Ten years after the introduction of the CP-Link technology, Beckhoff presents the next generation of this operating and visualization concept.

Perfect packaging with PC Control

Beckhoff Embedded PCs and TwinCAT provide reliable and flexible control for Multivac’s packaging machines.

New control generation with Intel® Atom™

Control cabinet PC C6915 with Intel® Atom™ processor 1.1 or 1.6 GHz – Ultra compact IPCs with the smallest CPU chip currently available from Intel.
Recent developments at Intel can be regarded as both an endorsement of PC-based control technology and as good news for automation technology. With the new generation of Intel® processors such as Intel® Atom™ on one hand and multi-core on the other, the scalability of PC-based control technology is further increased.

In addition to a cleverly chosen marketing name, Intel® Atom™ offers impressive specifications: the Z530 CPU, with a clock frequency of 1.6 GHz, uses just 2.5 Watts and has a chip size of only 13 x 14 mm. The associated US15W system chip combines north- and southbridge functions on an area of just 22 x 22 mm and uses a maximum of 2 Watts. Together with DDR2RAM and Ethernet controllers, it can be used to configure a PC system with a power consumption of around 8 to 10 Watts.

Due to their low average CPU power, these moderately priced controllers can be very compact. They offer potential for optimization in a wide range of applications.

Further customer benefits arise from the fact that Atom™, with its x86 architecture, supports Windows XP and Windows XP Embedded in addition to Windows CE. With ready-made software for Windows XP, the customers benefit from automatic investment protection.

Thanks to in-house motherboard development, Beckhoff is able to utilize these features by installing the Atom™ processor in space-saving devices that offer plenty of reserve computing power capacity for a wide range of applications. Examples include the CP77xx series Panel PCs that combine a TFT display and electronic PC components in a solid IP 65 aluminum housing that is only 30.5 mm deep. Or the miniature PC from the C6915 series, a device that can be installed in a control cabinet, is equipped with three Ethernet interfaces and offers all other standard PC features. And, last but not least, the CX5000 Embedded PC series, which offers direct connection to EtherCAT or Bus Terminals on a DIN rail. In terms of computing power, Beckhoff intends to position the device slightly below a 1 GHz Intel® Celeron® M, while the graphics performance of the Atom™ processor exceeds that of the 1 GHz Celeron® M.

Thanks to the low thermal power dissipation of the Atom™ processors, all Beckhoff devices equipped with it are fanless. Depending on the device design, Compact Flash or solid-state drives are used as storage media and form a robust hardware platform for PC-based automation.

With the development of efficient Atom™ processors, Intel sets its sights on applications currently dominated by ARM and MIPS architectures — and therefore by manufacturers such as Freescale or Texas Instruments. The contest is open, although Intel has some way to go in view of the fact that current ARM processors show a power consumption of less than half a Watt and offer complete, system-on-a-chip design. Although, to be fair, it is worth noting that in terms of pure computing power, Atom™ plays in a higher league, so to speak.

Multi-core technology is also good news for automation since it forms the roadmap for further performance increases.

Andreas Thome
PC Control Product Manager
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IPC | Intel® Atom™ and Core™2 Quad processors for finer scaling of PC-based control technology

The new generation of Intel® processors further enhances the scalability of PC-based control technology. “High Performance – Low Power” is the motto of the Industrial PCs with Intel® Atom™ CPU processors. Due to their low processor power consumption, these moderately priced controllers can be very compact and offer great potential for optimizations in a wide range of applications.

Atom™ processors, currently Intel’s smallest CPU chip, make their entrance in a wide range of products. The highlight among the IPCs is the new C6915 control cabinet PC with 1.1 or 1.6 GHz Intel® Atom™ processor. It is the smallest Beckhoff IPC, measuring only 47 x 157 x 116 mm (W x H x D). Atom™ processors are also integrated in the CP62xx built-in Panel PC series and the CP77xx Panel PC series.

New Industrial PCs with Intel® Core™ 2 Quad extend the performance range even higher. These multi-core processors for particularly “performance-hungry” controllers, such as Motion Control applications with many servo axes, are integrated into the new C6640 and C6650 IPCs, for example. For RAID systems, the C6650 includes two hard drive frames for SATA drives. The highly flexible control cabinet IPCs are equipped with the new Beckhoff CB1052 ATX motherboard for Core™2 Quad processors with GM45 (Montevina) chipset, which will also be used in other Beckhoff IPCs.

Embedded PC | Even more compact with Atom™ processor

The new CX5000 Embedded PC series is also based on the Atom™ processor. In terms of performance, this series with ultra compact design is positioned between the CX1010 und the CX1020. The CX5000 is available in two versions: the CX5010 is equipped with a 1.1 GHz Atom™ processor, the CX5020 with a 1.6 GHz Atom™ processor. The CX5000 series integrates interfaces for either Bus Terminals or EtherCAT Terminals.

Between November 25 and 27, 2008, around 1,400 exhibitors will present advanced products, technology trends and solutions at SPS/IPC/DRIVES in Nuremberg, Germany. The fair covers 11 exhibition halls with a total floor area of more than 90,000 m². The complete range of Beckhoff products and PC-based and EtherCAT-based automation solutions will be on display at the 1,000 m² Beckhoff booth in Hall 7, Booth 406. The trade show booth is split into different sections for IPC, I/O, Motion and Automation, plus the Solution Forum, where industry-specific solutions will be shown.
CP-Link 3 | Ethernet-based multi-display link

At SPS/IPC/DRIVES 2008, ten years after the introduction of CP-Link technology, Beckhoff will present CP-Link 3, the next generation operating and visualization concept. CP-Link 3 is a pure software solution based entirely on standard hardware (100 Mbit/s Ethernet) and IP-based protocol for real-time transfer of image data. Networking can be done using cost-effective standard Ethernet cables (CAT 5), which are suitable for drag chains.

The screen content is recorded via a virtual graphics adapter on the host PC and sent via Ethernet to one or several Beckhoff Ethernet Panels or Panel PCs with Windows operating system (Windows CE, XP Embedded, XP). For display communication, TCP/IP or UDP/IP (Multicast) can be configured, depending on the operating mode. Up to 255 panels can be connected via different operating modes: single, extended or multi-desktop. As yet another highlight, CP-Link 3 also transfers USB, in addition to image data. “Virtual USB” emulates a USB root hub in the host PC (see page 16).

EtherCAT Terminals | Power over EtherCAT and other functional extension options

The EtherCAT Terminal system from Beckhoff optimally supports the technological features of EtherCAT. To this end, the I/O system has been complemented with additional terminals: the EK1132 EtherCAT branch terminal supports Power over EtherCAT, based on the IEEE standard 802.3af. A standard EtherCAT/Ethernet cable is used for the fieldbus signal and the power supply. EtherCAT sensors up to 15.4 Watts can be connected to the EK1132. When using TwinCAT as the EtherCAT master, the EK1132 also supports coupling and uncoupling of EtherCAT devices during operation (Hot Connect) (see page 19).

With the EtherCAT distributed clocks, all devices in an EtherCAT network can be synchronized with a tolerance of less than 100 ns.

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 (see page 12).

XFC – the 100 µs class of performance

Advanced Industrial PCs, ultra-fast I/O terminals, EtherCAT and TwinCAT automation software form the basis for XFC – eXtreme Fast Control Technology. XFC permits high-speed machine control systems with response speeds up to ten times higher. This leads to better control quality and faster sequences on the machine, so that the material, energy and production efficiency is significantly optimized. Special auxiliary controllers and expensive instrumentation interfaces can now be replaced with standard, cost-effective I/O terminals.
Scientific Automation: instrumentation integration

The Beckhoff I/O systems have also been complemented for measuring applications: the "digital multimeter in a Bus Terminal" for current and voltage measurement can process measurement readings directly in the I/O system or from the higher-level control system. The use of the new Beckhoff KL3681 I/O terminal (Bus Terminal) and EL3681 (EtherCAT Terminal) significantly increases flexibility thanks to the wide range input and automatic measuring range selection. High precision and simple, high-impedance measurement from 30 mV to 300 V allows the Bus Terminal to be used like a modern digital multimeter (see page 9). The new EL3201-0010/-0020 PT100 terminals are designed for high-precision temperature measurement with an accuracy of 0.04 K. They offer an ideal solution for high-performance and high-precision instrumentation.

Instrumentation is also increasingly becoming an integrated component of the software PLC. TwinCAT Scope 2 is the new software oscilloscope for the suite of automation software from Beckhoff. Graphic display of curves is essential for optimizing controllers and setting drive axes. In order to utilize the extended graphics features of new PC generations, including DirectX, Beckhoff has redesigned the scope software for the TwinCAT software suite, which was originally developed several years ago. The system’s simple configuration, advanced graphics and functional extensions offer a robust foundation for measuring tasks (see page 8).

Water- and dust-proof EtherCAT I/Os

The Beckhoff EtherCAT system has been expanded with new IP 67 modules. In parallel with the Beckhoff EtherCAT Terminals, all modules have a direct EtherCAT interface. The high performance of EtherCAT is therefore maintained right down to each IP 67 box. With dimensions of only 126 x 30 x 26.5 mm (H x W x D) the modules are exceptionally small and are particularly suitable for applications where space is tight. The EtherCAT connection is established via screw connectors.
Beckhoff Automation Srl., with its head office in Milan, inaugurated a new branch office in Bologna in May 2008. With this step, the Italian Beckhoff subsidiary is confirming its rapid economic growth over the last five years. “On account of the positive development of the local market,” says Pierluigi Olivari, Executive Manager of Beckhoff Italy, “we recognized that, alongside Milan, it was necessary to open another office in the Emilia Romagna region and, above all, to strengthen technical support for our customers.” The manager of the Bologna branch office is Vincenzo Tampellini, who knows the Italian packaging industry inside-out and is very familiar with Beckhoff products and system solutions.

Microsoft awards the Windows Embedded Partner Excellence Award to companies in recognition of especially successful Windows Embedded applications. This year, three German companies are among the 10 prizewinners worldwide. Along with Beckhoff, the German companies Wechsler Consulting and Keith & Koep also received awards.

According to Manoj Rami, Senior Marketing Manager, Microsoft Windows Embedded Business, EMEA, Beckhoff received the award in recognition of its outstanding developments based on Windows Embedded and its committed marketing of the Embedded version CE 6.0 R2, which Microsoft introduced in 2007. Over recent years, Beckhoff has continuously developed and launched new equipment and solutions based on Windows Embedded and has long-standing experience and advanced technologies in the Embedded segment. TwinCAT automation software from Beckhoff permits the creation of real-time control systems under Windows XP Embedded and Windows CE. The Embedded operating systems are used in Beckhoff Industrial PCs (IPCs) of all performance classes. The Beckhoff IPC product range includes compact Panel PCs and conventional Industrial PCs as well as the modular CX family of Embedded PCs, which delivers PC technology with a direct connection to modular I/O as a DIN rail mountable unit for control cabinet installation.

Microsoft appointed Beckhoff as an Embedded Gold Partner in November 2006. This status is awarded to companies with considerable expertise and commitment to the Embedded technology. Cooperation based on this partnership is beneficial for both sides: it enables optimum integration of Beckhoff automation products into the Microsoft world, while Microsoft can utilize experience with PC-based control technology in order to optimize its products for automation requirements. In this way, the technological convergence of IT and automation technology is successfully advanced.

Beckhoff receives the 2008 Windows Embedded Partner Excellence Award from Microsoft

As a leading manufacturer of PC-based automation components and systems, Beckhoff has received the 2008 Windows Embedded Partner Excellence Award in recognition of its innovative and creative application of Windows Embedded technology. The award was officially presented on October 7, 2008 during the Microsoft European Partner Conference in Monaco.

Beckhoff Italy: new branch office opens in Bologna

Beckhoff Automation Srl., with its head office in Milan, inaugurated a new branch office in Bologna in May 2008. With this step, the Italian Beckhoff subsidiary is confirming its rapid economic growth over the last five years. “On account of the positive development of the local market,” says Pierluigi Olivari, Executive Manager of Beckhoff Italy, “we recognized that, alongside Milan, it was necessary to open another office in the Emilia Romagna region and, above all, to strengthen technical support for our customers.” The manager of the Bologna branch office is Vincenzo Tampellini, who knows the Italian packaging industry inside-out and is very familiar with Beckhoff products and system solutions.

www.beckhoff.it

www.microsoft.com/windowsembedded
The new TwinCAT Scope 2 features separate Logger and Viewer. The Logger, which can also be installed in a Windows CE control system, records the data from different channels with time stamps and saves them intermediately. The data can come from different PCs and different software devices, including PLC and Motion Control. The Viewer fetches the data from the Logger by means of ADS and displays it.

The configuration of the Scope is also carried out in the Viewer. An assistant supports the search for variables to be recorded. Following selection of the controller, it is possible to browse inside the corresponding PLC. Individual variables can simply be selected.

The modular approach of new TwinCAT Scope 2 makes extension with new features easy. Various defined interfaces are already integrated, e.g. for alternative axes (logarithmic) or special output formats (Microsoft Excel). The data can be processed before they are graphically displayed, e.g. through a fast Fourier transformation.

Scientific Automation from Beckhoff includes integration of additional functions in the software PLC. In addition to sequential control, Motion Control and control technology, the software PLC also includes measurement technology and other components. PC Control technology with high-performance CPUs offers an ideal platform. The new TwinCAT Scope 2 is part of the Beckhoff Scientific Automation initiative.

www.beckhoff.com/TwinCAT
Utilizing a powerful CPU, ultra fast communication (e.g. via EtherCAT), real-time software and an I/O interface to the outside world, Beckhoff PC-based control technology offers the ideal system for high-precision, high-speed measuring equipment. The use of the new Beckhoff KL3681 (Bus Terminal) and EL3681 (EtherCAT Terminal) significantly increases flexibility thanks to the wide input range and automated measuring range selection. High precision and simple, high-resistance measurement from 30 mV to 300 V allows the Bus Terminal to be used like a modernized digital multimeter.

In measuring applications in particular, the expected voltage is often not known during the planning phase. Automatic adjustment of the measurement range simplifies use and reduces stock levels. The digital multimeter terminals measure DC and AC voltages; in the case of AC voltage, the effective (RMS) value is determined.

Very good immunity to interference is achieved via the complete galvanic isolation of the electronic measuring system and a measurement interval of typically 200 ms. The measured result is equivalent to that of a good hand-held multimeter, but the Bus Terminal also has an interface to all common fieldbuses via which it can be read out and parameterized.

**Measurement ranges:**

- Voltage: 30 mV to 300 V DC, 100 mV to 300 V AC
- Current: 100 mA, 1 A, 10 A AC/DC
- Resistance: 10 Ω … 10 MΩ

With its new digital multimeter terminals, Beckhoff has added enhanced measurement technology functions to its leading edge I/O system. Using the digital multimeter with fieldbus interface for measuring current and voltage, measured values can be processed directly in the I/O system or by the master controller. These dynamic measuring terminals will be available for both the Beckhoff Bus Terminal system and for the EtherCAT Terminal system.
The Industrial PCs within the C65xx series feature a heat sink for external cooling that reaches ambient temperatures through a suitable cut-out in the panel of the control cabinet. Integrated seals provide a water- and dust-proof IP 67 design.

The new C65xx series offers users maximum flexibility in terms of Control Panel configuration. The IPC can be chosen independent of the number and type of control keys or switches on the control cabinet front. The C65xx series’ compact, slimline housing with integrated IPC connections at the rear enables a flexible number of buttons in the cabinet front panel, depending on the application. In combination with TwinCAT automation software, the C65xx offers a powerful PLC and Motion Control system. Equipped with a 3½-inch Beckhoff Motherboard, the C65xx Industrial PC series is available with four types of processors:

| C65xx-0000: Intel® Celeron® M 1.5 GHz or Pentium® M 1.8 GHz |
| C65xx-0010: Intel® Core™ Duo 2.0 GHz or Core™ 2 Duo 2.16 GHz |

This IPC series is available with two kinds of storage options. The C6515-0010 is a PC without moving parts and can accommodate up to two Compact Flash cards. The C6525-0010 basic model has a hard disk and can be fitted with a second optional one for a RAID system.

New Beckhoff C65xx Industrial PC series uses control cabinets as the housing

**Built-in PC for flexible IPC solutions**

Beckhoff enhances its Industrial PC range with a new generation of built-in IPCs: with optimum flexibility in mind, the new C65xx series is designed to be installed in control cabinets or in the rear panel of a control or console housing. By integrating the IPC into an existing housing, this solution is extremely compact and, in addition, enables highly flexible push-button configurations and extension options at the front of the console housing.
Flexible IPC concept: the control housing, with integrated C65xx in the rear as well as standard panel, enables a flexible number of buttons in the cabinet front panel, depending on the application.

### Technical data: C65xx-0010
- built-in Industrial PC with external cooling for installation in control cabinets, control or console housing
- passive cooling through external cooling fins
- 3½-inch Beckhoff motherboard
- processor: Intel® Core™ Duo 2.0 GHz (optional Intel® Core™2 Duo 2.16 GHz)
- main memory: 512 MB DDR2RAM, expandable to 2 GB ex factory
- on-board graphic adapter: Intel® GMA950, DVI-I connection
- on-Board dual Ethernet adapter:
  - 1 x 10/100BASE-T and 1 x 10/100/1000BASE-T
- interfaces: 1 x RS232 and 4 x USB-2.0 ports
- operating system: Windows XP Embedded
- operating temperature range: outside 0…45 °C, inside 0…55 °C
- protection class: outside IP 67, inside IP 20

### C6515-0010
- mass storage: 1 x 1 GB Compact Flash, 1 slot free for Compact Flash
- 1 Mini PCI slot free for NOVRAM cards installed ex works
- dimensions (W x H x D): 240 x 230 x 81 mm

### C6525-0010
- mass storage: 1 x SATA hard disk, 2½-inch, 40 GB and 1 slot free for Compact Flash card (optional second hard disk for a RAID system instead of CF card)
- on-Board SATA RAID 1 controller, Intel® Matrix Storage Technology
- 1 free Mini PCI slot for fieldbus or NOVRAM cards installed ex factory
- dimensions (W x H x D): 330 x 230 x 81 mm

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www.beckhoff.com/C65xx
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 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.

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 timestamp 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 values 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.

**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.
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, 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 tunnelled so that two EtherCAT networks can also transmit large quantities of data acyclical-ly via the EL6692.

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.

www.beckhoff.com/EtherCAT
Ten years after the introduction of the CP-Link technology, Beckhoff now presents CP-Link 3, the next generation of this operating and visualization concept. CP-Link 3 is a pure software solution based entirely on standard hardware (Ethernet) and IP-based protocol for real-time transfer of images. Networking can be done using cost-effective, standard Ethernet cables (CAT 5) which are suitable for drag chains.

Using the CP-Link concept, Beckhoff has relied on remote operating elements since as far back as 1998; i.e. the control and display elements make up an independent unit, separate from the control level. The computer is housed in a control cabinet. The flexible positioning of the Control Panels gives the user a great deal of scope. While the existing CP-Link 1 and CP-Link 2 solutions are based on special hardware components, CP-Link 3 is a pure software solution.

CP-Link 1 transfers the data using a proprietary, high-speed serial bus. The IPC must have a special interface card for each display so the number of displays that can be connected is limited by the number of available slots in the PC. Data transfer to the panel takes place by means of two coaxial cables. For longer distances – over 70 m – complex, expensive coaxial cable must be used in order to guarantee fault-free data transfer.

CP-Link 2 is a combination of DVI and USB, known as “DVI/USB Extended” at Beckhoff. Both are standardized transfer techniques, however they have limitations with regards to the range and the number of displays that can be operated simultaneously. With the help of additional hardware solutions (DVI splitters, DVI extenders, USB extenders) distances of up to 50 m can be covered.
**CP-Link 3 mode of operation**

In contrast to previous solutions, the CP-Link 3 concept is based entirely on standard technologies: 100 Mbit/s Ethernet and IP protocol. The screen contents are captured by a virtual graphic adapter in the host PC and sent using Ethernet to one or more Beckhoff Ethernet Panels with Windows operating systems (CE and XP Embedded, XP). For display communication, TCP/IP or UDP/IP (Multicast) can be configured, depending on the operating mode. Four panels can be connected in the TCP/IP mode and up to 255 in the UDP mode.

There are three different operating modes for the screen display which are parameterized using the configuration menu in the CP-Link 3 software.

- **Single Desktop:** A virtual graphic adapter shows the image of the host PC on a display connected via Ethernet.
- **Extended Desktop:** One or several virtual graphic adapters are used as extensions to the host PC desktop. In this way, windows can be shown on addressed displays, i.e. program windows can be moved to any additional screen, for example. Communication takes place using TCP/IP.
- **Multi Desktop:** All connected displays show the same image. Communication takes place using TCP/IP (up to four panels) or via UDP Multicast (up to 255 panels). The benefit of Multicast lies in the fact that messages can be transferred to several Ethernet Panels simultaneously without the transmitter bandwidth multiplying by the number of receivers.

In multi desktop mode, an input can be made to each panel at the same time. The displays can be interlocked (mouse and keyboard) to coordinate the inputs. The locking functions are controlled by means of TwinCAT PLC or using an application program. The signals necessary for this are transferred by means of the CP-Link 3 protocol. Appropriate software interfaces (APIs) and PLC blocks are available for this.

The host PC transfers image signals, “virtual USB,” as well as touch screen and special key functions to the Ethernet Panel. The USB devices that are connected

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**CP-Link 1 | CP-Link 2 | CP-Link 3**

<table>
<thead>
<tr>
<th>Data transfer</th>
<th>serial high-speed bus CP-Link</th>
<th>DVI/USB Extended</th>
<th>Ethernet TCP/IP (UDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. distance from PC</td>
<td>100 m</td>
<td>50 m</td>
<td>100 m</td>
</tr>
<tr>
<td>Data transfer medium</td>
<td>2 x coaxial cables</td>
<td>1 x DVI cable, 1 x Ethernet cable (CAT 5), 1 x power supply</td>
<td>1 x Ethernet cable (CAT 5), 1 x power supply</td>
</tr>
<tr>
<td>What is transferred?</td>
<td>image, touch RS232 (keyboard, special keys), PS/2 mouse, special keys with LEDs, K-bus, voltage</td>
<td>image (DVI), USB 1.1, touch, special keys with LEDs</td>
<td>image, USB 1.1(2.0) touch, special keys with LEDs</td>
</tr>
<tr>
<td>Required hardware</td>
<td>CP-Link PCI card per display</td>
<td>DVI-E/USB-E cable set including USB Extender CU8800 or DVI/USB splitter CU8810 for up to four displays</td>
<td>–</td>
</tr>
<tr>
<td>Control Panel</td>
<td>CP60xx, CP70xx</td>
<td>CP69xx, CP79xx</td>
<td>Panel/Panel PC e.g. CP66xx, CP67xx, CP77xx (Windows CE) or CP62xx, CP72xx (CE, XP)</td>
</tr>
<tr>
<td>Software</td>
<td>Beckhoff TwinCAT or TwinCAT CP</td>
<td>Beckhoff TwinCAT or TwinCAT CP</td>
<td>Beckhoff CP-Link 3</td>
</tr>
<tr>
<td>Operating system</td>
<td>Microsoft Windows XP, XP Embedded</td>
<td>Beckhoff TwinCAT or TwinCAT CP</td>
<td>Panel/Host PC: Windows CE, Windows XP, XP Embedded</td>
</tr>
<tr>
<td>Max. number of panels which can be connected</td>
<td>3</td>
<td>1 (4)</td>
<td>4 (TCP/IP), 255 (UDP/IP)</td>
</tr>
</tbody>
</table>
transfers the standards USB 1.1 and USB 2.0. As communication takes place using 100 Mbit/s Ethernet, the USB 2.0 transmission performance (400 Mbit/s) is restricted.

The CP-Link 3 software needs to be installed on both the server and client sides. All functions, such as control locking using PLC, can also be accessed in the TwinCAT automation software suite. Ethernet Panels (Windows CE) or Panel PCs (Windows XP, XP Embedded) can be used as clients. Once started, the application software (PLC/NC, HMI, etc.) runs on the host PC; any necessary software license fees are charged only once for the host PC. The Control Panels only contain image data. If there is more than one graphics card in the PC, then only one license per application is required.

The CP-Link 3 concept is supported by all Beckhoff Ethernet Panels and Panel PCs. The requirement for this is the CP-Link 3 client software and Windows CE or XP Embedded as an operating system. The aluminum Control Panels have high-quality TFT displays in a variety of sizes and resolutions. A touch pad or touch screen can be integrated as an option. The following Panel/Panel PCs are some of the options for use with the CP-Link 3 concept:

| Built-in Control Panel CP66xx: Intel® XXP420 with XScale® technology, 533 MHz, Windows CE |
| Built-in Panel PC CP67xx: 500 MHz processor for Windows CE or XP Embedded |
| Built-in Panel PC CP62xx: incl. Intel® Core™2 Duo processors, Windows XP or XP Embedded |
| Panel PC CP77xx: 500 MHz processor for Windows CE or XP Embedded |
| Panel PC CP72xx: incl. Intel® Core™2 Duo processors, Windows XP or XP Embedded |

“Virtual USB”

In addition to image data, CP-Link 3 also transfers USB. “Virtual USB” emulates a USB root hub in the host PC. If a USB device is plugged into an Ethernet Panel, the virtual hub logs the device onto the operating system of the host PC and transparently transmits the ensuing communication. For the operating system, the USB device behaves as though it was directly connected to the PC. Virtual USB

Beckhoff Ethernet Panel/Panel PC

The Beckhoff Ethernet Panel/Panel PC concept is supported by all Beckhoff Ethernet Panels and Panel PCs. The requirement for this is the CP-Link 3 client software and Windows CE or XP Embedded as an operating system. The aluminum Control Panels have high-quality TFT displays in a variety of sizes and resolutions. A touch pad or touch screen can be integrated as an option. The following Panel/Panel PCs are some of the options for use with the CP-Link 3 concept:
EtherCAT branch terminal for PoE sensors

Power over EtherCAT has arrived

The EtherCAT I/O Terminal system from Beckhoff takes optimum advantage of the technological features of EtherCAT. To this end, this I/O system has been complemented with an additional terminal: the EK1132 EtherCAT branch terminal that supports Power over EtherCAT, based on the IEEE standard 802.3af. A standard EtherCAT/Ethernet cable is used for the fieldbus signal and the power supply.

The EK1132 EtherCAT branch terminal is particularly suitable for sensors such as shaft encoders or length measuring devices that can now be connected via a single cable. The sensor supply voltage of 48 V is generated in the branch terminal from the 24 V voltage used as the industry standard. The maximum current input of the terminal devices is 350 mA. The signal and energy transfer takes place on the same wire so four-wire cables can be used. The Power over EtherCAT (PoE) sensors are connected via a 4-pin connector, e.g. M12. The maximum cable length is 100 m.

The EK1132 uses the “resistive power discovery” procedure to determine whether the connected EtherCAT device supports Power over EtherCAT and to which performance class (as defined in the standard) it belongs. If PoE is supported, the supply is enabled. An intelligent power distribution system detects which consumer belongs to which performance class and distributes the total available power (15.4 W) to the connected devices accordingly.

Like the 2-port EK1122 EtherCAT branch terminal, the EK1132 also enables configuration of EtherCAT star topologies. Through TwinCAT and other suitable EtherCAT masters, the EK1132 also supports coupling and uncoupling of EtherCAT devices during operation (Hot Connect).

www.beckhoff.com/EtherCAT

Connection of two PoE sensors to the 2-channel EK1132 EtherCAT branch terminal

estimated market release 2nd quarter 2009
After this year’s summer slump, which was felt by the entire automation industry, Beckhoff is on the rise again, as usual. “In October, incoming orders were back to normal numbers,” Hans Beckhoff said. Also, Beckhoff managed to compensate for the summer slump with large orders from the wind energy industry. Beckhoff expects a 20% increase in sales overall for 2008, which would equate to total sales between €270 m and €280 m (roughly between $342 million and $355 million). Growth was split evenly between Germany and abroad, with the current export share of the business at 44%.

Double-digit growth strategy

The company’s long term strategy continues to be based on double-digit growth rates every year. "We are optimistic that double-digit growth is achievable over the next 10 years, and in an organic manner," the managing director said. He is convinced that, notwithstanding slowdowns, the world economy overall, and the automation market in particular, will continue to grow. "The market for our technologies, such as PC-based automation, EtherCAT and local I/O products, is developing even more dynamically since more and more users recognize and utilize their inherent benefits." Despite certain challenges associated with the global financial crisis, Hans Beckhoff is not at all pessimistic for 2009 – on the contrary, he focuses on the benefits of globalization.

Fast control technology based on standard components

The success of Beckhoff is to a large degree based on progressive technologies: two years ago, Beckhoff presented XFC (“eXtreme Fast Control Technology”) – the fastest control technology based on standard components. "With XFC, we introduced a new performance class: the 100 microsecond (µs) generation." According to the managing director of Beckhoff, the market introduction was very well received by many users: XFC is in commercial use in a wide range of sectors, including packaging, metal forming, plastics engineering and drive technology applications. For the printing industry, XFC acts as a door opener for this dynamic market segment. According to Hans Beckhoff, there are signs that the XFC idea is understood across the board and Beckhoff regards it as a fundamental technology. XFC can be used as a technology standard: software optimization, specific hardware components and fast analog and digital I/Os form the system. In addition, a significant development is expected in the area of drive equipment based on XFC technology.

Hans Beckhoff: “XFC enhances the performance of machines as well as the process and energy efficiency, which in turn, results in environmental and economic benefits for the whole economy that should not be underestimated.” According to Beckhoff, XFC therefore plays an important socio-political role: "Automation companies literally contribute to the progress of humankind." The physicist sees further scope for improvement in the already market-leading I/O response time of 100 µs: future developments will bring further improvements up to a factor of 5. "PC Control technology is very efficient and will continue to increase the performance limits and open up new application areas," Hans Beckhoff said.

New processors for Industrial PCs

Industrial PCs in particular benefit from the developments in PC technology. New Intel® processors are a driving force for automation technology. With their low power dissipation, the cost-effective Atom™ processors enable automation technology to be rounded off at the lower end of the spectrum. At the SPS/IPC/DRIVES 2008 fair in Germany, Beckhoff will present the new CX5000 Embedded PC. According to Hans Beckhoff, this Embedded PC, the ultra-compact C6915 control cabinet PC and the Panel PCs from the CP62xx and CP77xx series, equipped with Atom™ processors, offer “great potential for optimizations, not least in terms of price, for many applications.”

"Multi-core processors are more good news for automation," Hans Beckhoff said. "They represent a roadmap for further performance enhancements." One example is the C6640/C6650 control cabinet PC series with Beckhoff ATX motherboard and GM45 (Montevina) chipset. "With the Core™ 2 Quad processor, we currently cover the upper performance range," Beckhoff said. "This processor is designed for particularly ‘performance-hungry’ controllers used for synchronizing many axes, for example." According to Hans Beckhoff, the new Intel processor generation...
produces new thrust for automation. The Intel® roadmap leads to more and more processor power with decreasing power consumption, making the x86 world more and more diverse.

Software becomes even more open

The Scientific Automation concept continues to be pursued purposefully. "Scientific Automation complements the conventional areas of control technology such as PLC, Motion Control and control technology with precise and fast instrumentation and associated engineering algorithms."

What motivates a "dyed in the wool" automation company such as Beckhoff to get into instrumentation? "The performance of our PC Control philosophy offers sufficient reserve capacity for considering additional functions far beyond those handled by conventional control systems. Besides, we have already mastered the required basic technologies with high-performance CPUs, fast I/Os with measuring functions, fast EtherCAT and our TwinCAT software for signal processing." With this approach, Beckhoff seeks to create the prerequisites for signal acquisition and provide measurement solutions for the large group of PLC programmers in their familiar world: "We offer the basis for users to implement their own ideas. The aim is to take instrumentation out of its black box and into the PC." According to Hans Beckhoff, users have welcomed Scientific Automation with open arms. However, he does not regard Beckhoff as a competitor for established instrumentation providers: "The world of instrumentation is large and diverse, with little overlap."

TwinCAT already integrates a wide range of functionalities for Scientific Automation, such as TwinCAT analysis, signal display and tracking with TwinCAT Scope. According to Hans Beckhoff, one of TwinCAT's key advantages is that it can correlate external and internal software-generated signals. "External instrumentation boxes can only handle external signals," Hans Beckhoff said. This limits flexibility.
The I/O terminals are also consistently complemented for these requirements. Solutions that have already become established include high-precision EtherCAT I/Os for temperature measurement or general analog value acquisition. A more recent addition is a digital voltmeter terminal for logging electrical parameters.

Published in openautomation 06/2008, VDE-Verlag, www.openautomation.de
The use of regenerative energies is, of course, highly topical on account of the world’s ever dwindling fossil fuel resources. The wind turbine market is booming and competition among suppliers is increasingly fierce. This is why it is not unusual for wind turbines made by different manufacturers to be operated in the same farm by the wind farm operators. Up until now, proprietary protocols have often been used for the necessary communication between the wind turbines and the control station, which was the cause of considerable expense for the required adaptations on both sides. In order to minimize these costs, wind turbine manufacturers and operators sat down together at the table and, during harmonization work that lasted several years, wrote the IEC 61400-25 standard, which governs communication for the supervision and control of wind turbines. On the basis of this standard, turbines and control stations from different manufacturers can now communicate with one another without problem. Particular importance was placed on the simplicity of the communication. However, this does not mean that complex procedures cannot also be managed using this protocol. The object-oriented approach simplifies configuration, diagnostics and maintenance for all concerned.

IEC 61400-25 is based on IEC 61850, a general transmission protocol for protective and control equipment in medium and high voltage electrical switchgear (station automation). Physically, the communication is based on Ethernet and TCP/IP (Transmission Control Protocol/Internet Protocol); MMS (Manufacturing Message Specification) is used for client-server communication. Published in 2004, IEC 61850 is strictly object-oriented and its data models are hierarchically structured. The objects are self-descriptive, i.e. the structure of the objects is transmitted with the telegram. Besides MMS and TCP communication, the standard also offers fast access to measurement data, which is exchanged directly via Ethernet. An OPC layer can also be used in place of an MMS layer.

In the field of telecontrol engineering, Beckhoff has implemented a great many protocols in its TwinCAT automation suite. The protocols from IEC 60870-5, the predecessor to IEC 61850, are already used in many areas of telecontrol engineering. Alongside classic telecontrol in the field of energy supply, this also includes the automation of tunnels and roads, for example. IEC 60870-5 describes connection-oriented protocols for various areas of application: IEC 60870-5-101 (telecontrol tasks with serial communication), IEC 60870-5-102 (counter state evaluation) and IEC 60870-5-103 (serial communication of digital protective devices). Communication can take place via TCP/IP with the IEC 60870-5-104 protocol.
IEC 61400-25 communication standard
The TCP/IP basic transmission protocol is data-stream-oriented, i.e. no statements about the start, end or length of a message are contained in the telegrams. However, these statements are extremely important for the automation technology since, as in the upper layers of the IEC 61400-25 communication stack, the working method is message-oriented. One possibility of sending and receiving single messages via a TCP data stream is represented by the ‘Request for Comments 1006’ (RFC1006). This protocol extension with the title ‘ISO Transport Service on top of the TCP’, which is integrated in the TwinCAT PLC, is based on the data-stream-oriented TCP protocol and makes message-oriented communication available to applications. In addition to the TCP data, further information is transmitted between the devices here in order to provide certain services to the user (ISO services as an extension to TCP).

The ‘Abstract Syntax Notation One’ (ASN.1), see figure 1, is a description language with which data and information can be described independently of the environment in which they specifically occur. It is used, for example, to describe the data transferred from the ‘session layer’ to the ‘presentation layer.’ The ‘Basic Encoding Rules for ASN.1’ (BER) provide the necessary clear encoding of the data. ASN.1 is the only abstract syntax to have been standardized by the ISO so far. Special TwinCAT PLC blocks assume the encoding and decoding of the BER rules, independent of the IEC 61400-25 protocol.

The ISO standard 9506 ‘Manufacturing Message Specification’ (MMS) defines the object-oriented exchange of data. The protocol concerned is an application protocol (application layer) that, among other things, forms the basis for the IEC 61850 transmission protocol. MMS provides the subordinate protocols with a large number of services for manufacturer-independent communication. Furthermore, MMS is based on a strict client-server model, in which a client sends orders or requests to a server. The services required for this communication are usually ‘confirmed services.’ The principle of this classic type of communication can be seen in figure 2.

The services defined in IEC 61850 for the exchange of data are mapped on MMS services so that access can be gained to the communication stack. In order for the standard to be independent of the MMS protocol, the mapping of the services takes place via an abstract service interface. This ACSI Interface (Abstract Communication Service Interface) allows universal connection of the standard to the subordinate protocols. In this way, connection via Web services (OPC) could be possible in future without specially adapting the IEC 61850 standard for this purpose.

The IEC 61400-25 data model
IEC 61850 forms the basis for IEC 61400-25; for this reason, the data or object models are identical for both standards. The data contained in the basic standard is used to a large extent by IEC 61400-25 and is supplemented by several pieces of information specific to wind power. This also applies to further specializations of the basic standard. For example, standards for hydroelectric power plants and distributed energy resources are currently being defined.

Since the data exchange is standardized rather than the application functions in this standard, it is referred to as a data or object model. This is subdivided into five hierarchical levels:

- Server
  - Logical Device
  - Logical Node
  - Data Object
  - Data Attribute

The server offers the connection point of a device to the communication system, thus forming the uppermost hierarchical level. Since this logical connection point can be implemented at several points, it permits a redundant structure.

The second hierarchical level subdivides a single physical device into several sep-
'Alpha Ventus' pilot project: offshore application at sea

The TwinCAT PLC libraries for IEC 61400-25 communication will be used for the first time in a German offshore wind farm on the North Sea. The test phase with the responsible control system manufacturers went very well and speaks in favor of the development strategy pursued by Beckhoff.

The Alpha Ventus offshore wind farm, around 45 kilometers (28 miles) north of the island of Borkum, is the first German wind farm at sea. The design, construction, operation and grid integration of the Alpha Ventus research project will provide invaluable insights for the future commercial utilization of offshore wind farms. For 2008 the project schedule includes construction of the southern half of the wind farm with six Multibrid M5000 turbines and an offshore substation. The M5000 is a 5 MW offshore turbine. Multibrid has overhauled the control concept in close cooperation with Beckhoff and has based it on a uniform platform.

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Wind special PC Control 02/2008 www.pc-control.net
Multibrid www.multibrid.com
Alpha Ventus project www.alpha-ventus.de

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The third hierarchical level is formed by the logical nodes. These represent the information from all conceivable sub-functions that could exist in the digital station control technology in wind turbines, such as all safety functions, automation functions and functions for the processing of measured values and counter readings, among others. Defined identifiers in the form of an abbreviation with four functions and functions for the processing of measured values and counter readings, are thereby appended to one another, for example as in the status query variable is required. The different hierarchical levels down to the basic type are thereby appended to one another, for example as in the status query WEA/WTFRSTrOpTmRs$manRs$StVal, which a control station sends to a wind turbine. In this case, the object status of the node 'wind turbine transformer information' is queried or read.

Several such references can be summarized by means of so-called data sets and transmitted together by means of reporting functions, which are defined in the standard as 'saving' or 'non-saving.' In this way, the individual calling of the references for data objects that are mostly communicated in context to one another can be dispensed with.

Realization in TwinCAT PLC

The communication stack has been implemented in the TwinCAT PLC in the form of libraries. In doing so care was taken that, if possible, every layer of the 'Open System Interconnection Reference Model' (OSI model) is implemented independently, i.e. its own library. The decisive libraries for the user are TcIEC61850.lib for the basic standard and TcIEC61400_25.lib for specialization in the field of wind turbines. TcIEC61850.lib contains all of the basic data types defined in the standard. On top of that, the entire data model described in the standard can be found in this library; 91 predefined logical nodes and 29 common data classes are available to the user for the compilation of their logical devices. All of the services required for reading the created data structure are similarly contained in this library. All nodes and data classes specific to wind turbines are implemented in TcIEC61400_25.lib and can be used in conjunction with TcIEC61850.lib for communication in wind farms.

This division into individual libraries provides the advantage of ensuring the clearness and modularity of the products. After all, we are dealing with two different standards, each of which can be considered to be a separate implementation layer. Therefore, the consistent and independent development of libraries, as applied to the OSI model, will be continued.

The simple configuration of logical devices is clearly shown by the following example: a logical device with the name MyWEA (instance of ST_LD_WEA) is created as a structure in the TwinCAT PLC. The mandatory nodes LLN0 (logical node zero) and LPHD (logical node physical device) must be integrated in each logical device, as is also described in the two standard parts described here.

Figure 3: Instances of several logical nodes in a logical device ST_LD_WEA

On top of that, all of the nodes specific to this device can be implemented. In our example, these are the logical nodes WGEN (wind turbine rotor information), WROT (wind turbine rotor information), WTW (wind turbine tower information), WTRF (wind turbine transformer information) and WTW (wind turbine general information). Since all of the logical nodes are already available in the respective libraries, they need only be instantiated by the user. The data objects of the nodes are located on the next lower hierarchical level and the standard thereby distin-
guishes whether it is mandatory, conditional or optional for a data object to be contained in a logical node. If a customer wishes to communicate the default data objects, it is sufficient to create the device MyWEA. If optional data objects are not to be communicated, it is possible to comment these out. This procedure is clearly shown in figure 4 using the logical node WROT as an example:

![Logical Node WROT with ‘mandatory’ and ‘optional’ Data Objects](image)

In this case, the optional data objects for the hydraulic pressure of the pitch system are not communicated. Further development work will be aimed at making “commenting out” easier for the user.

All in all, it becomes clear that the high development expenditure is reflected by a low application expenditure for the customer. Once the user has configured all of their devices, the user can begin communication with any client that supports the IEC 61850 and IEC 61400-25 standards. In the initialization step, the created data structure of the server is loaded first. After that, it is possible to execute a password query during the establishment of a connection with the Beckhoff server. In this way, connection requests from unauthorized clients can be denied. To do this, only the password query (bAccessControl) needs to be switched on and the authorization mechanism set up, as can be seen in figure 5. Several passwords for various users can be specified using the accessCtrl array.

If the server has accepted the client’s connection request, the latter can read out the data structure of the server. The exchange of the data, which is encoded with the BER Encoding Rules, takes place via TCP/IP. For this type of communication, the TwinCAT-TCP/IP connection server is used, which enables one or more TCP/IP server clients to be implemented in the TwinCAT PLC. This tried and tested supplementary product from Beckhoff allows a server to be implemented on the basis of Windows XP and Windows CE systems. The IEC 61850 communication services responsible for data exchange are, as described, mapped on MMS services.

The most important of these are the reading and writing services. In order to use the reporting function mentioned in the 'Data model' section, the user must create data sets, which allow access to an arbitrary number of data objects using a single name. This name, or rather the reference to the data set itself, is merely a single reference to several specific references of the data objects. In order to create such a data set, the number of objects and their references must be transferred to the function block (see figure 6). The data set is given a unique name, which is transferred to a report block that, on account of occurring events, triggers the transmission of the data set. Events are taken to mean the evaluation of the so-called trigger options. The report block can thereby be informed of the type of event to which it should react: if it reacts to a data change, it communicates the data as soon as a value within this set changes.

**Practical experiences and outlook**

During the initial server development phase, demo clients from various suppliers offered an initial useful test platform. The development team deliberately developed no test client of its own so as to avoid any vendor-specific solutions. In this way, it was possible from the first development step onwards to test and ensure the server’s conformity to the standard.

The next development steps will focus on the further improvement of user-friendliness. Among other items, it is intended to develop tools to replace the commenting out of optional data objects in common data classes. Similarly, other protocols besides MMS, such as Web services or OPC, should be integrated in order to offer the customer more flexibility. A completely different aspect is the development of the GOOSE channel used by this standard. GOOSE stands for ‘Generic Object Oriented Substation Events’ and is responsible for the exchange of high-priority real-time data. Real-time communication can be used for protective triggers and blocks, and is based directly on Ethernet technology.
EtherCAT topology types and their influence on system characteristics

EtherCAT is the real-time Ethernet fieldbus for automation applications. In addition to top performance and low system costs, EtherCAT also offers flexible topology options. The Beckhoff system fully utilizes all EtherCAT technology features such as redundancy, Hot Connect, hot swap or synchronization of several EtherCAT networks. To this end, the EtherCAT Terminal system has been continuously expanded with a vast range of I/O terminals.

EtherCAT operating principle
EtherCAT is an Ethernet-based communication technology that is optimized for the special requirements of advanced automation technology.

It uses standard Ethernet cables, such as those used for office networking. The EtherCAT master controlling the network and the communication (EtherCAT is a master/slave system) is managed in software on an Industrial PC, for example. The only hardware requirement is a standard network card.

The EtherCAT slave devices are based on a special EtherCAT communication chip referred to as the EtherCAT Slave Controller, or ESC, which handles all process data communication. It ensures uniform transfer speed and reliable communication, irrespective of the device-specific implementation.

The process data are exchanged between EtherCAT and the application controller via common process data interfaces with a DPRAM.

The network topology can be determined online via the EtherCAT network configurator by reading the port number and link status for each individual device. The address space offers the opportunity to address more than 65,000 devices in one segment. The operating state of all devices is checked during each cycle. Device errors are detected synchronously with the cycle, so that the application program can respond in real-time.

Processing “on the fly”
EtherCAT datagrams are processed dynamically. Read and write accesses are only executed on a small section of the telegram. The telegram is immediately forwarded to the next EtherCAT device (see figure 1) (i.e. it is not received first, then processed and then sent).

Processing sequence
EtherCAT operates in full duplex mode. Telegrams are sent on a wire pair in the processing direction, from the master to the slave. The EtherCAT device processes the frames only in this direction and forwards them to the next device until the telegram has passed through all devices. The last device returns the telegram via the second wire pair in the cable back to the master in the forwarding direction. EtherCAT always forms a logical ring structure, irrespective of the chosen topology (see figure 1).

Standardized system time and synchronization
EtherCAT devices implement a high-precision time in hardware, more precisely in the ESC. These distributed clocks (DC) give the EtherCAT synchronization mechanism its name. The first DC device after the master is usually used as a reference clock to which all other devices are synchronized. This includes compensation of different clock start times, including the master clock, and delay due to cables and other hardware. The uniform timebase generated in this way can be used to implement applications with simultaneous and synchronous read or write access to several devices. This mechanism provides a timebase with a deviation of well below 1 µs for high-precision drive or measuring applications.

Physical layer and signal generation
EtherCAT is transferred on the following media: 100BASE-TX, 100BASE-FX and E-bus. E-bus, which is based on the LVDS physical layer, is used for internal com-
munication and can be implemented in a compact and cost-effective manner. The 100BASE encoding options are connected with the ESC via PHYs. The MII (Media Independent Interface) is used as the interface. Each ESC generates a new physical signal so that a uniform signal quality is achieved, irrespective of the topology. It also permits an unlimited number of media changes.

**Topology options with EtherCAT**

Topologies can differ significantly in terms of complexity. Bandwidth options include simple topologies such as line, tree, star or mixed configurations, as well as topologies with cross-segment and cross-system data and time stamp exchange.

**Tree structure**

The tree structure combines the "daisy chain" topology with a stub/line topology. EtherCAT supports these classic topologies in pure form and in any combination. EtherCAT devices differ in terms of the number of ports. Devices with more than two ports (many ESCs support up to four ports) are used for connecting stubs (figure 2).

**Star topology**

In the EtherCAT Terminal system, the star topology can be conveniently implemented with the EK1122 2-port EtherCAT branch terminal. Like the tree topology, the star topology has the advantage that a device failure or line interruption does not lead to uncoupling of other devices (see figure 3). With this topology, the logical ring and the real-time characteristics based on it are maintained.

**Hot Connect**

Hot Connect allows decoupling and coupling of devices or segments during operation. The EK1101 and EK1501 EtherCAT Couplers (fiber-optic) with additional ID switch make this process particularly convenient: they are detected regardless of their position in the network and can be connected to any free port. Thanks to the characteristics of the EtherCAT Slave Controller, the coupling process is detected very quickly. Ports can be switched off from the master before the device or segment is uncoupled.
Ring structure for cable redundancy
The ring topology is used for implementing cable redundancy (see figure 4). To this end, the last device in the processing sequence is connected to the master. Any device with at least one free MII port can be used as the last device. The only additional hardware device used for redundancy purposes is a second Ethernet port; otherwise the master remains a software implementation.

Synchronizing several EtherCAT networks
Data exchange between two or more EtherCAT networks can be easily achieved using several switch ports or a bridge (figure 5). Two switch ports from different segments can be connected for data exchange purposes. In addition to data exchange, the EL6692 EtherCAT bridge terminal can also be used for synchronizing networks in order to make a homogeneous timebase available across system boundaries. This is particularly beneficial for test rig construction or modular machines with several controllers, for example. In addition, EtherCAT offers further master/master communication options.

Master/master communication
For acyclic or cyclic data exchange, masters can be connected directly with standard switches and a second network card, or alternatively via an EL6601 (1 port) or EL6604 (4 ports) EtherCAT switch port terminal.

Slave/slave communication
For data exchange between different slaves, the master takes on the function of a router. The master copies the data read by a device from the input process image to the output process image before they are sent. This may even take place within the same control cycle. For applications with particularly stringent requirements, the topology-dependent version of slave/slave communication can be used: one device adds data to the telegram in transit, which are then analyzed by downstream devices.

The full article is available from www.pc-control.net

- EtherCAT www.beckhoff.com/EtherCAT
- EtherCAT Terminals: www.beckhoff.com/EtherCAT-IO
Planning aid for users

Some of the main network planning issues are explained below.

Calculation of the pass-through time
Since EtherCAT uses full duplex, several telegrams can be sent successively without having to wait for the return of the previous frame. The cycle time is, therefore, not the same as the pass-through time. However, in practice the latter is often specified as the minimum cycle time. Disregarding all optimization options and the symmetry of input and output data, it can be determined as follows:

\[ t_{\text{Delay}} = m \times t_{\text{E-bus}} + n \times t_{\text{MII}} + t_{\text{PD}} + 2 \times t_{\text{Cable}} \]

### Delay Description
- \( m \times t_{\text{E-bus}} \): delay due to \( m \) devices with 2 E-bus ports
- \( n \times t_{\text{MII}} \): delay due to \( n \) devices with 2 MII ports
- \( t_{\text{PD}} \): + delay due to process data length (outputs + inputs)
  - at 100 Mbit/s (neglecting the fact that the process data length in the frame is halved for a symmetric ratio of I/O data per device)
  - + 26 bytes overhead per Ethernet frame
  - + 12 bytes overhead per datagram
- \( t_{\text{Cable}} \): delay due to 100BASE-TX cable (~ 5 ns/m).
- \( t_{\text{P}} \): delay in processing direction
- \( t_{\text{F}} \): delay in forwarding direction

### Delay due to a device with 2 E-bus ports (\( t_{\text{E-bus}} \))
The delay due to an EtherCAT device with two E-bus ports (e.g. modular I/Os) is determined through the hardware delay of the ESC and is around 0.3 µs.

### Delay due to a device with 2 MII ports (\( t_{\text{MII}} \))
The delay due to an EtherCAT device with 2 MII ports (e.g. drive) is determined through the hardware delay of the ESC and the two PHYs. It is around 1.2 µs, depending on the PHYs.

Choice of topology
With EtherCAT, the choice of topology has no negative influence on the functionality, real-time or other features. This fact allows the topology to be tailored to the physical extent of the system and the application of special functionalities, such as Hot Connect or redundancy.

Use of Hot Connect
Many applications require a change in I/O configuration during operation. Examples include processing centers with changing, sensor-equipped tool systems or printing machines in which individual printing units are switched off. The protocol structure of the EtherCAT system takes account of these requirements: the Hot Connect function permits parts of the network to be linked and decoupled or reconfigured “on the fly,” offering flexible response capability for changing configurations (see also figure 3).

Use of Hot swap
If a complex device is replaced, the replacement device must be parameterized identically. This requires knowledge of special configuration tools and the relevant parameters. In many cases, this expertise is not available on the spot. With EtherCAT, this problem can be circumvented through the hot swap functionality. The parameter data are stored in the master and automatically transferred when the device is switched on.

Use of distributed clocks
The functionality of the distributed clocks (DC) synchronization mechanism is independent of the network structure. Devices with and without DCs can be positioned as required. The EtherCAT master automatically synchronizes the clocks without the need for special user settings.
Multivac, the packaging machinery specialists with headquarters in Wolfertschwenden, Germany, makes its mark with peerless competence in packaging, products and applications. Multivac thermoformers are considered by many in the packaging industry to be the best in the world. But the company also represents top quality and unique solutions as a manufacturer of traysealers and chamber machines. For control technology, Multivac relies on PC-based control from Beckhoff.

Perfect packaging with PC Control

Whether in the refrigeration room of a meat products plant, in the clean room of a sterile goods producer or on the deck of an offshore fishing trawler: Multivac packages the goods anywhere, anytime.
Packaging machines from Multivac are efficient, robust and reliable. The development, design, manufacture and mounting of the machines is carried out exclusively in-house, so that all development and production processes dovetail precisely. Total commitment to quality is Multivac’s recipe for success. This means that the company’s expectations on its business partners, the manufacturers and suppliers of components and accessories, is equally high. Multivac only uses individual components with optimum functionality and the highest possible performance.

Performance, price and strength of innovation are what count

The Multivac R 535 thermoformer series raises the bar for performance: it fully and automatically packs the most varied food products, such as sausage, fish and cheese, but also industrial goods and sterile medical goods in – depending on requirements – vacuum, protective gas, skin or blister packs. "With a cut-off length of 1,600 mm and up to 30 cycles per minute, the R 535 is currently the best thermoformer on the market," according to Alois Allgaier, division manager for control technology at Multivac. One of the many ways the R 535 sets itself apart from previous thermoformers is its innovative control technology. When choosing the control technology, Multivac investigated a total of 10 leading companies in the automation industry. The selection requirements were: modularity with a wide range of functionality, optimum networking capability, scalability, reliability, ease of maintenance, simple operation and open architecture. The decision was finally made in favor of Beckhoff. "We were able to implement all the requirements set out in our specification book for the ‘New Generation of Control Technology’ project using the Embedded PC solution from Beckhoff," explains Alois Allgaier. "PC-based technology has been tried and tested for years and is widely used. Using Beckhoff, the technology leader in PC-based control technology, we are confident not only of meeting our current requirements, but also of being able to react early and quickly to new trends and rising market demands looming in the future, guaranteeing our technical advantage," Claus Botzenhardt, departmental manager for software development at Multivac, explains the decision, adding: "Naturally, the impressive price-to-performance ratio was also a deciding factor."
Embedded PCs at the core of the control system

Multivac now employs PC-based control technology from Beckhoff in all fully automated machines in its production range. At the core of the machine control systems are Embedded PCs from the Beckhoff CX series loaded with Windows XP Embedded as the operating system and TwinCAT automation software. “It all began with the development of the new R 535 thermoformer,” recalls Claus Botzenhardt. “At the end of 2005 we used the CX1000 Embedded PC in our first prototypes. We have gone into large-scale production since the beginning of 2007 and have so far delivered approx. 1,500 packaging machines equipped with the CX1020 Embedded PC.”

The space-saving CX1020 controller for the terminal stations is located in the control cabinet. “Depending on the complexity of the machines and the control technology, we install an Embedded PC with the appropriate performance level. We use it for the PLC, Motion Control and our visualization developed in Java. Installing the PC Control technology with Microsoft Embedded operating system provided the opportunity for integrating the HMI in the control system. This meant we could do without an additional PC for visualization,” explains Alois Allgaier. The Multivac operating panel is connected to the CX via DVI/USB. The Ethernet interfaces allow integration into the company network and provide the Internet connection, giving the option of remote maintenance. CX system interfaces and fieldbus connections (which can be added as modules) can integrate motion solutions using CANopen or DeviceNet, for instance.

The Multivac product series ranges from small machines for manual packaging up to complex packaging plants for large-scale production. In the fully automatic machines, the Embedded PC used as the central control unit ensures optimum machine processes. Due to the CX being directly connected to the I/O terminals, an additional fieldbus is unnecessary in the more compact models. A local control system with several Embedded PCs can be supplied for very large and complex packaging plants.

Modularity permits individualized offerings

“Our packaging machines are a standard product to a large extent, however no one automated packaging line is like another. We develop our packaging solutions flexibly and in accordance with our customers’ requirements,” Alois Allgaier explains. “Our machines are constructed on a modular basis so that we can individually configure customized solutions and adapt the modules in the best possible way. The modular product range from Beckhoff suits us very well at the control technology level. For every configuration we are able to select the optimum components for each application, e.g. from the comprehensive Bus Terminal I/O product range.”

In the R 535, Multivac integrates Beckhoff Bus Terminals and sensors for temperature recording using thermocouples or odometers with SSI sensor interfaces as well as ancillary equipment for printing or cutting the film in the control system. For example, special function I/O terminals are used to position the stepper motors in the printers. Communication terminals and the wide range of Bus Couplers can also integrate devices with serial interfaces and other fieldbuses such as CANopen or DeviceNet.

TwinSAFE: safety simplified

Safety components such as emergency stop switches and protective coverings provide the necessary safety elements for packaging machines. Previously, Multivac wired the safety components in a conventional way. In the R 535, the safety functions are integrated directly in the Bus Terminal system using TwinSAFE terminals. The safety data are recorded on site and evaluated in the TwinSAFE Log Terminal. The certified TwinSAFE protocol ensures secure communication.

“TwinSAFE drastically reduces the costs and time involved in wiring,” according to Alois Allgaier. “The benefits of the modular, scalable technology from Beckhoff are obvious here too. We select the necessary TwinSAFE terminals depending on the...
machine and integrate them in the control system. This is simple, convenient and cost-effective as well.” In order to fully exploit the potential of TwinSAFE and to improve the reproducibility and precision of the machines through shorter cycle times, Multivac changed its control system to EtherCAT, the ultra fast Ethernet-based fieldbus for industrial applications. “EtherCAT brings us a big step forward technologically. The signals are captured more quickly and the machine cycle times are optimized. This enables us to better exploit the potential of the PC-based control system with its high-performance processors and to control the axis modules of our plant more rapidly and precisely. This means our machines will be even more efficient and reliable,” remarks Alois Allgaier confidently on the introduction of EtherCAT technology and adds: “Thanks to the technological innovations from Beckhoff in the area of control technology, such as TwinSAFE and EtherCAT, we see ourselves well equipped for the future.”

Implementing complex processes simply with TwinCAT

The R 535 thermoformers package large batches of product with optimum heat-sealed seam strength and functionally diverse labeling in a short space of time. TwinCAT controls the complex packaging processes such as molding, filling, sealing and cutting very precisely and reliably in real-time and synchronizes them. However, Multivac uses TwinCAT not only as a control platform, but also as a development environment. “Programming our new modular software architecture according to IEC 61131 using structured text was managed without difficulty by our experienced C programmers. The debugging functions in the TwinCAT PLC controls in particular saved time in the case of complex function blocks,” explains Alois Allgaier. PLC libraries with blocks based on PLCopen Motion Control and the OMAC PackSoft standard (PackAL) facilitate programming. Standards such as the OMAC Packaging Guidelines offer a consistent interface for packaging machines worldwide.
Important parameters for the quality of the packaging are well molded cavities, a precise positioning of the lower film in relation to the upper film and strong sealed seams. This requires precise control of temperature, time and pressure and printing mark control. For the controllers, Multivac makes use of the comprehensive TwinCAT libraries. The temperature controller sets the heating temperature for molding the cavities and for sealing. In thermal sealing, the temperature is controlled in such a way that a homogeneous temperature distribution is produced and as a result, reliable and strong sealed seams can be made even under conditions which are not quite optimal. Positioning of the lower and upper films with one another is carried out using the printing mark control system. By stretching the upper film, the product imagery is aligned with the cavity and is positioned on the packaging with great precision.

One machine, many diverse applications

Repeated change-overs are no problem for the R 535. Depending on the packaged goods, one machine can produce both round, angular and oval packages as well as tall or flat ones. The machines are equipped with several format settings for this. A change of format can be initiated at the touch of a button i.e. the molding plate and the sliding sealing unit are exchanged and new instructions are loaded and started in the machine control system. “Using TwinCAT we are able to perfectly coordinate all components and configurations in the machine. This results in high reliability and perfect packaging results all the time,” says Claus Botzenhardt and adds: “Independent of the hardware, we are able to use applications developed using TwinCAT on different types of packaging machines.” For example, Multivac transferred the application software for the R 535 thermoformers to chamber machines in the Multivac TC range, which are based on a different functional principle. “This level of flexibility is unique to-date. We equip simpler machines with an existing, more complex software and achieve additional functionalities as well as standards which enable completely new applications,” adds Alois Allgaier. For instance, it was possible to integrate the temperature controller for the thermoformer into the chamber machine in the TC range in order to achieve validation of the sealing temperature. In addition, the operating software for the chamber
Multivac

Multivac has created innovative packaging solutions for over 45 years. Multivac’s thermoformers, traysealers, chamber machines and special machines package food, industrial products and consumer goods, as well as medical products and pharmaceuticals safely, reliably and hygienically. Every year Multivac produces over 1,200 automated packaging machines and more than 4,200 semi-automatic machines and is a worldwide market leader in the thermoformer sector. Developing countless customized packaging solutions has resulted in an unsurpassed expertise in the market sector. The global company has over 2,600 employees today.

Networked and reliable

Packaging alone is not enough – only integration with upstream and downstream components leads to a complete packaging line. Depending on the application, the automatic packaging machines are combined with slicers and infeed, dosing, weighing, labeling, testing and discharge systems of all kinds. The additional modules are registered in TwinCAT and integrated in the machine process sequence. Additional test programs for optimizing individual parameters and fine adjustment can be easily integrated in TwinCAT. The machine control synchronizes all the modules, irrespective of whether they are before, on or after the machine, and controls the timing.

The king of clean

The food and medical industries in particular demand the highest cleanliness and sterility standards. For the R 535, Multivac developed a novel cleaning process, currently unique to thermoformers, the CIP self-cleaning system (Clean in Place). The CIP automates the chemical cleaning of chain carriers, chain profiles and internal components using a comprehensive system of nozzles and pipes. After pre-cleaning, a simple touch of a button starts a standardized cleaning program which proceeds in clearly-defined stages. The process is automated and logged in the machine control system using TwinCAT. Users can employ a set cleaning program from Multivac or define one of their own and integrate it into TwinCAT. Depending on the program selected, TwinCAT loads the correct instructions and processes them. The cleaning process proceeds in full each time with consistent thoroughness and can be documented and followed at all times.

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The automated packaging machines must be able to operate with high productivity and reliability. Current machine data, production volume, current process status and errors must be recorded, analyzed and evaluated. The Embedded PC records all machine data and stores it for further applications. The data can be accessed via the Internet for remote maintenance of the machine. The recorded data can be exchanged between the machine control of a packaging plant and production data acquisition (PDA) using Ethernet and the optional TwinCAT OPC interface. Here, data is stored, evaluated and visualized. The easily operated process control enables rapid recognition of deviations from the desired condition so that counter-measures can be taken immediately. This guarantees permanently stable machine performance and consistently high daily reproducible packaging quality with more calculable running costs.

Packaging long-term success

Thanks to its presence in over 100 countries with almost 60 of its own marketing companies and decentralized spare parts distribution, Multivac guarantees on-schedule delivery, a reliable spare part supply with availability even after 20 to 30 years, as well as rapid response to market requirements. In line with this, Multivac also places obligations on its suppliers to adhere to a demand-oriented component supply in accordance with the Kanban principle. Claus Botzenhardt is satisfied with the control system solution for the R 535: “This new generation of machines – and the control technology which goes with them – is significantly more complex than our earlier range of models. But despite the higher complexity, we can offer the dependability and process reliability typical of Multivac automatic packaging machines using the Beckhoff control system.” “This control solution also has the considerable advantage for us that a system with such scalable capacity also meets our economic requirements. Due to the modular design we can react in a flexible way to future demands," concludes Alois Allgaier.

Multivac thermoformers

Thermoformers provide the most diverse packaging solutions for food, industrial and consumer products and sterile medical goods: from the high-speed packaging line for 40,000 hypodermic needles or 3,000 kilograms of meat per hour to the flexible packaging center for small batches with programmable format change. Molding, filling, sealing and cutting take place inline on the same machine, but at successive stations. The packing material for the lower web is pulled from a roll, heated in a molding tool and shaped into cavities. The cooled packing cavities are filled manually or automatically. The upper web packing material (lid film) is pulled from a second roll and positioned on the filled cavities. In the sealing station, the air is evacuated; if necessary, a protective atmosphere is added and the package is sealed using heat and pressure. Finally, the web of packs is divided up, first cross-wise and then length-wise.
As the name implies, the Accel tandem press from Accurpress can operate in tandem or simplex mode. In tandem mode, the presses are synchronized such that they operate like a single press and can bend sheet metal components with a length of up to 14 meters with high precision. If the full capacity is not required, the presses can bend shorter components in simplex mode. This makes expensive special machines for bending longer parts that rarely operate at full capacity but require a lot of space unnecessary. Depending on the size of the sheet metal components and the batch size, the coupled press brakes operate in simplex or tandem mode with a speed of 20 mm/s and a parallelism accuracy of ±0.01 mm. “We created the first tandem press following a request by a customer,” said Alex Kvyatkovski, R&D Team Leader at Accurpress. “It was clear to us that the coupling should be implemented via the control system. Together with Beckhoff, our control equipment supplier for all Accell presses, we achieved the coupling via real-time Ethernet.”

Real-time Ethernet couples the work of two presses

At the core of each Accell press is a C6240 control cabinet Industrial PC from Beckhoff with Windows as the operating system and the TwinCAT automation platform. In addition to PLC functionalities and Motion Control, the C6240 also deals with HMI integration. Rugged Beckhoff CP7037 Control Panels with TFT displays are used as HMI. EtherCAT, the ultra fast Ethernet-based fieldbus for industrial applications, links the I/O level with the control system. EtherCAT offers low cycle times and therefore high precision and repeat accuracy in a cost-effective
manner. Beckhoff EtherCAT Terminals integrate the sensor and actuator level with the control system. Serial interfaces are available via the IPC.

**Openness simplifies coupling**
The clear hardware architecture, in conjunction with the open TwinCAT automation platform, creates practically unlimited flexibility. Accurpress can adapt any press to customer requirements without great effort. Functions can be modified and complemented simply through programming, without the need for special hardware.

Similarly, two presses can be easily coupled to form a tandem press via real-time Ethernet communication. On the hardware side, the C6240 IPCs are complemented with a standard Ethernet fieldbus card and networked with standard Ethernet cables, further reducing cost. The devices are addressed directly via the hardware addresses of the network cards.

The press brakes operate based on the master/slave principle. Depending on the application, one press acts as the master while the other press acts as the slave. For switching from simplex to tandem operation, the machine operator selects the respective master and slave, and uploads the recipe to be processed to both control computers. From then on, the machine operator only uses the operating panel of the master and the slave follows the mode of the master (manual, semi-automatic or automatic).

**Real-time communication optimizes processes**
The controllers of the coupled presses communicate using the publisher/subscriber model (TwinCAT network variables). Each controller acts as publisher and subscriber, creating a permanent bidirectional data link. In general, the publisher sends information without concern for proper configuration. Communication monitoring takes place in the subscriber. The publisher makes its current machine data (actual and set positions, velocities, recipe steps, job and machine status) available to the subscriber of the other machine with a cycle time of 2 ms. In simplex mode, the receiver deletes the data. In tandem mode, the subscriber receives the data intended for it, while the machine control system processes them and controls the press according to the current process data. While running in tandem mode, the presses are synchronized through continuous bidirectional data exchange and adaptation of the machine control parameters. In parallel, the machines also monitor their respective states and main bending parameters such as mute, pinch and retrack point. “Real-time Ethernet coupling based on the publisher/subscriber model offers a cost-effective and convenient way of implementing precise tandem presses with high repeat accuracy and process reliability,” said Alex Kvyatkovski. “In addition to bending straight edges, we can now bend oblique edges by using different recipes with different start or target positions.”

Accurpress  [www.accurpress.com](http://www.accurpress.com)

Beckhoff Canada [www.beckhoffautomation.com](http://www.beckhoffautomation.com)
The production company Pollmann, based in Karlstein, Austria, has been competing successfully for almost three decades in the global, perpetually hard-fought automotive supplier industry. This innovative company has specialized mainly in the development, prototype manufacture and series production of electro-mechanical subassemblies made of plastic and metal used in insert and outsert techniques, and today manufactures components for sunroofs, door locking systems and drive units for lumbar supports in vehicle seats, among numerous other products. The customer specifies the functions to be integrated, the installation space and the interfaces and Pollmann elaborates upon the process and mounting criteria. The manufacturing process is determined and the plant is designed and built based upon this close collaboration.

In addition to its headquarters in Karlstein, Pollmann has production facilities in the United States, Czech Republic and, since the end of 2007, in China. “Our intention was to manufacture locally for the Asian market and in the immediate vicinity of one of our largest customers,” says executive manager Markus Pollmann, explaining the reasons why the company has strengthened its position in the Asian market with its own factory there. The decision was underlined with a concrete order from MAGNA, a Pollmann customer of many years, for the production of electromechanical gearboxes for General Motors’ automotive locking systems.

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The new Pollmann production facility during the test phase at the Karlstein factory: in the foreground, the laser welding machine by Trumpf, in the background, the 4 meter high storage tower that serves for the curing of the cast parts coming from the two-component casting station. At the same time, it is used as a buffer store within the overall production process.

A freshly-produced electromechanical gearbox, including already mounted microswitches for General Motors’ automotive locking systems

Precision and reliable automation unlock new global potential

Car door locking systems produced in China with PC-based automation

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A high precision, economical solution

Pollmann’s remarkable strength lies in the combination of metal and plastic materials to make electromechanical subassemblies. “We have many years of experience in plant construction and series production here,” explains Markus Pollmann. “Since, as a development partner, we are usually involved very early on in new projects, it is possible for us to create solutions that are not only highly precise, but also very economical.”

The production facility developed and constructed specifically for this large order has a high degree of automation. “The particular challenge was to find the optimum mix in degree of automation and use of personnel for the operation of this plant,” says Reinhard Ringl, responsible for the conception and implementation of control technology at Pollmann. “The production of a total of 27 different model versions had to be made possible. At the same time, the goal was to make do with a maximum of 16 employees per shift.”
Complex production strategy
A finished part reaches end storage every eight seconds. The efficient chaining of individual production steps, each representing in principle a self-contained work step, are the basis for the complex manufacturing strategy: at the start, injection molding tool inserts are fitted with the externally punched conductor tracks (pre-molded parts) in the provisioning stations. From there the pre-molded parts are placed fully automatically by a robot in the injection molding machine, which ‘spits out’ the actual plastic housing with up to ten molded-in conductor tracks. The housing is placed on a transport tray and subsequently arrives at the final assembly area of the plant via a sophisticated transfer system. Depending on the version, various microswitches are inserted here, welded by laser and completed in the two-component casting station. The material cures in a 4 meter high storage tower, which works on the paternoster principle and at the same time serves as a buffer store within the overall process. Extensive quality checks follow, which are similarly integrated in the automated circuit: the parts are checked both for correct configuration and model version and their electrical functions are also checked. The test and measurement data is documented and saved in a database running on a Beckhoff Industrial PC, Pollmann is naturally certified to ISO/TS 16949 and ISO 9001:2000. Finally, laser marking is performed and the finished electromechanical housing arrives at the removal station. Transport between the individual working stations takes place fully automatically. “The completion of the locking system, such as the installation of the motor and the wiring, then takes place at our customer’s facility,” says Reinhard Ringl, explaining the further procedure.

Universal PC-based automation architecture
The technicians at Pollmann have relied on PC-based automation technology for years and swear by the advantages and flexibility of the software PLC. On the control side, the heart of the new plant is formed by the C6140 Industrial PC with TwinCAT PLC real-time software. TwinSAFE, the safety solution from Beckhoff. The integration of the safety functionality into the existing control architecture simply works perfectly,” reports Reinhard Ringl. Local automation architectures are similarly standard at Pollmann: In this specific case, there are 25 local Bus Terminal stations with approx. 3,000 I/Os for the plant’s many sensors and actuators.

Ultra fast communication via EtherCAT
EtherCAT is used for communication. “This extremely fast communication is necessary above all for the laser welding systems. Four laser cells access a single laser source here. Switching between the cells is coordinated by the Beckhoff controller, wherein the switching time must not exceed 60 ms,” explains Reinhard Ringl. However, the pneumatic valve terminals, which control various pick-and-place units in the individual workstations, also communicate with the software PLC via EtherCAT. “A great many component manufacturers now offer EtherCAT interfaces, which means that this bus system can be used very practically,” says Reinhard Ringl. The Servo Drives in the system are also from Beckhoff.

“The Beckhoff components simply match each other perfectly, and they can all be managed, programmed and diagnosed via a single automation software platform.”
Anyone who has to fill in a lengthy stopover at Munich Airport can make use of the convenient cabins from Napcabs GmbH, Germany, for sleeping, relaxing or working in peace. The passenger in transit can book and operate a Napcab simply and conveniently using a Control Panel from Beckhoff.

Napcabs were invented by five students from the Technical University of Munich, Germany. They developed the approx. 3.5 square meter cabins for a student project with the aim of creating some privacy, in particular for passengers on intercontinental flights. In 2007, the students’ business plan won the Innovation Competition held by UnternehmerTUM, the center for innovation and start-ups at the Technical University of Munich. In addition to UnternehmerTUM, Munich Airport, Lufthansa, b. a. Werbung, OSRAM, PLAN 3 and Joka, Beckhoff also provided support for the start-up, so that the idea has become a highly marketable product after only a year.

Since July 2008, passengers have been able to rent Napcabs after security check at Lufthansa Terminal 2 in Munich Airport. Protected from the hustle and bustle of the world outside, travelers can put up their feet and relax with music, movies or lighting and sound effects. The passengers can also use the built-in table as a desk and access the Internet with their own laptop using UMTS.

The customer gains access to a Napcab using the CP6202 15-inch Beckhoff touch panel from the “Economy” series. The traveler can learn how the Napcab works and is able to check in and out using the screen. On check out, the traveler can pay conveniently by credit card. A CP6203 19-inch Beckhoff touch panel from the Economy series is also installed in the Napcab. The user can access all the Napcab functions from this. He or she can select various movies or types of music, adjust the sound levels and lighting as desired or switch on the timer for a wake-up alarm. The Panels are connected via DVI/USB to the controls – which have been developed in-house – for light, entertainment, checking into and out of the Napcab and to additional services. For example, immediately after a customer checks out, the airport’s cleaning team is automatically alerted.

“The Napcabs can be occupied 24 hours a day and are used by a wide range of customers. They therefore need to be very efficient and robust,” explained Michael Krause, managing director of Napcabs. “The selection of high-quality components was a top priority for us. But the design also has to be right in order to fit with the concept as a whole. The Control Panels...
Considering the rapid development in the high-tech electronics sector, worldwide demand for printed circuit boards is continually growing and has created an enormous market. The manufacturers of printed circuit boards include Hsiangkuo Computer Co. Ltd, which has various production sites in China. The company sells its products to well-known manufacturers of computers and electronic appliances in America, Europe and South-East Asia, among others. Plant monitoring at the individual factories is based on Beckhoff components. In 2007, Hsiangkuo Computer decided to introduce a monitoring system to record and remotely retrieve the current operating status of its production equipment. After thoroughly testing various control solutions and comparing them with one another, Beckhoff was chosen as supplier.

The plant monitoring system is based on the Beckhoff Bus Terminal I/O system. The differing degrees of automation in the individual manufacturing facilities at the factory in Suzhou represented a particular technical challenge: besides semi-automatic and fully-automatic machines, manually operated machines also had to be integrated in the plant monitoring concept.

In the first phase, essentially only semi-automatic or manually operated equipment was integrated in the monitoring concept. At the same time a large number of machines were in use that work independently from one another and whose location is not permanently fixed. Bus Couplers and I/O terminals form the starting basis of the plant monitoring system. If the machine is relocated, as occurs occasionally, only the cabling needs to be changed.

Almost exclusively, fully-automatic machines, which are part of a production line and feature PLC controllers from different manufacturers, were integrated in the second phase. Hsiangkuo chose Modbus RTU as the fieldbus. For this purpose, BX series Ethernet Bus Terminal Controllers were used, which transmit the data to the PC via the communication interface.

All real-time signals from more than 400 machines in the factory are input via Ethernet to the central Beckhoff C6140 Industrial PC. The recorded signals are converted via TwinCAT PLC into the data required to monitor the plant status. By means of connection to a database, status protocols relating to a year, a quarter, a week or a day can be created. The decisive advantage is that the plant status can be viewed from anywhere via an Ethernet connection.
EWE opens "Zentrum Zukunft" ("Future Center") energy house at ecopark.

"Zentrum Zukunft," ("Future Center") located in the ecopark at the A1 motorway near Cloppenburg, Germany, is intended to illustrate future requirements for domestic buildings in terms of energy supply, communication and automation. In early 2005, EWE with the support of the University of Applied Sciences of Oldenburg, Ostfriesland and Wilhelmshaven, invited architecture students to develop ideas for such a building as part of a design competition.
The panel was particularly impressed by the design developed jointly by two of the students. The automation of the complete energy and communication structure of "Vision Wohnen" ("Vision Living") was achieved using standard I/O components and the CX Embedded PC from Beckhoff.

The almost cubical building consists of three zones: the energy center, seminar rooms with state-of-the-art presentation equipment and a three-storey living area. The energy center utilizes advanced heating, cooling and power facilities that simultaneously generate electricity and heat via an air conditioning system based on solar energy or a Stirling motor and a fuel cell. "Future sustainable energy supply systems will be based on central, combined heat and power installations," Robert Münning of EWE said.

Enhanced comfort and increased energy awareness
Claas Loewenstein of EWE building management illustrates the technical trends for the homes of tomorrow: "In the future, there will be little visible technology in houses." A central installation core that runs through all three levels of the building forms the electronic and energy heart of 'Vision Wohnen' at 'Zentrum Zukunft.' All data points required for building automation are connected directly to the Beckhoff Bus Terminal system. The I/O components distributed at the individual levels are linked via Ethernet to the central PC controller, in this case a CX1020. Rooms can be defined as required and quickly adapted to the lifestyle habits of the occupants.

RGB LEDs are available for effect lighting that can be controlled separately in small groups via EIB terminals. Other lamps for indirect lighting can be controlled via DALI terminals. A wide range of equipment such as RFID readers, LCD monitors, mirror displays and microphone switches can be operated via KL6001 and KL6031 serial interface terminals. Motor drives deal with lowering and covering of LCD monitors, adjusting the height of the kitchen worktop and the desk or adjusting the headboards and foot sections of beds and lounge furniture.

The high flexibility of the e-core system means it can continuously be updated to reflect the latest state of the art trends. Outdated technology can easily be replaced with the newest developments. "The focus is on enhanced comfort and increased energy awareness," Loewenstein said. Examples include an intelligent refrigerator that is integrated with an energy management system or a wall mirror that can display messages.

One user interface for building services, media and telecommunications
Networking of technical devices will be even more important in the future. "Media, building services and telecommunications will be controlled via a single user interface," Loewenstein explained. For example, an alarm system will no longer have to be installed locally, but could instead be installed on a server in the EWE computing center. Only the sensors for reporting broken glass, smoke or intrusion to the central alarm system will be installed locally. Operation can take place via a monitor in the house or a mobile phone.

Realizing visions for the future with standard technology
According to EWE’s CEO Dr. Werner Brinker, the company intends to offer training on energy efficiency and new media at "Zentrum Zukunft" for market partners, schools and universities, builders and trade contractors, architects and engineers, local authorities and relevant associations in order to prepare them for the technologies of the future.

The building management system at “Vision Wohnen” was implemented by Detlef Coldewey GmbH, based in Westerstede, Germany. “Good cooperation with an experienced integration partner such as Coldewey, with whom we had already completed other projects in the past, is an important factor for us as a control equipment supplier,” said Georg Schemmann, Building Automation Manager at Beckhoff. "The additional costs for installing the building control not only pay off in terms of enhanced comfort and safety, intelligent technology literally pays for itself through significant energy savings.”

EWE AG, Germany www.ewe.de
Detlef Coldewey GmbH www.coldewey.de
The office development in Fairland, Randburg (on the outskirts of Johannesburg) was built to house WesBank and First National Bank (FNB) Home Loans Head-offices (consumer divisions), based on an energy-conscious overall design concept. Comprising two levels of 64,000 square meters the structure houses a 1,600-car super basement, two separate office buildings of three floors, a shared facilities building and related external and site works. Beckhoff Bus Terminals and CX9000 Embedded PCs manage the entire lighting interface.

According to Richard Angus, Chief Operating Officer of FNB Home Loans, one of the divisions that will occupy the building, this is an example of best-of-breed environmentally friendly development. This commitment began with the digging of the foundations for the project. “It took a year to dig the foundations but soil was not moved from the site. Instead it was dispersed around the site and used in some of the landscaping. We also had an onsite concrete batching plant, which meant that trucks were making shorter trips and using less fuel,” says Angus.

The building automation solution focuses on occupant comfort and energy-efficient operation. The lighting management has been fully automated using Beckhoff Building Automation products. The contractors involved were: Claassen Auret Incorporated, the project consulting engineers; A to Z Electrical, the main electrical contractor; and Systems Automation & Management (SAM), the system integrator responsible for lighting control in the building.

Flexible lighting management with DALI
A total of 24 Beckhoff CX9000 Embedded PCs manage the entire digital addressable lighting interface (DALI) through 150 KL6811 DALI master terminals. The goal was to ensure code re-usability and flexibility that would easily accommodate changes to the building’s design, thus maximizing the energy efficiency of the entire system.

Throughout the facility, presentation and meeting rooms are controlled via EnOcean switching technology. Beckhoff KL6023 terminals interpret the wireless switching signals used to generate and control the selected lighting scenario required in each room. The presentation rooms also allow for integration with the audio visual (AV) systems, ensuring the lights adapt automatically to the selected AV mode. In the shared facilities area, large function venues can be split into separately controlled lighting zones or joined together to form one large zone.

Light management in the open office areas has been implemented using time, presence and occupancy information – no external switches have been installed. Motion detectors detect presence and occupancy in all open areas and are connected straight onto the DALI bus, from which they are also powered. Approximately 800 of these sensors have been used throughout the
The sensors are read directly by TwinCAT. The information is used to switch lights on or off, as well as to regulate the light output in order to create pleasant and constant ambient lighting conditions at maximum energy efficiency.
Advanced wood processing is increasingly based on fully automatic high-performance lines, starting with cutting of raw wood. An upstream scanner forms an integrated component of the overall system. The scanner picks up the relevant lumber data (knots, warps and discoloration, etc.) and transfers them to the downstream machines such as ripsaws and optimizing miter saws at full production speed. Exact measurements help promote optimum wood yield and quality. Without such automatic detection systems the high system performance would be inconceivable. The tasks handled by the system are very demanding in terms of control technology. Control Logic is a leading provider of rip optimizing technologies and develops high-performance process control systems for lumber ripping, cutting, grading and tracking. Since 2002, Control Logic has been an operating company of the Weinig Group based in Tauberbischofsheim, Germany. Control Logic’s customers range from small cabinet shops of less than 10 people, all the way to enormous multi-national suppliers of consumer furniture products. Most of Control Logic customers are manufacturers that produce consumer goods such as furniture and cabinets or building products like flooring, moldings and board materials.

Efficient, flexible and accurate scanning
Control Logic rip optimizing machines offer advanced, accurate, 2D shape scanning with powerful, industry-proven 2D optimization. The ripping platform is completely scalable and supports fixed or moveable ripsaws. The precision servo-driven fence system is as reliable as it is accurate. The scanners measure the shape of the boards to be ripped and detect surface defects. The systems mathematically determine the optimum ripping path for each board based on these conditions. “This process is ‘computationally intensive,’ requiring far more from processors than just control functions – a major reason why the PLC approach became limiting,” said Chris Aiken, President of Control Logic.

Machine re-design ensures competitiveness for changing markets
Like most machine builders in North America, Control Logic is facing the double-edged sword of having to provide ever-increasing productivity and value at a lower cost. “To stay competitive, we must focus on delivering our solutions with an affordable price tag, while improving both functionality and sustainability,” Aiken said.

This has been very pronounced in the furniture industry so most of Control Logic’s remaining North American customers are small to mid-size companies that require more innovative and flexible solutions and require a lower cost of ownership. “Many of our customers do not have a full-time maintenance staff, but rely instead on the machine builders to help with diagnostics, trouble-shooting and provide efficient remote service,” Aiken said.

In order to help their customers stay competitive in a difficult market, Control Logic sought to optimize its ValuRip™ product offering line via a complete system re-design. The primary goals of the re-design were to:

| maintain a lower system price point, |
| offer a cost-effective yet high-speed shape scan function as standard, |
| create modular software and controls that enable the end user to select machine modules that match unique production needs, |
| reduce the number of hardware components, |
| and design a system that was still easy to troubleshoot and service remotely. |

CX Embedded PC deals with control system and data management
“When we evaluated our current offerings, we found that all Control Logic systems included both a PC and traditional PLC control hardware. This was not efficient in terms of software or in space usage, resulting in larger electrical cabinets, more complex software as well as more problematic support and remote service conditions,” Aiken said.
“When we began our new design, we looked across the control landscape, and found the concept of combining both our PLC and PC platforms on a single DIN-rail intriguing,” Aiken said. “The Beckhoff Embedded PC platform allowed us to remove many of the extraneous interface layers that we had in the previous system design, while becoming both space- and cost-efficient. It was the only method we found that gave us the comfort of a hard real-time PC environment and rugged, cost-effective industrial hardware,” Aiken said.

EtherCAT enables communication at microsecond level
Finding the optimum processing power for the ValuRip Plus™, Control Logic selected the CX1020 Embedded PC with TwinCAT NC PTP for complete automation, axis positioning and controls device management. The CX1020 is connected to a Beckhoff CP6901 Control Panel with DVI/USB interface as the HMI hardware. AX2003 Servo Drives with EtherCAT interface are used for the drive system.

“The CX1020 brought Control Logic software efficiency, scalability and fewer required communication layers,” Aiken explained. “In addition, the Embedded PC format provides ‘mechanical efficiency’ via a single DIN rail mounted device. Furthermore, networking with EtherCAT I/O Terminals provided industry-leading performance via real-time, high-speed updates at a lower cost than I/O technologies that aren’t Ethernet-based.”

Scan function optimized in terms of speed and cost
“In addition to the obvious controller efficiencies with regard to size and cost, the biggest functionality improvement in the new control system was with I/O update rates,” Aiken said. “This was very important to us because we wanted to create a very low-cost 2D shape scanner.” This requires a photo-electric array (one per foot) over which the lumber is transported with a high-precision surface – in the case of the ValuRip Plus™, a high-friction belt. To perform the measurement, Control Logic had to sample the presence of the material at a very high rate.

“In the past, we couldn’t poll the inputs with a PLC at this rate and were forced to perform the task using a PC I/O card and a custom device driver which we developed and maintained,” Aiken explained. “So, the great improvement for Control Logic is that with the high-speed performance of both the EtherCAT I/O and the CX1020 processing power, we are able to accomplish the scanning task without custom I/O frameworks, or delicate in-house software.”

Control Logic  www.controllogic.com
Beckhoff USA  www.beckhoffautomation.com
Kays Engineering, located in Marshall, Missouri, USA, has two well established deep hole drilling systems for bore diameters between ¾-inch (Eldorado) and 2-inch (DeHoff). The DeHoff line incorporates control of the coolant system, fixturing system, automation system and many other optional components in the machine control according to the specifications required by the customer. A major differentiator with the DeHoff machines is the use of flat ground ways rather than using linear guide ways. This provides peerless stability and helps minimize vibration in the drilling process, which could otherwise cause numerous quality problems in the finished product. DeHoff machines also offer a vast range of spindle speeds to provide maximum drilling flexibility.

More flexibility with the help of PC Control

In addition to maximum precision, key customer requirements for a deep hole drilling machine are to be highly adaptable and flexible to every unique application. “While Kays offers a job shop-oriented and standardized machine with the Eldorado line, the DeHoff line of drills is often subject to requests for rather high levels of customization,” Brandon Snell, Controls Engineer, Kays Engineering said. “Usually our customers have already finished the design and dimensions of their parts that are to be drilled, with nearly limitless variance in shape and size.” The DeHoff gun drill line has some standard elements such as the servo drives, motors and other standard motion components, but the machine is very application-specific. In the past, Kays Engineering utilized a traditional PLC to control both a servo drive and Variable Frequency Drive (VFD) via an analog interface. A grayscale, low-resolution display panel served as the operator interface. In early 2006, Kays first started looking for new controls packages and weighed six different vendor options, seeking a highly flexible controls platform that could efficiently accommodate a wide range of customizations and provide a hardware platform that could scale in processing power.

The DeHoff gun drill from Kays Engineering now features a Beckhoff control system with the CX1010 Embedded PC. The PC-based controls cost well over 50 percent less than the machine’s previous PLC-based system.
Compact and cost-effective control platform with Embedded PC

“With the Embedded PC from Beckhoff we found a solution that exactly matched our requirements,” Snell said. For the Eldorado series drills, Kays Engineering selected the CX9010. The higher performance DeHoff machines feature a CX1010. The CX controllers utilize EtherCAT as the high-speed Industrial Ethernet communication system. “Another major benefit to the Embedded PCs is that they utilize Compact Flash for boot and memory instead of a hard drive,” Snell noted. “Many Motion Control alternatives we evaluated were typically priced quite a bit more than the PC-based approaches. Simple economics was a major deciding factor in favor of PC-based control,” Snell said.

The previous displays were replaced with full color 6.5-inch Beckhoff CP7829 Control Panels with custom DeHoff and Eldorado logos integrated into the front. The CP7829 also features numerous function keys and a numeric keypad, adding to the flexibility of the new display. The panels connect to the CX Embedded PCs via DVI/USB. The Control Panels can help reduce cost and required space when compared to a standard IP 20 rated touch screen.

Optimized programming

With TwinCAT, the Embedded PCs have integrated Motion Control functionality. “TwinCAT has built-in Motion Control libraries, which saves a tremendous amount of programming time — we’re able to simply drop in the standard blocks of code we need,” Snell said.

“The ability to choose Structured Text (ST) with TwinCAT has greatly streamlined our programming. While we can still use it, we are not restricted to Ladder logic and can program in all the languages established in IEC 61131-3,” Snell said. The system Kays Engineering created includes a “drilling parameters calculator” that allows end users to simply enter data on the material to be drilled, the required hole diameter, and the system automatically generates the appropriate feed rate and spindle speed for the materials to be drilled.

EtherCAT for ultra fast control

AX2000 Servo Drives with EtherCAT interface are used as drive system. “One of the biggest factors that led to selecting EtherCAT was the almost ‘plug and play’ functionality it brings to our machine design,” Snell said. Previously, the Servo Drives and VFDs on the Eldorado and DeHoff machines required an analog 4 – 20 mA loop and excessive cabling to communicate the machine load. That method was not as reliable as Kays Engineering wanted, especially considering the long cable runs that were required.

“EtherCAT constitutes a major improvement because it offers deterministic performance and provides much higher speed and reliability. Troubleshooting cabling that consists of basic CAT 5e Ethernet cables is also inherently simple and cost-effective. It’s just one type of cable to manage rather than having to worry about six different types,” Snell explained.

Higher performance at a lower cost

“Overall, the new Eldorado and DeHoff control systems have become more economical than the previous systems,” Snell said. “In addition to the higher performance, energy usage has been reduced by using more efficient Servo Drives. Today, there’s a more compact Beckhoff motor controlling the gun drill’s axis slide that can generate the same level of torque as the larger motor in our previous system.”

This improved flexibility and efficiency did not come at an increased cost for Kays Engineering. “We saw a dramatic controls cost optimization with the DeHoff machine — the Beckhoff control system with the CX1010 costs well over 50 percent less than the previous traditional PLC-based system. The Eldorado system with CX9010 costs over 10 percent less than the lower performing system it replaced. I’ll pay less for higher performance any day!” Snell said.

The savings Kays Engineering experienced did not stop at hardware cost. Using EtherCAT and standard Ethernet cabling, the company was able to cut two entire work days from the required wiring time of its control cabinets.

Customer reception for the new Eldorado and DeHoff machines has been equally positive and highly encouraging to Kays Engineering. “As a result of the strong feedback for these redesigned machines, at least 90 percent of the Eldorado and DeHoff machines will be fully equipped with Beckhoff PC-based control systems and EtherCAT going forward,” Snell said.

Kays Engineering has by no means reached the end of their PC-based control evolution. The CX1020 and CX1030 Embedded PCs from Beckhoff provide even higher performance options and room to grow when the company decides to add more axes of motion and further enhance the system features of their deep hole drilling systems. “We have the ability to simply scale up to the next controller in the CX Family,” Snell said. “Most of the existing programming and controls design will remain the same for each new machine variant. We’ve optimized our machine design flexibility today and well into the future.”

### Kays Engineering
www.kays-dehoff.com

### Beckhoff USA
www.beckhoffautomation.com
To date, 40 vendors have readily available or publicly announced high-performance EtherCAT servo drives. This support from drive vendors is clear evidence that EtherCAT has taken the leading role in motion control: no other Industrial Ethernet technology has such a variety of products from various drives vendors. This fact is underlined by the dynamic, new multi-vendor demo at the EtherCAT Technology Group booth that will debut at the 2008 SPS/IPC/Drives show in Nuremberg, Germany.

With 40 servo drive vendors from 13 countries, EtherCAT even leaves special motion control fieldbus systems that have been around for decades behind — EtherCAT is on its way to becoming the world’s leading motion control standard. Even more vendors are currently developing their EtherCAT servo drives, but have yet to announce these new products publicly.

At the EtherCAT Technology Group’s cooperative booth at the SPS/IPC/DRIVES show in Nuremberg, Germany, (Hall 6, Booth 208)
In order to ensure the compatibility of device implementations, numerous efforts are being made within the EtherCAT Technology Group. Among other things, the Plugfest (see page 52) is aimed towards the interoperability of the devices. In order to now also test the compatibility of devices to the EtherCAT standard, a conformance test tool has been developed that automatically tests the EtherCAT slave devices.

The test tool sends correct and deliberately incorrect telegrams and the device’s response is compared to the expected response. Besides the EtherCAT state machine, the behavior of the mailbox layer (necessary for asynchronous communication) and the implementation of the object directory can also be tested.

The test tool is informed of which functions the device supports by the included device description file, the so-called ESI (EtherCAT Slave Information). Unsupported functions are excluded from the test, while supported functions are tested intensively. The validity and the consistency of the device and of the ESI file itself are checked. The test results are available to the manufacturer in a comprehensive test report which, along with information about the device description and the test environment, includes the test cases performed and their results.

The conformance test tool provides the device manufacturers an in-house tool that supports development and can be used for prompt compatibility testing of EtherCAT implementations. The licensing of the test tool is based on a ‘subscription,’ which is updated annually. This ensures that the manufacturer always uses the latest version of the tool. Manufacturer-specific test cases can also be supplemented on the basis of an XML schema.

A certificate of conformance is issued by the ETG if the test has been performed in an official EtherCAT Test Center (ETC) and has been passed. The first ETC has already been opened at the ETG head office in Nuremberg, Germany. Further laboratories are planned in Europe, the United States and Asia. All users of EtherCAT technology are called upon to request an official certificate of conformance from the device manufacturer in order to secure the compatibility of the devices available on the market. Certified devices are permitted to bear the logo ‘EtherCAT conformance tested,’ assuring the quality of the implementation.
Another successful EtherCAT Plugfest ensures interoperability

The 6th EtherCAT Plugfest took place in late September 2008 in rooms at the LTi company’s site in Lahnau, Germany. More than 50 participants representing a total of 13 master and 17 slave manufacturers from Germany, Europe and the United States took up the invitation, evidence of the great interest from EtherCAT Technology Group (ETG) member companies in the event.

The EtherCAT devices presented at the Plugfest are often about to go into series production so their behavior is tested once more in an environment with other industrial devices and optimized if need be.

To this end, all slave devices are operated alone and in various combinations with all masters during the two days of the event. The devices are additionally tested using the official ETG conformance test tool. However, the manufacturers of already established devices and master implementations are also present in order to ensure the continuous interoperability of their products with new ones.

The idea of the event is to ensure that the commissioning of the system is as simple as possible for the end users of EtherCAT devices. Devices from different manufacturers are often attached to one master in real applications. The master itself is usually determined by the chosen controller. The combinatorics resulting from these possibilities are reenacted at the EtherCAT Plugfest. Commissioning difficulties, e.g. due to missing information regarding start-up commands or due to a PDO configuration that was incorrectly set up, etc. are quickly discovered and eliminated before the release of the product.

For the first time ever this year, there was an Asia Plugfest especially for the Asian ETG members on October 15 and 16, presented by Prof. Moon from the Sunchon University in South Korea. Participants from South Korea, Japan and several other Asian countries joined the event. This development underlines once more how internationally widespread EtherCAT technology has become.
Trade show review 2008

EuroBlech: PC-based control for sheet metal forming

The EuroBlech fair took place at the end of October 2008 in Hanover, Germany. The focus at the Beckhoff booth was on PC Control with fast EtherCAT communication that enables scalable and flexible solutions with high performance and high precision.

Motek 2008

“Open automation solutions for handling and assembly technology” was the motto from September 22–25, 2008 at the new trade fair center in Stuttgart, Germany. At the 27th Motek fair, Beckhoff presented its IPC, I/O, motion and automation technology forums.

Husum WindEnergy 2008

The Husum WindEnergy was the scene of the world’s largest wind energy trade show from September 9–13, 2008. Around 700 companies, manufacturers of wind turbines and sub-suppliers from 35 countries were presenting their solutions in four halls. In hall 4, Beckhoff presented its open automation solutions for wind turbines.
Trade shows 2008/2009

Europe

Germany

SPS/IPC/DRIVES
November 25 – 27, 2008
Nuremberg
Hall 7, Booth 406
www.mesago.com/sps

Tire Technology Expo
February 17 – 19, 2009
Hamburg
Booth 4415
www.tiretechnology-expo.com

Intec
February 24 – 27, 2009
Leipzig
Hall 1, Booth E11
www.messe-intec.de/en

Embedded World
March 03 – 05, 2009
Nuremberg
Hall 9, Booth 329
www.embedded-world.de/en

Cebit
March 03 – 08, 2009
Hanover
www.cebit.com

Hanover Fair
April 20 – 24, 2009
Hanover
www.hannovermesse.de/homepage_e

Achema
May 11 – 15, 2009
Frankfurt
Hall 10.2, Booth K36-N38
www.achema.de

Ligna
May 18–22, 2009
Hanover
www.ligna.de/homepage_e

Motek
September 21 – 24, 2009
Stuttgart
www.motek-messe.com

SPS/IPC/DRIVES
November 24 – 26, 2009
Nuremberg
www.mesago.com/SPS

France

SCS Paris
December 02 – 05, 2008
Paris
www.scs-expo.com

Italy

MC² Motion Control for
March 11, 2009
Bologna
www.lib2b.it/mc4

Plast
March 24 – 28, 2009
Milan
www.plast09.org

Denmark

Hi-Industri
September 01 – 04, 2009
Herning
www.hi-industri.dk

C² Control & Communication
September 11, 2009
Turin
www.lib2b.it/c2/torino

54 events
For additional information on our worldwide subsidiaries’ and partner companies’ trade show schedules please check: www.beckhoff.com

C’ Control & Communication
September 16, 2009
Pescara
www.ib2bi.com/c2/pescara

Norway
PEA
September 27 – 29, 2009
Lillestrøm
www.pea-messen.no

Slovenia
Ifam
January 28–30, 2009
Celje
www.ifam.si

Sweden
Scanautomatic
October 13 – 16, 2009
Stockholm
www.scanautomatic.se

Turkey
WIN World of Industry
February 26 – March 01, 2009
Istanbul
www.win-fair.com

United Arab Emirates
Middle East Electricity
February 08 – 10, 2009
Dubai
www.middleeastelectricity.com

Switzerland
Go
September 01–04, 2009
Basel
www.go-automation.ch

Asia
China
Chinaplas
May 18 – 21, 2009
Guangzhou
www.chinaplasonline.com

Russia
PTA Ural
December 02 – 04, 2008
Ekaterinburg
www.pta-expo.ru

India
Industrial Automation India
December 10 – 13, 2008
Bangalore
www.ia-india.com

Turkey
WIN World of Industry
February 26 – March 01, 2009
Istanbul
www.win-fair.com

Switzerland
Go
September 01–04, 2009
Basel
www.go-automation.ch

Asia
China
Chinaplas
May 18 – 21, 2009
Guangzhou
www.chinaplasonline.com

Russia
PTA Ural
December 02 – 04, 2008
Ekaterinburg
www.pta-expo.ru

India
Industrial Automation India
December 10 – 13, 2008
Bangalore
www.ia-india.com

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imprint
PC Control
The New Automation Technology Magazine

Published:
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Eiserstraße 5
33415 Verl/Germany
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Picture Proof:
Accupress, Canada
Multivac, Germany
Napcabi, Germany

Graphic Design: www.a3plus.de
Printed by: Scholz, Germany
Circulation: 23.500