need to be added to the controller with each new gateway.

Besides the gain in performance, a further advantage is that PC cards are no longer required and the PCs can be designed to be much more simple. Embedded controllers also benefit from this since they require only an Ethernet connection as an interface to the process peripherals.

EtherCAT as a system bus

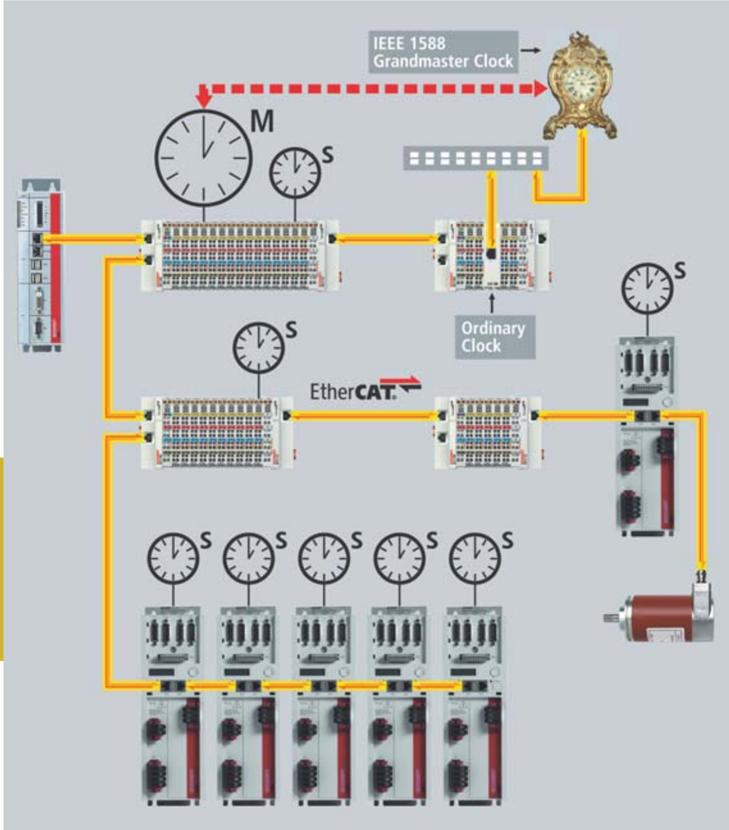
Thanks to its outstanding characteristics, EtherCAT is also ideally suited as a system bus for more complex devices, such as welding controllers. These require a fast system bus, via which they can transmit I/Os with a 125 µs cycle with chronological synchronism, for example. However, these devices must also support many different fieldbus interfaces so that, depending on the application, they can be integrated in superordinated fieldbus networks. Depending on system requirements, the appropriate EtherCAT/fieldbus gateway can be integrated simply.

EtherCAT External Synchronization Interface

Furthermore, such complex devices often need to be synchronized to external applications to the exact microsecond. The control accuracy of distributed clocks and the standardized EtherCAT External Synchronization Interface are advantageous here, so that synchronization to an external event always takes place in the same way, independent of whether the external application is connected via EtherCAT, IEEE 1588, PROFIBUS MC, PROFINET IRT or even via a digital input.

With the distributed clocks principle and the distributed clocks regulators in the EtherCAT Slave Controllers, all devices in an EtherCAT network can be synchronized with one another with an accuracy of less than 100 ns. To do this, the EtherCAT master sends a special telegram, with which the system time is read out at the first distributed clock device (local master clock) and written at the subsequent distributed clock devices (slave clocks). The distributed clock regulator in the EtherCAT Slave Controller is stimulated by the write access to the slave clocks to compare the received system time with the local time. In accordance with the deviation, the local system time is changed by a very small increment, either in one direction or the other. The comparison of the two system times is a simple larger/smaller comparison, which the external synchronization principle also uses.

If the EtherCAT network is to be synchronized to a global master clock, the local master clock must be readjusted. This takes place by means of slightly changing the system time of the local master clock in similar fashion by writing a value that is too large or too small in one direction or the other. The number of write accesses and the direction of the change is determined by the EtherCAT/fieldbus gateway. This is bound to the global master clock via



the fieldbus and the standardized External Synchronization Interface to the EtherCAT network.

The above figure shows an EtherCAT/IEEE1588 gateway (e.g. EL6688) to which a global clock (grandmaster clock) is connected. Via the standardized External Synchronization Interface of the EtherCAT/IEEE1588 gateway, the EtherCAT master receives the information regarding how many write accesses to the system clock or the local master clock are to take place and whether a value that is too small or too large should be written. The external synchronization interface consists of standardized CoE objects, which can be read by the EtherCAT master acyclically per SDO or cyclically via the process data. Besides the number of write accesses (time control value with corresponding sign that specifies whether a value that is too small or too large is to be written) and the information regarding whether or not the time control value has been regenerated, the External Synchronization Interface also encompasses one time stamp each from the local and the global master clock. In this way, the calculation of the time control values can also take place in the EtherCAT master application.

The task of the master or the external synchronization may be restricted to reading out the time control value cyclically and, according to its sign and value, executing a number of write telegrams with a very small or a very large value to the system time of the local master clock. At the same time, this system has the advantage that the EtherCAT slave with the External Synchronization Interface can be located at any desired position in the EtherCAT network.

Fieldbus interfaces for the Beckhoff EtherCAT Terminals system

PROFIBUS DP master EL6731

Besides the standard PROFIBUS DP and DPV1 functions, as well as extensive diagnostic options, the EL6731 also supports isochronous DPV2 functions (PROFIBUS MC). Furthermore, a complete FDL interface is integrated, which can be used to communicate with Siemens controllers via the MPI protocol, for example.

PROFIBUS DP slave EL6731-0010

Besides PROFIBUS DP slave functions, this gateway also supports a DPV1 interface so that DPV1 services can be transmitted via EtherCAT as far as the application. Furthermore, the EL6731-0010 can also function as a PROFIBUS MC slave, whereby the EtherCAT External Synchronization Interface is used.

CANopen master EL6751

Besides the complete CANopen master functionality, a CAN layer 2 message interface is also integrated in the EL6751. This means that any CAN protocol can be easily transmitted. The EL6751 offers a simple option to decentralize any of the many CAN applications via EtherCAT.

CANopen slave EL6751-0010

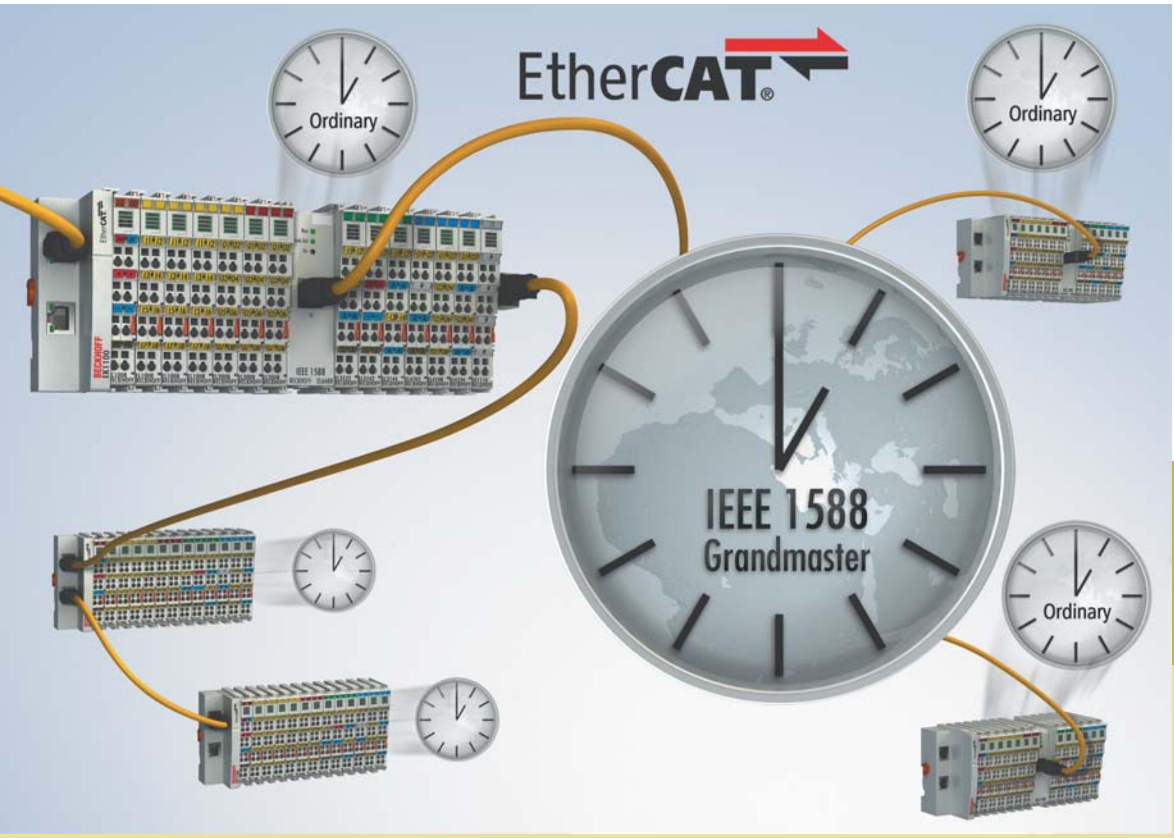
The EL6751-0010 can support up to 64 RxPDOs and 64 TxPDOs. Furthermore, an object interface is integrated so that application-specific objects can be accessed per SDO.

DeviceNet master EL6752

The EL6752 supports the complete range of DeviceNet master functions.

DeviceNet slave EL6752-0010

The EL6752-0010 can be connected to a DeviceNet master as a DeviceNet slave with up to 255 bytes of I/O data in all I/O modes.



With the new EL6688 communication terminal, synchronization according to the IEEE1588 standard can also take place across sites and locations, so that different machines, system components or production lines can be synchronized with each other or with an external clock – for example a GPS receiver – with high precision. In this way, a high-precision, technology- and vendor-independent global timebase is available that can be used for time stamping of measured data, for example.

Interbus-Slave EL6740-0010
The EL6740-0010 supports the exchange of data of up to 128 bytes with an Interbus master.

EL6201 | AS-Interface master terminal
The EL6201 with an AS-compliant interface supports digital and analog slaves with the versions 2.0 and 2.1. The connected devices are supplied via the EL9520 AS-Interface potential feed terminal with filter.

IO-Link master EL6224
The EL6224 allows the connection of up to four IO-Link slaves. All standard IO-Link baud rates are supported, which can be set individually for each connection to an IO-Link slave.

Ethernet EL6601
Any number of Ethernet networks can be connected via the EL6601 without restricting the real-time characteristics of the EtherCAT network. In this way, TCP/IP communication can take place via the EL6601, even with an EtherCAT cycle of 100 µs, in order to perform remote diagnostics via the Internet, for example.

PROFINET IO controller EL6631
Besides the complete range of real-time (RT) functions, as well as extensive diagnostic options, the PROFINET IO controller also supports isochronous real-time (IRT). Protocols such as LLDP or SNMP can be used for network diagnostics. In addition, full media redundancy functionality (MRP) is integrated in the EL6631. Optionally, the controller can be operated as an MRP client or server. All services in accordance with Conformance Class C are supported. Up to 255 PROFINET IO devices can be connected via the EL6631. (available from 2nd quarter 2009)

PROFINET IO device EL6631-0010
Besides the complete range of real-time (RT) functions, as well as extensive diagnostic options, the PROFINET IO device also supports isochronous real-time (IRT). Protocols such as LLDP or SNMP can be used for network diagnostics. In addition, full media redundancy functionality (MRP) is integrated in the EL6631-0010. Optionally, the device can be operated as an MRP client or server. All services in accordance with Conformance Class C are supported. (available from 4th quarter 2008)

IEL6688 IEEE 1588 master and slave
The EL6688 can function both as an IEEE 1588 master and as an IEEE 1588 slave. The EtherCAT External Synchronization Interface is used for this.

EtherCAT slave EL6692
Besides input and output process data, each up to 512-bytes with cycle times < 100 µs and a configurable object directory, the EL6692 also supports the standardized EtherCAT External Synchronization Interface. In this way, it can be synchronized to a subordinate EtherCAT network to the exact microsecond. Furthermore, the AoE and EoE protocols are tunneled so that two EtherCAT networks can also transmit large quantities of data acyclically via the EL6692.

→ www.beckhoff.com/EtherCAT