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Three examples of the wide range of EtherCAT P I/O products with IP 67 protection:
EtherCAT junction, digital input box (8-channel) and analog input box (4-channel) for ±10V/0…20 mA.
EtherCAT P with a wide range of IP 67 I/O options

Minimised cabling and assembly costs at the field level

The extensive IP 67-rated I/O range available for EtherCAT P minimises wiring requirements and facilitates the highly flexible, decentralised data acquisition of all I/O signals in a machine or system. It is based on the one-cable solution EtherCAT P, which integrates proven EtherCAT technology with a power supply for connected devices.

With EtherCAT P, Beckhoff combines ultra-fast EtherCAT communication and power supply (2 × 24 V DC/3A) in a standard 4-wire Ethernet cable. It enables direct power supply for both EtherCAT P slaves and the connected sensors and actuators in such a way that separate power lines can be eliminated, considerably simplifying system cabling. This makes EtherCAT P the ideal sensor, actuator and measurement bus, providing advantages both for connecting small remote I/O stations in terminal boxes and for decentralised I/O components located throughout the actual process.

EtherCAT P Box modules for all data acquisition requirements
A full range of EtherCAT P system and I/O components in protection class IP 67 is currently available for the 24 V I/O level. For connecting sensors and actuators, users can integrate any of the wide range of well-established EP Box modules from Beckhoff in the new EPP versions for EtherCAT P. These include a variety of 4, 8 and 16-channel digital input box modules; 4, 8, 16 and 24-channel digital output modules; numerous 4, 8 and 16-channel IP 67 I/Os with combined digital inputs/outputs; as well as RS232 and RS422/RS485 serial interfaces. There are also new EPP Box modules for analog input and output quantities, such as ±10V/0...20 mA, differential/absolute pressures, and data from resistance sensors, thermocouples and incremental encoders.

Free and flexible choice of topology, as enabled by EtherCAT, is equally possible with EtherCAT P. The following IP 67 infrastructure components are available to set up the required network architecture in the field:

- EPP1111 EtherCAT P Box with ID switch
- EPP1322 EtherCAT P junction with power feed-in and junctions with or without power refresh (EPP1332/EPP1342)
- EPP9001 EtherCAT P/EtherCAT connector with power transmission
- EPP9022 EtherCAT P Box for diagnosing Ue (system and sensor supply) and Ua (peripheral voltage for actuators)

Significant benefits for machine engineering applications
EtherCAT P – which is now fully supported by the EtherCAT Technology Group (ETG) – reduces material costs for machinery, time and cost of installation as well as the frequency of errors in the installation process. In the machine itself it also minimises the installation space required for drag chains, cable trays and control cabinets. The entire automation process benefits from the reduced size of sensors or actuators, made possible by the new EtherCAT P cables. Overall, equipment manufacturers now have considerably more freedom when designing their machinery and more leverage to reduce machine footprint.

Further information:
www.beckhoff.com/EtherCATP
Industrial PCs with high performance and functionality for the smallest, most compact applications

**New entry-level class for cost-effective PC-based control technology**

PC-based control technology from Beckhoff can be finely scaled both in terms of hardware and software, with solutions tailored precisely to the application. Three entry-level Industrial PCs (IPCs) are now available for the cost-sensitive lower and medium performance ranges. The C6905 control cabinet PC and the CP6706 Panel PC for Intel® Atom™ multi-core CPUs with one, two or four processor cores, as well as the CP6606 Panel PC for ARM Cortex™ A8 processors form the new entry-level class for PC control. Robustness, open compatibility and long-term availability are just a few of the key benefits for broad industrial use.
The C6905 control cabinet IPC and the CP6606 and CP6706 7-inch built-in Panel PCs form the entry-level IPC class for low and medium computing power applications. As the lowest cost device, the CP6606 is equipped with an ARM Cortex™ A8 processor and represents the starting point of the fully-scalable IPC product range. The C6905 and CP6706, with higher performance Intel® Atom™ processors (up to four cores), ideally complement the entry-level of the product portfolio. These devices are particularly suitable for use as small and medium-sized machine controllers, for implementation in motion applications or in more elaborate, graphics-intensive applications. This completes the already excellent scalability of Beckhoff’s Industrial PC family. Completely new, price-sensitive market segments can now be addressed as a result. With a large number of devices introduced within a very short period of time, the CP6606 represents the beginning of a success story that continues unabated through the new CP6706 and the C6905 offerings.

Focus on flexibility and reduced complexity
The new entry-level IPC class pares down the usual variety of different panel types within a series. The focus is placed instead on elaborate, variable housing constructions and a nearly infinite variety of extensions. In particular, these devices are focused on simplicity and easy integration of standard components. If unique application requirements need to be addressed, such as additional interfaces, special keys or housing-specific adaptations – the existing 100 % scalable Industrial PC portfolio comes into play. However, the products from the new entry-level IPC class are ideal for small and medium control, HMI or motion applications without special requirements. The reduction of complexity and variants makes it possible for high-quality Industrial PC solutions to optimally address the most cost-sensitive applications.
Entry-level class of Industrial PCs: still industrial-grade

The housing concept comprises minimally reduced variants of the existing Industrial PC series, relying primarily on durable metal components instead of plastic components. Beckhoff thus stands for high-quality, robust and industrial-grade housing designs, including in the entry-level product lines. The aluminum/steel housings employed for the two fanless Panel PCs have been redeveloped and designed for protection class IP 54. Also worth highlighting is the housing concept of the fanless C6905 IPC, which slots perfectly into the well-known C69xx series. Somewhat smaller than the previous smallest C69xx device (the C6915), the C6905 still features easy-to-access components, such as mainboard battery and storage media, which are freely accessible simply by removing four screws. The housing concept becomes less complex by reducing the number mechanical pieces, while continuing to provide accessibility to the internal components.

Highly-integrated 3½-inch motherboards

Proven motherboards are used in the new device class – in a condensed, but dependable form. The interfaces and functions of existing 3½-inch motherboards are tailored exactly to the corresponding range of uses. The devices still offer a comprehensive basic configuration: the C6905 and the CP6706 include 2 GB DDR3L-RAM (expandable ex works to 8 GB), onboard dual-Ethernet adapter with 2 × 100/1000BASE-T connector, 4 GB CFast card with high-quality SLC flash, four USB 2.0 ports, a DVI-I connector and an optional third Ethernet port. Additionally, the CP6606 is designed for even more compact applications with 1 GB DDR3-RAM, an Ethernet adapter with 10/100BASE-T connector, an EtherCAT adapter and a MicroSD card that can range from 512 MB to 8 GB.

Both 7-inch Panel PCs are equipped with resistive single-touch and 800 × 480 WVGA TFT display.

C6905 and CP6706 – powerful processors, flexible choice of operating system

The bottom end of the entry-level IPC class for cost-sensitive control applications includes the CP6606 built-in Panel PC and the CX9020 Embedded PC. Both are equipped with an ARM-Cortex™ A8 CPU and Windows Embedded Compact 7. The higher computing power of the Intel® Atom™ processors in the C6905 and the CP6706 enables more sophisticated control, motion and visualization applications in the same price segment. At the same time a broader range of operating systems can be used: Windows Embedded Standard 7 and Windows 10 can be used in addition to Windows Embedded Compact 7.

100 % scalable – including TwinCAT software

Not only is the hardware 100 % scalable, the TwinCAT automation software enables users to install only the truly necessary features through its modular design. Starting from a simple PLC runtime, for example on a CP6606, up to a complex CNC or XFC controller with maximum performance, a fully-scalable software system is available in the TwinCAT platform. The highly-affordable TwinCAT licence costs are based on the performance level of the hardware device used. Beckhoff thus offers ideally-matched TwinCAT software components for each respective Industrial PC product – even at the entry level.

Industrie 4.0 implementation with entry-level products

The new entry-level IPC class not only fully meets the requirements for a true...
Beckhoff Industrial PC product, it also fits in with the future direction of PC-based control technology. With up to three Ethernet adapters in the C6905 and CP6706, integration of the devices into existing IT systems is easy. The linking of IT and control technology, as required by Industrie 4.0, is already possible with the entry level Beckhoff hardware. As the heart of PC-based control hardware, the Industrial PC is ideally equipped for Industrie 4.0, even in the lower price/performance segment. The use of various cloud services through TwinCAT, or the operation of the CP6606 as a Web client in the field, demonstrate just some of the real-world applications that have already been implemented.

An ideal Industrial PC for every application
Beckhoff has introduced three robust, industrial-grade devices to the market with the new entry-level Industrial PCs. Through simplification and streamlining, PC-based control technology from Beckhoff becomes more affordable and functional for the most cost- and space-constrained applications. Beckhoff makes the most compact PC-based controllers possible through maximum utilization of limited space. Reducing the number of interfaces on proven motherboards and fundamentally revising the housing concepts result in significant cost savings in direct comparison even with comparable performance classes. Compared to the somewhat more flexible devices in the same performance class – the C6915 and CP6707 – the C6905 and the CP6706 bring cost reductions of approximately 13 % and 20 %, respectively. The CP6606 sets entirely new standards and brings PC-based control, with integrated display and touchscreen operation, proven Beckhoff quality and with long term availability and industrial compatibility, into the most compact and price-sensitive applications. In addition to the finely scalable hardware, the equally scalable TwinCAT automation software rounds off the product of solutions. Performance class, operating system, and a combination of TwinCAT licences are specified depending on the application. In conclusion, Beckhoff provides an Industrial PC that perfectly suits every conceivable application.

Further information:
www.beckhoff.com/ipc-entry-level
Now all data can be saved and evaluated for advanced analysis – without exception

TwinCAT IoT and TwinCAT Analytics are the first “real” Industrie 4.0 products, said Hans Beckhoff at a company presentation during the SPS IPC Drives 2015 trade fair. Michael Corban, editor-in-chief at Elektro Automation, talked to Dr. Josef Papenfort, Pascal Dresselhaus and Sven Goldstein at Beckhoff global headquarters about this. The bottom line: Machine and plant engineers are now able to save all the data available from control systems – either locally or in a cloud – providing the ability to obtain more detailed knowledge about the machines in operation. Predictive maintenance and machine learning are only two of the key technologies that demonstrate the advantages for automation engineers and plant operators.
Elektro Automation: Hans Beckhoff said that “All Beckhoff control systems should be able to talk with the cloud and it should be possible to send ‘all’ the data if required,” at last year’s SPS IPC Drives trade fair and referred to TwinCAT IoT (Internet of Things) and TwinCAT Analytics as the first “real” Industrie 4.0 products. What is the motivation behind these developments and what benefits can the user expect?

Dr. Josef Papenfort: The idea of being able to seamlessly record and save ‘all’ process data in a cyclically synchronized manner is very tempting in principle. Once the data is available, this would make online and offline analysis possible to an extent never known before – especially because now all sensor data really can be recorded. One goal in particular is using predictive maintenance to increase system availability. However, the data could also be used to optimize machine performance and processes. Many customers are already running condition monitoring as an application on the machine control system. Of course, this can be used to analyze machine data locally, as well. If the data is saved to the cloud – or better yet in a network that many people have access to – other specialists can analyze the data and form valuable conclusions. This is where the machine manufacturers, and their automation and system engineers, are in demand as specialists. New business models could be implemented, allowing manufacturers – who know their machines best – to offer remote services such as predictive maintenance or machine optimization.

Elektro Automation: There are two tasks involved in your offer – first, collecting and transmitting the data, and then analyzing it. Let’s take a look at data acquisition first of all, with TwinCAT IoT: where can data be saved and what role do cloud services play?

Dr. Josef Papenfort: The user has the choice – they can use TwinCAT to deposit data in the local network environment, in a local cloud (private cloud) or in a ‘real’ cloud (public cloud). Looking at the cloud offerings from Amazon and Microsoft in particular, we provide support for the standardized MQTT (Message Queue Telemetry Transport) and AMQP (Advanced Message Queuing Protocol) communication protocols. These two protocols cover a wide spectrum of cloud providers and cloud services, and we have been able to cover the issue of security with them. This is critical for Industrie 4.0, and authentication and data security are inherent parts of these protocols. When we talk about ‘all’ the Beckhoff control systems – the functionality of transferring data into the cloud and performing analyses – it’s important to know that we offer this not only for TwinCAT 3, but for TwinCAT 2 as well, via the TwinCAT IoT Data Agent. The TwinCAT IoT Data Agent can also retrieve and send data from third-party control systems via the OPC UA communication standard.

Sven Goldstein: I would also like to mention that we enable the installation and configuration of MQTT and AMQP devices in a local machine network as well – use of a public cloud is not required. This decision is often dependent on which IT infrastructure the customer has available and their IT expertise. Anyone who doesn’t want to invest intensive time and effort in this will find a public cloud system solution quite attractive.

Elektro Automation: When ‘all’ the data is saved, you quickly end up with enormous amounts of data. Does it make sense to send only a certain selection to the cloud in order to keep the data volumes manageable?

Pascal Dresselhaus: That always depends on each individual application, and when particularly large data volumes are involved, it can make sense. On the other hand, the ability to explicitly access the complete data can be quite appealing. When, for example, a machine malfunctions in a way that it never has before, the analyst can go back to the complete set of data to find out exactly what happened. This makes it possible to avoid the frustrating situation that we
so often encounter today of having to wait for an error to occur again. Regardless, we are also thinking about data compression and ring buffers. However, it is our goal to lay the foundation for the future and for the ability to handle more complex analyses now, and that means it makes sense to be able to collect and analyze all the data. To do so for a longer period of time enables reliable analysis of the wear and tear on machine parts, for example.

Elektro Automation: Let’s suppose that all the data is saved. This poses the next exciting question – how can one best analyze it?
Pascal Dresselhaus: An important prerequisite for optimum analysis is the knowledge of the mechanics of a machine, and that’s exactly what mechanical engineers know. Meaningful analyses, for vibrations in particular, require detailed knowledge of the mechanical structure. That is why Beckhoff introduced the TwinCAT Analytics Configurator, an easy-to-use tool which can be used, first and foremost, to view the data. The user can select certain time periods and use this tool directly to perform basic analyses (such as frequencies and runtimes). Then the values can be viewed in the TwinCAT 3 Scope View tool, simply by using drag and drop to “move” them from the Configurator to Scope View. Relevant results – such as the occurrence of a maximum value – are then marked directly in Scope View. That makes it a great deal easier to search through the proverbial “haystack” and find exactly the data that you are interested in. In this way, the operator is able to analyze and identify the results of a loss in pressure, for example, which has an effect on the machine cycle.

Elektro Automation: With PC Control, it was already possible to perform analyses before; now what’s new is the Industrie 4.0 idea...
Pascal Dresselhaus: …which enables me to perform the analysis separately from the machine. The analyses can be done directly at the machine, but just as well at your desk in the office – and not only for just one machine, but for many. IoT communication protocols make this high degree of flexibility possible because the data can be stored in a cloud, regardless of whether it’s a private or a public one.

Dr. Josef Papenfort: The main benefit for the users – often the machine or system manufacturer – is that data availability enables better resolution of problems occurring in the field, as far as their analysis is concerned. This sheds a whole new light on error analysis and the optimization of a machine in particular. It also addresses the following question: under which concrete conditions can a product be manufactured at peak efficiency and which conditions create more of a hindrance. In this way, it will be possible to find new and exciting answers to questions that involve maintenance and tool-change times.

Sven Goldstein: Then it is also possible to compare several different machines in the field – for example, compare an entire series of different machines in use by different customers. This uncovers enormous potential for the machine builder because it is possible to obtain a wider range of results that can lead to process improvements in all kinds of applications.

Elektro Automation: This lays the foundation for optimization processes in Industrie 4.0 scenarios. Are there already research projects in progress on this subject?

Dr. Josef Papenfort: Yes. Through our membership in the “it’s OWL” (intelligent technical systems OstWestfalenLippe) Leading-Edge Cluster, Beckhoff is the project leader for two projects. One project is entitled “ScAut” (Scientific Automation) with the goal of transferring engineering expertise from various disciplines into automation technology. The focus here is on collecting data that relates to intelligent measurement technology and optimization algorithms in particular. Only when automation technology integrates such intelligent processes and technologies can intelligent production systems be
Elektro Automation: And the second project?

**Dr. Josef Papenfort:** The second project is called “efa” – eXtreme Fast Automation. The main goal of this project is to provide highly powerful PC-based control technology that automates the most complex production systems. This includes, for example, the distribution of control tasks to several different computing cores, as in our many-core computers. This also makes development tools and a drafting methodology available so third parties can integrate this technology into their own solutions. High computing power is one of the basic prerequisites – this is the only way in which all complex tasks, such as condition monitoring and image processing, can be realized in the first place.

Elektro Automation: Let’s take another look at the analysis options. You described the interaction between the TwinCAT Analytics Configurator and TwinCAT 3 Scope View. For the purposes of analysis, is it also possible to integrate simulation tools that product developers can use to take better advantage of these findings?

**Dr. Josef Papenfort:** The TwinCAT system we offer already provides an excellent engineering environment that automation and controls engineers are familiar with. This same environment is also used for analysis tasks, and can be used to operate a MATLAB®/Simulink® runtime. Algorithms from MATLAB®/Simulink® are available in different toolboxes and can, for example, be used for pattern recognition. Through seamless integration of PLC code, C++ code and MATLAB®/Simulink®, the engineer is completely free to choose a programming language or use existing solutions to create their own specific analysis system in this way. The goal is to provide an engineering environment that really does contain everything. This is the only way to provide end-to-end engineering within the realm of Industrie 4.0.
PC-based control automates innovative flow pack machine

Packaging at 500 cycles per minute
When Hartmuth Bauer decided in 2015 to build a flow pack machine, he was already quite familiar with the project’s engineering requirements. He founded his company in 1999 as a one-person business for services related to control cabinet design and construction. In 2011, what is now called Bauer Steuerungstechnik GmbH in Bretten, Germany, began developing smaller machines and systems for material handling applications. From the start, Bauer depended on control technology made by Beckhoff. He recalls the early days: "When we started to build custom-designed material handling systems, we also began to develop smaller machines, such as ergonomic equipment for control cabinet manufacturers. Together with Beckhoff we designed several positioning tools and successfully combined mechanical engineering with control technology." Hartmuth Bauer depended on Beckhoff and the company’s Industrial PCs from the start, because Bauer Steuerungstechnik counts on PC-based control from Beckhoff for its latest flow pack machine to ensure fast, accurate and highly flexible packaging processes. The powerful system of modular, scalable hardware and TwinCAT 3 software facilitates a wide range of interfaces, numerous motion control functions and efficient energy management. Other benefits include integrated engineering, easy software updates and rapid remote diagnostics.
PC-based control technology and the TwinCAT automation platform delivered the openness and future-oriented capabilities Bauer was seeking: "We appreciate the lack of any interface limitations with this technology, as well as the great variety of I/O components and the numerous software modules with important special functions," says Bauer. "Most importantly, we work with Beckhoff because they deliver complete automation technology from a single source, operate worldwide, while offering flexible and reliable service."

Working together to build an innovative flow pack machine
In the field of control cabinet construction and automation, Bauer Steuerungstechnik offers customized solutions, designed according to customer specifications for a wide range of industries. These include everything from the automobile industry, to forming technology and machinery for the food and medical industries, as well as specialty machines. The latest product is the B500SH, a horizontal high-speed flow pack machine that packages pharmaceuticals and cosmetics, as well as food and non-food items, quickly, gently and safely. The stainless-steel flow pack machine can package almost any material, even those in wet production areas.

Together with Beckhoff, Bauer Steuerungstechnik developed an innovative solution: a machine with a user-friendly visualization concept that stands out with rapid setup capabilities and a compact design. Emanuil Benner, who is in charge of the technical features of Bauer machines, explains: "The exceptional flexibility of the Beckhoff control and drive technology enables the kind of rapid product changeovers necessary in packaging applications. The 15.6-inch CP2916 multi-touch Control Panel displays all settings at a glance. The operator can call up all necessary data, such as product-specific parameters, and respond instantly to any recipe changes. With the highly dynamic and precise drive technology from Beckhoff, the machine can package products not only quickly, but with exceptional accuracy – from the slowest to the fastest machine cycles.

The machine is controlled via a CXS140 Embedded PC running TwinCAT NC PTP and a TwinCAT Camming software module. In addition to the CP2916 multi-touch Panel, additional Beckhoff components include EtherCAT and TwinSAFE I/O terminals, two AX5206 Servo Drives with AX5805 TwinSAFE cards, and AM8000 servo motors. The drive components are connected via One Cable Technology (OCT), which simplifies the modular approach considerably.

Günter Breithaupt, Application Software Engineer at the Beckhoff Pforzheim sales office, explains: "With the cam scaling function in TwinCAT NC PTP, the curve for the separation process is computed in the PLC and transferred to the NC immediately after the recipe has been selected. As a result, you can change the package length and height directly in the recipe and start running a new product without having to make adjustments on the machine or spending time on conversion. The integration of NC and cam scaling in the PLC with ready-made TwinCAT motion control function blocks made this easy. Also, with OCT employed on the AXS206 Servo Drives, we had the interfaces we needed to integrate another encoder without having to add more hardware. That way, we could compensate directly for any foil slippage."
Standardized and consistent engineering

Hartmuth Bauer lists what he sees as the unique selling points (USPs) of the flow pack machine: “Depending on the specific product and packaging material, the B500SH can churn out 500 packages per minute with a maximum foil speed of 50 meters per minute and setup changeover times of less than 10 minutes.” Günther Breithaupt adds: “During the development phase, we worked with Beckhoff to design the system’s drives for the desired speed and dynamics. The feeder components can be quickly adjusted to the selected recipe with additional user guidance on the screen and via an integrated control workflow. That way, the system controls the changeover setup process itself.”

Other benefits arise from the integration of TwinCAT 3 software into Visual Studio®, because it features a consistent engineering environment irrespective of the control system size. Emanuil Benner adds: “We believe PC-based control technology is flexible enough to handle all future requirements, and the open technology enables us to easily import third-party programs” – a feature that demonstrated its usefulness just recently, when a machine had to be retrofitted with a vision system.

EtherCAT power metering terminals for comprehensive energy management

Whatever additional technology the user may need in the future, Bauer Steuerungstechnik will be ready, since the PC-based control technology offers a very broad range of interface capabilities: “EtherCAT, PROFIBUS, Ethernet, CAN – who knows what will be needed for future applications,” says Emanuil Benner. “The same applies to new features. When new regulatory requirements had to be satisfied, the EL34xx EtherCAT power measurement terminals were available to supply the machine with functionality for a comprehensive energy management system. Now users can even document how much energy was consumed to package each individual product.”

Since controlling the flow pack machine requires considerable computing power, Bauer Steuerungstechnik selected the CX5140 Embedded PC with Intel® Atom™ quad-core processor. One core handles the NC functions, while the second handles the PLC operations. Visualization and image processing run on the two remaining cores. With these features, Bauer Steuerungstechnik is confident that the company is ready for the future.

Remote control and maintenance capabilities are other areas where PC-based control scored important points for Hartmuth Bauer, particularly since their machines are used all over the world. He didn’t want to have to use VPN routers – as required with traditional PLC technology – to access the machine or be forced to use a third-party provider. “With PC-based control, we have full access to the system. An Internet connection is all we need to look at everything down to the individual axis, no matter where the machine is located.”
Headquartered in Chengdu, the capital city of the Chinese province of Sichuan, Dongfang Electric Corporation (DEW) is a leading company in the fields of energy, electrified railways, environmental technology and heavy industry. DEW has been involved in wind turbine manufacturing since 2004 and is one of the driving forces toward sustainable power generation in China. The company has since delivered more than 7,000 wind turbines – both directly driven and double-fed plants – for Chinese and foreign customers, clearly setting itself apart from its competitors through the use of state-of-the-art PC-based control technology in its wind turbine pitch systems.
The pitch system is particularly important for the control and regulation of wind turbines, as it sets the optimum pitch of the rotor blades for every operating state of the plant. In the partial load area, i.e. at wind velocities below nominal velocity, the blade angle can be adjusted very precisely within a small range, enabling plant operation with optimum aerodynamic efficiency, even during very unsteady wind conditions. At wind velocities above the nominal speed, the blade angle is adjusted over a wider range to ensure that the power output of the plant is restricted to a narrow range close to its nominal power. In extreme cases, e.g. serious malfunctions, the pitch system drives the rotor blades back to the so-called flag position, thus stopping the plant. The reliability of the pitch system is a critical requirement for the safety of the wind turbine. It must guarantee high availability and robustness, in particular when the plant is operated under extreme environmental conditions.

**CX9020 Embedded PC as the core of the pitch control system**

DEW has leveraged experience gained from the installation of over 7,000 wind turbines and the development of its own pitch system. After careful analysis, DEW opted to use AC servo drives and AC servomotors. These are distinguished by their simple design, high reliability, low costs and easy maintenance. The system architecture of the pitch system developed by DEW essentially consists of three identical axis units: For each of the three blade axes, there is an axis control cabinet, a backup power supply cabinet, a pitch motor, two redundant blade angle encoders, two limit switches and further accessories. The core of the pitch system is a central control unit, which provides overall control of the three axis units. The control platform used here is a CX9020 Embedded PC with inline connected EtherCAT Terminals, all from Beckhoff. Servo drives and servomotors specially developed for use in wind turbines are employed. In addition, the pitch system features a redundant safety chain, which guarantees the optimization and reliability of the safety solution.

The CX9020 Embedded PC is characterized by its extremely compact size. Also, its operating temperature range extends from -25 to +60 °C, making it compatible with extremely harsh environmental conditions. DEW’s self-developed user program runs on the controller, directing and regulating the pitch of the rotor blades, monitoring the complete pitch system in real-time and taking care of error management. EtherCAT Terminals are used for the I/O system, offering fast reaction times, robust diagnostics and flexible communication interfaces.

Specifically, a EL6751 CANopen slave terminal is used in the pitch system for communication between the central CX9020 of the pitch system and the main controller of the wind turbine. The connection between the central CX9020 and the three axis controllers is established via a EL6751 master terminal directly connected to the CX9020, as well as a CANopen slave each within the I/O system of the proprietary axis controllers. The RS485 interface integrated in the CX9020 is used for monitoring the status information of the backup battery chargers. Online access, e.g. for software updates and error analysis in case of pitch system problems, can be implemented via the network interface on the Embedded PCs.

**Easy programming with TwinCAT**

As a universal development environment and control platform, TwinCAT supports the high-level programming languages Structured Text (ST) and Ladder Diagram (LD), as well as all IEC 61131-3 languages, making programming processes easy. “During the development of the pitch system, the engineers from DEW were assisted by the Beckhoff wind industry experts, making it possible for DEW to expedite completion of software development,” comments Li Bo, development engineer at Dongfang Electric Corporation and responsible for this project. The next generation pitch system from DEW reflects the spirit of continuous technical innovation. Li Bo is convinced that the two companies’ cooperation, which is advantageous for both sides, will accelerate the development of sustainable power generation in China and represent a significant step forward.
Efficient turbine foundation monitoring in Dutch offshore wind farm

CX2020 Embedded PC ensures high availability of wind turbines

Following a two-year construction period, the Dutch energy company Eneco opened the Luchterduinen offshore wind farm in September 2015. The order for monitoring the foundations of the wind turbines, situated 23 kilometers off the North Sea coast between Zandvoort and Noordwijk, was placed with Zensor, a specialist for intelligent monitoring solutions. A Beckhoff CX2020 Embedded PC processes the data acquired from sensors distributed in the wind turbine foundations and enables the transmission of measured data into the cloud.

Offshore wind energy is a booming business; however, specific requirements must be satisfied. Regular inspection and maintenance of offshore wind farm turbines is necessary to ensure reliable operation, particularly as they are exposed to extremely harsh weather conditions and a highly corrosive environment. However, dispatching a technician for on-site service of the turbines is very time-consuming and costly. Another problem is the subsidence, the gradual caving in or sinking of land around the wind turbine over the course of time. "In some offshore wind farms, the turbine pylon is fastened by means of a transition piece to the monopile on the sea bed," explains Yves Van Ingelgem, Business Development Manager at Zensor. "The space between transition piece and monopile is filled with a specially-developed concrete just for this application. Due to the force of the wind, however, the concrete can loosen from the steel, which ultimately leads to subsidence around the turbine. Further potential problems in the structure of the wind turbines can arise from corrosion, material fatigue, the elongation of bolts and walls, and cracks in the concrete."

High computing power in a compact design

Zensor – a spin-off company of the Vrije Universiteit Brussel – specializes in the monitoring of concrete and steel construction projects. The company initially concentrated on the development of specific sensors for the detection of material fatigue; today, Zensor offers all-inclusive monitoring solutions, which include data acquisition and reporting in addition to the sensor systems.

The company has installed around 30 sensors in four of the wind turbines at the Luchterduinen wind farm. They monitor not only the most diverse parameters of the structure itself, but also the environment inside the foundation as well as indirect indications of the level of the seabed through the tower dynamics. The CX2020 Embedded PC collects all measured data, pre-processes it and transmits the compressed data to the mainland via a fiber-optic cable integrated into the main power transmission line from the wind farm. "We utilize the performance potential of PC-based control to the fullest," Yves Van Ingelgem stresses. "The PermaZEN sensor, a proprietary development from Zensor that is used in other offshore wind farms to measure corrosion on the inside of the steel foundation, requires high computing power." Zensor performs the calculations in software written in Python that runs on the PC.

Voltage pattern delivers a picture of corrosion activity

The PermaZEN sensors consist of a series of electrodes suspended at different heights in the water inside the foundation of the wind turbine. Gori Nieubourg, Product Development Engineer at Zensor says: "Voltage is generated between the electrodes and the wall of the foundation according to a certain pattern. By comparing this pattern with the measured voltage and current values, we can obtain a picture of the corrosion activity on the surface."

"The performance of the PLC, integrated via software, was a major factor in our decision in favor of Beckhoff," Gori Nieubourg states. "With PC-based automation, there was no need for further hardware, since not only the PLC, but also visualization and data storage can be executed on the Beckhoff platform. The decrease in the number of components, as well as the elimination of additional interfaces, ultimately makes the system more reliable. The pylons of the wind turbines are 100 meters high; with the aid of EtherCAT technology, however, it is easy to use even very remote fieldbus ‘islands’ to transmit the sensor signals to the controller over long distances without signal losses."

No limitations in the connection of peripheral devices

In addition to controlling the PermaZEN sensors, the CX2020 also takes care of the control and readout of IntegriZEN, a system that can track the current state of concrete structures on the basis of conductivity measurements. All relevant factors, such as moisture content, crack sizes or changes in the pressure on the structure, have an impact on the conductivity and can be detected promptly by the monitoring system. In addition, the openness of PC-based control enables the connection of essentially any type of sensor or instrument.
Electrodes are suspended at different heights in the water inside the wind turbine foundation. Between the electrodes and the wall of the foundation, voltage is generated according to a certain pattern. By comparing this pattern with the measured voltage and current values, a picture can be obtained of the corrosion activity on the surface.

"We are offering a modular solution," explains Yves Van Ingelgem. "This allows us to implement the ideal application for every project without the PC platform imposing any restrictions. For some measurements, we make use of standard sensors connected to the PLC via analog or digital I/Os or via Modbus. Regardless of whether we are dealing with a simple temperature sensor or a sonar measuring instrument that scans the seabed, it is sufficient just to add the corresponding terminal to the system for each additional measurement type."

XFC terminals with high sampling rate secure competitive advantage

The majority of the measured values are read via EL3602 24-bit analog I/O terminals. "Zensor uses the eXtreme Fast Control (XFC) terminals with integrated oversampling technology, which are available with a sampling frequency of up to 100 kHz. The performance of these terminals reaches the level of high-end measurement technology applications, which is not a typical offering in the PLC world," as Gori Nieubourg emphasizes. "The resolution with which the measured values can be read, coupled with the high sampling rates, account for the competitive advantage of our solution. Another advantage is that Beckhoff offers this performance in a standard automation system that features all the robustness necessary for industrial applications. On top of that, the properties of the PLC software running on PC-based hardware were a strong argument for us: on the PLC side, we have the flexibility of the I/Os and the XFC terminals. On the PC side, we use the computing power to filter and process data, to carry out frequency analyses and to compare measured values with threshold values defined beforehand."

Early detection of potential problems maximizes availability

However, the monitoring solution installed by Zensor goes beyond the equipment in the wind turbines: all measured values are compressed in the CX and transmitted via optical fiber links to a server on the mainland. There, a cloud solution is available through which the wind farm operator can monitor the system. All measured values can be retrieved in real-time; trends and deviations are illustrated by means of graphs. In addition, Zensor can carry out ad-hoc analyses of the available data in order to answer specific questions regarding the structure of the wind turbines. This allows regular checking and determination of preventive measures if required.

"Since an offshore wind turbine is sometimes not even accessible due to changing weather conditions at sea, it is not possible to quickly solve a problem," Yves Van Ingelgem adds. "However, the fact that we can identify possible problems early on gives our customer the time to prepare and plan for maintenance or repair work well in advance and determine the most suitable time." Intensive monitoring therefore also helps save costs and guarantee maximum availability of the wind turbine.
Credimex uses the extremely flexible XTS as a linear transfer system with mover return via a spindle-driven system located underneath.
The modular automation platform CresaLine made by Credimex AG from Alpnach in Switzerland consists of intelligent process stations and, according to Roger Schelbert, joint owner of Credimex and head of the motion technology department, corresponds to the requirements for production sequences in accordance with Industrie 4.0: "The modularity of the machine gives us the possibility to produce different products efficiently. The big advantage is that one can automate difficult and complex processes that previously had to be carried out manually. The most diverse process stations from the standard range are available for the CresaLine. Handling and pick-and-place processes as well as assembly and test stations can thus be integrated as desired. These stations are linked by XTS from Beckhoff. Workpiece carriers with a length of 250 mm and a maximum width of 70 to 90 mm are mounted on its movers. Products of the same size or several small products can be processed on these workpiece carriers. That makes the system very flexible and interesting for the watchmaking and electronics industries, as well as for motor manufacturing and medical technology. What is particularly advantageous is that batch sizes of one can be produced and retooling for new products is very fast."

In addition to parts handling, the process stations include joining by gluing or welding, laser triangulation for product recognition and image processing for quality assurance. Further customer-specific stations may be added to these, depending on requirements, and according to Roger Schelbert this clearly demonstrates one of the main advantages of PC-based control technology from Beckhoff: "PC Control with its openness and variety of interfaces as well as XTS with its flexible motion functions offer an ideal platform for integrating any desired components or additional stations. The integration of robotics, for example, is very simple with TwinCAT. In addition, a wide range of components, high-performance EtherCAT communication and, with TwinSAFE, system-integrated safety technology are available."

**XTS – flexibility in functionality and layout**

The eXtended Transport System of the current CresaLine system, which consists of eight stations, is made up of nine 250-mm long linear motor modules. Nine 250-mm long movers move along this track as workpiece carriers. In the case of the CresaLine Starter, the whole thing is reduced to half the size of the CresaLine, but with the same approach. This shows that XTS provides enormous flexibility in motion control, not just by replacing mechanical components, but also by means of software functionality. In addition, the system configuration is easy to adapt to the user’s needs: the application-specific movers use the magnetic plate and the encoder system from XTS on the one hand and the customer’s
own guide rail on the other. In addition, Credimex has in this case implemented a linear XTS design instead of a closed one. Roger Schelbert explains: "The special feature here is that the movers in the CresaLine Starter are lowered at the end of the XTS section and returned to the start via a 3-axis linear system. In the large CresaLine the movers are shifted onto the opposite XTS transfer line by means of a cross-transfer system. The return section is thus also used for assembly stations. This way we can design a very compact system and thus meet the market demands for smaller assembly lines."

According to Roger Schelbert it is easy to extend the compact system design: "Thanks to the modularity in hardware and software, other machine layouts can also be realized with XTS with no great effort, simply through configuration. For example, the mover return section under the processing table can be replaced by a cross-transfer or closed XTS system in order to integrate additional populating or processing stations."

**Software functionality replaces hardware expenditure**

Motion functions that would often necessitate enormous hardware expenditure can be realized with XTS in a simple manner by software means. Roger Schelbert mentions a few examples of this: "The production flow can be adapted to the addition of process stations by software configuration with no hardware changes at all. In addition, the motion and the positioning can be controlled so precisely that hardware components that used to be necessary can be omitted. For instance, with XTS it is no longer necessary to lift the workpiece off a conventional conveyor belt in order to achieve the indispensable positioning accuracy for the processing. As a result, much simpler processing stations with fewer motion axes can be realized."

In particular with the assembly of small parts, many factors play an important role in attaining the desired precision. Even slight vibrations can cause problems here, which Roger Schelbert considers a further advantage of XTS: "The transfer system works completely independently and without a mechanical connection to the individual process stations. This means that no vibrations, for example due to the return movement of a handling robot, can be transmitted to the XTS and thus to other stations. This has a significantly positive effect on the achievable processing accuracy."

The flexibility of the movers also has a positive effect, as Roger Schelbert explains: "For one thing the movers can be designed specifically for the application — shorter or longer, larger or smaller — depending on how much space is available for their movement or how many individual products have to be transported per mover. So far we have been concentrating on the micro-assembly area, which extends from 500 microchips up to three or four large components per workpiece carrier. However, flexibility also means that individual movers can be removed from the transfer system and put back in again as required. One example of this is a special mover with a battery powered camera system which, if necessary, drives through the process, checks the accuracy of the individual process stations and saves the offset corrections again for the highest precision. This is important amongst other things in the case of large temperature differences, for example in the morning or in the middle of the working day."

**Variability as a prerequisite for Industrie 4.0**

Even today the CresaLine already meets the requirements for the realization of modern Industrie 4.0 concepts. For instance, the production efficiency is
traceable at any time and for each process, since the individual operations are saved in a database with a timestamp. The main requirement, however, is the consistent modular machine approach based on individual intelligent process stations that are linked with high flexibility via XTS. Roger Schelbert comments: "Entirely in keeping with lot size 1 manufacturing, an order-related decision is made for each project as to which process steps are necessary for manufacturing. On the one hand this is made possible by the linking of the C6920 central control computer and the CX5020 Embedded PCs of the individual process modules to the customer’s ERP system. On the other hand a big part is played by the individual controller of every single mover in conjunction with a uniquely assigned product, because in this manner the product to be processed becomes virtually intelligent and can guide itself through the assembly process. A further aspect has to do with the camera mover for the calibration of the entire process chain, which I mentioned before. Its information can be used directly for early corrections of the process sequences before unacceptable quality defects or too many bad parts occur."

Roger Schelbert, joint owner of Credimex and head of the motion technology department: “XTS enables us to design particularly compact machines and thus supports the optimum exploitation of the existing production area.”

Further information:
www.credimex.ch
www.beckhoff.ch
www.beckhoff.com/XTS
Telescope controlled by PC Control surveys the skies

Observatorio Astrofísico de Javalambre (OAJ), which went into operation in 2015 in the southern Aragón region of Spain, is regarded as an incredibly unique astronomical research facility. The observatory is operated by the CEFCA foundation, whose main research goal is to photometrically survey several thousand square degrees of sky. Two Javalambre telescopes with an unusually wide field of view will make it possible for the first time to record the positions of hundreds of millions of galaxies and their development in order to supply the first full 3D map of the universe. To ensure high quality and efficiency, the telescopes operate with robotic assistance, based on an industrial PC control platform.
The Centro de Estudios de Física del Cosmos de Aragón, or CEFCA for short, is a state institute concerned with research into the development of galaxies and cosmology. Its headquarters are located in Teruel, Spain – some 40 km from the OAJ site which was constructed on the “Pico del Buitre” at an altitude of 1,957 meters above sea level. The observatory is equipped with two telescopes: the JST/T250, a telescope with a mirror diameter of 2.55 m and a 3-degree field of view, and the smaller JAST/T80, with a mirror diameter of 83 cm and a 2-degree field of view. All data from the sky surveys carried out at the OAJ are sent to the main server in Teruel via wireless communication.

**EtherCAT network connects all systems and subsystems**

The observatory’s control system is based on a C6640 Industrial PC (IPC) as the master control platform and various CX5000 series Embedded PCs that provide decentralized control. The PC platform ensures the reliable control, monitoring and management of all systems and subsystems installed in the observatory. These systems are divided into five groups according to their location within the observatory: the operations building (Main PLC), the T080 telescope (B080), the monitoring room (BMON), the T250 telescope (B250) and the main operations building (Main Server Rack) (see fig. 1). The main control room is located in the main operations building and is used for the general control of all systems, including the observatory. Even though both telescopes can be controlled from the main control room, local control rooms are available for carrying out specific tasks, such as commissioning, maintenance or other technical work.

All control nodes are linked via EtherCAT in a ring topology, as well as via an Ethernet network with a star topology. The latter links the control units of the C250 camera with the observatory’s EtherCAT network over the EtherCAT Automation Protocol (EAP). Communication takes place via a fiber-optic cable using EtherCAT or Ethernet protocols. The high bandwidth of EtherCAT enables the transmission of status information with each cycle. A remote control center is installed at the CEFCA headquarters in Teruel, from which the observatory can be managed, controlled and operated. The status of the OAJ is displayed in real-time on a video wall.

**Embedded PC facilitates complex control of telescopes**

The smaller of the two telescopes, the T80, performs some sky surveys referred to as JAST, beginning with the planned J-PLUS, a photometric multiband survey of the entire sky with expected completion in around two to three years’ time. The results will be used to support the calibration of the astrophysical J-PAS survey, which is to be carried out with the JST/T250 telescope. In the next five years the T250 telescope will have surveyed 800 square degrees, or one fifth of the entire sky.
Installed on the T250 is a JPCam wide-field camera, specially designed for the photometric surveillance of the northern sky. It consists of a mechanical filter shutter unit and camera system. The latter consists of the cooling and vacuum systems, the CCD detector field, an optically controlled entrance window and electronics. Filter inserts, the shutter and the interface with the telescope form the mechanical basis for the unit. A total of four CX5020 Embedded PCs are used to control the optical lenses, the camera and the hexapod on which the camera is mounted (see fig. 2). The control of the temperature-regulating glycol water for the camera is also performed with an embedded controller, EtherCAT slave module and inline EtherCAT terminals. The cooling system ensures that all heat is removed from the system, including the electronics and the shutter, so that the camera remains at a constant temperature. This prevents irregularities in the imaging due to the expansion or contraction of camera components caused by heat.

**Control of the dome – an entire world of automation**

The dome that covers the T250 telescope is almost 13 m in height and weighs 17 tons. It is controlled by a CX5020 Embedded PC with TwinCAT 2 NC PTP software. The compact PC-based controller controls the azimuth movement, which reaches a speed of 27 m/min, the opening and closing of the windshield and the observation window, as well as the rotary movement of the dome. The entire system is driven by Beckhoff AX5xx Servo Drives with integrated safety option card and servo motors. Safety I/Os are also integrated seamlessly into the control system via TwinSAFE terminals. The CX5020 is connected with a slip-ring system over PROFIBUS to a further CX5020, which is mounted in the lower, immobile part of the dome.

**Mirror maintenance necessitates high-precision transport**

The mirror of the T250 telescope has a diameter of 2.55 m – a precision instrument whose surface must be polished with extremely high accuracy to ensure that the deviation of the reflected beams is as small as possible. Such a mirror is valued around several hundred million euros, which means that maintenance work, such as the renewal of the aluminum layer, requires the utmost care. The OAJ has a special aluminizing room for this, in which the characteristic values of the mirror surface are meticulously maintained, remaining as close as possible to the state in which it was delivered from the factory. In view of the size and weight of the mirror, its transport to the maintenance room some 16.5 meters away represents a remarkable challenge. The lifting system that moves the mirror up and down is controlled with the highest precision by an Embedded PC and a servo drive with integrated safety functionality. The speed is only 15 cm per minute – a movement that is barely perceptible by the human eye. However, each minute acceleration or deceleration could cause tiny scratches on the glass, which would result in sky observation errors.

**Integrated safety technology with TwinSAFE**

Many of the safety circuits in the OAJ were designed on the basis of the TwinSAFE system. “With the aid of the EL6900 TwinSAFE logic terminal, we are able to add functional groups that control the various inputs and outputs, enabling us to implement important tasks such as emergency stop, AND and OR logical function blocks, as well as power-on and power-off delays with TON and TOFF, among others,” explains Axel Yanes, head of engineering at the OAJ. “The OAJ control system is conceived as a global system in which all components are inter-connected and the devices constantly exchange information. They interact in a synchronous manner, so our entire safety system must be able to do the same.” The safety information is transmitted via the FailSafe over EtherCAT (FSoE)
protocol. With this protocol, the PLCs form a bidirectional publisher-subscriber relationship, enabling each PLC to publish a variable (publisher) and subscribe to another (subscriber). These variables must be linked within the safety logic terminal (EL6900), which treats them as safety inputs or outputs. If the EL6900 detects an error, it can publish a warning signal that is received by another CPU within the EtherCAT network, which then places its own system into a safe state.

**Extensions already planned**

Axel Yanes is already devising plans for the future: “We will put some more interesting devices into operation at the OAJ. We have been able to integrate some functions in the observatory control system that hadn’t been planned until now, such as BACnet/IP, condition monitoring and much more. We are very pleased to have Beckhoff as a technology partner. They have fulfilled our requirements with regard to a high-quality, reliable and, at the same time, flexible and easy to maintain system. The global support, which we have made use of for the coordination of the project in a total of 10 countries, was also extremely valuable for us.”

The JST/T250 is a telescope with a diameter of 2.55 m and a 3-degree field of view. It will make it possible to record the positions of hundreds of millions of galaxies and their development for the first time, and ultimately to supply the first full 3D map of the universe.
Grundfos "Living Lab"

As part of a project to explore energy monitoring and smart metering technologies, Grundfos, Microsoft and Beckhoff have equipped the "Grundfos Kollegiet" student dormitory in the Danish town of Århus with intelligent PLC systems that transmit data to an energy monitoring system in Microsoft’s Azure™ cloud computing platform. The dormitory is near the town’s port district and was built in accordance with the most advanced energy efficiency standards and equipped with the latest building and automation technology. The energy monitoring system creates a database for optimizing building operations. By including the residents of the "Living Lab" in the project itself, the building owners can increase efficiency without reducing the residents’ comfort.
residents and the building management system, Grundfos hopes to use the data to identify new usage options for its current products, as well as for new product offerings and business models. Also involved is the University of Århus, which analyzes the connection between resident behavior and energy usage.

The first version of the Grundfos project was implemented as early as 2012 by installing a special server infrastructure and database in the building. As the monitoring cycles grew shorter and the amount of data needed for the seamless analysis of current and historical conditions larger, administering this IT infrastructure became increasingly expensive in terms of both money and personnel. Protecting access to all this data by various groups of users also required increasingly complex systems. In order to meet these requirements in the future, the parties involved in the project decided in 2015 to redesign the project and migrate the server infrastructures to a cloud-based system. As part of this change, Beckhoff’s highly scalable control technology demonstrated its flexibility, providing a seamless retrofit of the local building automation platform with a link to the cloud. The PLCs and I/O subsystems now transmit the energy data to the cloud-based system via TwinCAT IoT software, which is easy to configure and does not require programming.

Microsoft’s Azure™ cloud platform provides everything necessary to create a fast, scalable infrastructure for processing and storing the data. Access to the energy monitoring data from the “Living Lab” can be defined and enabled for a wide range of user groups. The information is made available to the building’s residents and management, as well as to the research and technology department of Grundfos. By conducting various studies in connection with the residents and the building management system, Grundfos hopes to use the data to identify new usage options for its current products, as well as for new product offerings and business models. Also involved is the University of Århus, which analyzes the connection between resident behavior and energy usage.

The energy monitoring system is used to store and analyze all energy consumption data, as well as for managing alarms. The 12 floors of the building house
156 residential units, with 3,000 sensors that collect energy data every three seconds and transmit them to the higher-level system. The sensors are linked to Beckhoff BC9191 Bus Couplers and CX9020 Embedded PCs. A central Beckhoff Industrial PC runs the TwinCAT IoT Data Agent software to collect sensor data via OPC-UA and functions as the gateway to Microsoft’s Azure™ cloud, in particular the Azure IoT Hub. The TwinCAT IoT Data Agent effectively separates the PLC systems from the cloud environment. Thanks to the publisher/subscriber mechanisms and communication via the Azure IoT Hub as a central message broker, there is no need for the devices and services involved in the communication process to divulge their addresses to each other. They communicate exclusively via the central broker, which handles all message addressing functions. From the perspective of the firewall placed in front of the gateway PC, the data communication provides an encrypted link for both transmitted and received messages, and the firewall makes it possible to completely block all incoming communications, thus preventing any unwanted access from the outside. This protects the residents’ personal data, the companies’ intellectual property and building operations from accidental or intentional manipulation.

The Data Agent’s graphical user interface (GUI) makes it easy to configure the sensor data for transmission to the Azure IoT Hub. Through various parameters, the administrator can also define when the transmission will be initiated: cyclically, when certain values change or when certain actions are executed. Internal buffering mechanisms also ensure that any missing sensor data will be transmitted after a power failure. If the connection fails, the TwinCAT IoT Data Agent records a timestamp. As soon as the connection has been restored, the Data Agent retrieves the missing data from its internal memory and sends it to the Azure IoT Hub.

As a central and secure message-based connectivity service, the Azure IoT Hub is responsible for receiving and forwarding the energy data to all participating cloud services within Microsoft Azure™. Further analysis of the energy data is possible with the help of the Microsoft IoT Suite, which administers the devices and collects raw data for processing via the Azure SQL Data Warehouse and PowerBI. Azure Stream Analytics and Azure Machine Learning are used to detect anomalies. Special algorithms in these services recognize whether the values detected by the sensors over a specific period fall outside the normal range or could possibly not be recorded. If such an event occurs, the system issues an alarm via e-mail.

In addition, the various user groups such as the student residents can access the energy data via a special programming interface to develop their own apps or algorithms, as part of a project or to meet college course requirements, for

The energy-efficient Grundfos Kollegiet building offers students an attractive living environment in the new harbor district of Århus. State-of-the-art energy automation linked to Microsoft’s Azure cloud makes it possible to identify even the smallest energy savings potential.
example. The programming interface, which includes a function for retrieving historical energy data, is based on the Azure Service Fabric. The data is protected via Azure’s Active Directory and Application Insights services, which authenticate the various user groups.

As this project demonstrates in impressive detail, the Data Agent can be used to easily retrofit older, existing control systems with new technologies and connect them to the cloud. This is all possible without having to modify the actual TwinCAT automation project, protecting the investments made in existing systems. Using cloud-based services also makes it possible to flexibly adapt systems to changing needs without having to invest in your own hardware or software, which also significantly reduces operator costs.

Morten Lykkegaard, Lead Enterprise Architect, Grundfos: “Using products that are compatible with standards like OPC-UA, Beckhoff ADS and AMQP delivered huge benefits for Grundfos. It enabled us to provide all devices and services for this project quickly and easily.”
Hybrid solution combines conventional CNC machining with industrial 3D printing

Hybrid manufacturing process ensures maximum productivity in metalworking applications

Hybrid Manufacturing Technologies has developed a CNC-based hybrid tool solution, the Ambit™ multi-task system, which can be integrated into almost any CNC metalworking machine. Ambit™ enables the alternate use of metal removal and metal deposition heads in the tool spindle, and ensures optimized machine communication through the use of a PC-based control platform with EtherCAT as the fast fieldbus system.

The hybrid tool solution from Hybrid Manufacturing Technologies combines conventional CNC technology and additive production processes with the ability to provide both machining and metal deposition tools on the same spindle. The tool change is performed automatically. Machine tool manufacturers who opt for the Ambit™ hybrid solution can expand the possibilities of their standard CNC machine by integrating additive manufacturing without additional and tedious re-clamping operations and programming steps. The post-treatment of components, such as polishing, milling and surface sandblasting, can also be done with the same machine equipment – so that transfer to another production cell for finishing is not required. The use of different material compositions for the same product is also possible, and inspection during production guarantees quality grades that cannot otherwise be achieved or determined.

**Fully-automatic tool change for CNC machining and 3D printing**

"The Ambit™ hybrid kit was developed to offer compatibility with most CNC machine configurations and robot platforms," explains Dr. Jason Jones, Managing Director and founder of Hybrid Manufacturing Technologies. "Equipping an existing multi-axis CNC machine with automatically exchangeable deposition heads makes 3D printing in metal possible without having to purchase a separate machine. This not only reduces costs, but also enables extensive options in the operation of CNC machines."
The hybrid system supports a wide range of processing heads with different geometries, laser profiles, powder supply configurations and unfocused beams in order to enable a variety of processing steps. These include 3D metal application, welding, marking, chipping, drilling, pre-heating, annealing/relief, surface re-melting and cleaning, and much more. The standard equipment can accommodate up to 15 processing heads. However, an unlimited number of heads can be added, depending on the space in the tool changer and the control system performance.

**Beckhoff control technology selected as the new standard**

The Ambit™ control platform consists of a CP2218 Panel PC with 18.5-inch multi-touch display that runs TwinCAT 3 automation software, as well as an EK1100 EtherCAT Coupler with in-line connected EtherCAT I/O Terminals. "Hybrid Manufacturing Technologies was particularly impressed by the HMI solution from Beckhoff and the possibility to use EtherCAT technology in the processing head," stresses Dr. Jason Jones.

Peter Coates, co-founder of Hybrid Manufacturing Technologies, adds: "We can supply our customers with processing heads tailored precisely to unique application requirements that are usable on just about any machine tool. The use of EtherCAT as the communication system makes connection to other production cells simple. TwinCAT 3 also simplifies the connection to other company systems, even extending into the integration of customer-owned Ethernet-based control and ERP solutions. In the future, we will continue using Beckhoff control technology as the standard in the advanced hybrid solutions we supply to the global market."

**Efficient engineering with TwinCAT 3**

Peter Coates comments on the transition to the PC-based control solution: "It was a significant upgrade from our previous solution, and after a minimum amount of training, we were able to integrate all our engineering processes into TwinCAT 3. The advantage of programming with structured text is that we do not have to change the platform; instead, we can simply add new PLC code. This means that all controllers run programs made with the same code, which is incredibly helpful."

**The next steps in the development process**

In March 2015, Hybrid Manufacturing Technologies won the International Award for Additive Manufacturing (IAMA) at the MFG meeting in Orlando, Florida, USA, which was awarded for the first time. However, the innovative company is already looking ahead to the future, envisioning the next development steps: these include the migration of the machine tool into the offices to drive research and development, as well as the development of a user interface that is intended to become the basis of a future industry standard.
The “intelligent care” home

The French organization “Turbulences” recently built a home for autistic and handicapped adults in the city of Saint-Dié-des-Vosges that seeks to implement the latest in care technology. “Maison Mosaique” sets the gold standard in terms of integrative care concepts and intelligent building automation. Based on Beckhoff components, French systems integrator A2I implemented a solution in which all components are integrated, configurable, and remotely controllable.

In each room, the temperature can now be set according to the resident’s individual needs.
To protect the health of the residents, the “Maison Mosaique” features a monitoring system which is accessible by all care staff and educators. The operators decided from the start that they wanted to install a building automation system that featured the latest in advanced monitoring technology. This was the only way to implement a modern care facility that would be open to the outside while ensuring the residents’ safety. Using presence and motion sensors, the staff knows where residents are located at all times and can respond accordingly, if necessary.

Another building automation requirement involved the ability to use and remodel rooms in a flexible manner. In view of the broad spectrum of patient needs, the operators wanted the ability to adapt the rooms to the different needs of their residents. A2I, a French company specializing in building automation and technical building management, accepted this challenge.

Wireless communication permits flexible usage of space
"For the Maison Mosaique building, we envisioned an automation system where each device can be integrated and fully configurated," explains Olivier Franoux, head of automation projects at A2I. Since all lights, doors, rolling shutters and windows of the building are equipped with wireless sensors, very little wiring was needed. The sensor and switch signals are transmitted via EnOcean radio technology. "This is a huge advantage when a switch needs to be moved to another wall if a change is made in the way the space is used. It also enhances the safety of the residents, because the wireless, battery-less EnOcean devices are energized just by the kinetic energy generated from a button push," elaborates Olivier Franoux.

Diverse interfaces ensure reliable communication
A2I implemented the building automation system on the basis of Beckhoff control components. The controllers communicate via various protocols such as EnOcean for the wireless switches, remote controls, and door sensors, among other systems, and EIB/KNX for the heating system. One advantage of the Beckhoff controllers is the fact that they can handle all communication protocols common to industrial and building automation. “All in all, we installed 29 embedded controllers from the CX9000 series. Each of these handles two rooms or one office area in the building’s administrative section,” Franoux continued. “A CX5020, with a powerful 1.6 GHz Intel® Atom™ processor, runs supervisory control functions, as well as the monitoring software.”

Personal comfort at the push of a button
Developing the complex automation system, with its multitude of adjustable parameters for each object, took less than six months. Today, the operator of the “Maison Mosaique” building can specify a wide range of scenarios for each room. Some residents are allowed to open their rolling shutters themselves; others are not. Some patients must be wakened with light that slowly becomes brighter. A switch may control optional a single lamp or all of them. The care staff can even program an alarm that senses if a patient stays in the bathroom for an excessive amount of time (indicating that he or she might need help). Although the monitoring software itself is complex, the operation of the system is quite intuitive: “We received support from a web designer to make the application visually attractive. We also worked on its ergonomics so that no action requires more than three clicks,” emphasizes Franoux.

The browser-based monitoring application for various display types, such as touchscreens or tablets, is based on the Beckhoff controllers’ web server. The building automation system not only improved the comfort and safety of the residents, it also saves the operator money. Due to the intelligent integration of lighting, blinds and sunlight sensors into the system, the facility uses much less electricity than before. In addition, with access to historical data such as individual room temperature readings, the efficiency of the heating system could also be optimized.
The EtherCAT Conformance Test Tool, or CTT, is the official reference tool for specifying compliant implementation of EtherCAT technology into EtherCAT slaves. The CTT enables the hundreds of EtherCAT device manufacturers to ensure reliable interoperability in the field. The first version of the CTT was created in 2008 and all subsequent updates have proven to be stable in practice. To maintain continuity, version 2.0 retains all functionalities and tests from the first version while adding impressive new features.

With the updates in version 2.0, central extensions became available: Over and above the main purpose of the tool, which is to conduct device tests and detect possible errors, CCT 2.0 significantly extends functionalities that support and simplify EtherCAT development. This includes the ESI editor which can be used to edit the device description file, SII control to generate the EEPROM content, as well as additional functionalities such as the possibility to upload the object dictionary from the device and save it for the ESI.

In addition to the extensions of the new version, test coverage has been increased systematically, leading to a much higher number of possible test cases. Furthermore, CTT 2.0 supports the operation of devices in the highly accurate synchronization mode (Distributed Clocks) which can now be tested via a fully automated process. Additionally, users can create any number of configurations in one project for an EtherCAT slave – even automatically. This enables the developer to test devices comfortably and quickly in all available configurations. The test results themselves can be exported for documentation into Microsoft Excel or .csv format.

The test logic, and thus the tests themselves, are defined and released by a special working group within the EtherCAT Technology Group, the Technical Working Group, Conformance. The test software of the CTT, which conducts the logic defined in the tests and evaluates the behavior of the EtherCAT devices with this logic, is developed and maintained by Beckhoff. This ensures continuous development of the tool, which also includes new functionalities in the built-in configurator, as well as support of all Windows operating systems, including the new 64-bit architecture.

Version 2.0 of the Conformance Test Tool is now available to all members of the ETG.
In June 2016, the Semiconductor Technical Working Group of the EtherCAT Technology Group (ETG) met for the 10th time. The meeting was hosted this time by ETG member company Lam Research in Fremont, California. Just in time for the meeting, a series of EtherCAT specification updates have been finalized, adding numerous extensions for the long-approved slave device standards as implemented in semiconductor manufacturing processes. Based on these updates, automated tests have also been optimized and prepared for approval. Another highlight of the meeting was the establishment of two new working groups, as subsets of the greater Semiconductor Technical Working Group, whose task is to define device profiles for chillers (cooling systems) and VI probes (special voltage measuring systems). Furthermore, the semiconductor manufacturers announced strong interest on the part of large clients in the development of further specific device profiles.

The active member participation with 50 participants, the initiation of new profile development, as well as the demand for new profiles from customers, highlights the major impact the Semiconductor Technical Working Group has on suppliers and machine builders. Just some of the reasons for this include the fact that semiconductor-specific device profiles for a unique interface have been published in the past and currently serve as the basis for faster development of reliable machines for tool manufacturers. In addition to the currently available specifications and their extensions, a further benefit comes from how the working group, together with the ETG specialists, reliably makes new profile tests available to guarantee high quality EtherCAT implementations. The next meeting of the ETG Semiconductor Technical Working Group is scheduled for October 2016 and will be hosted by industry heavyweight Applied Materials in Santa Clara, California.

Since its founding in November 2003, the EtherCAT Technology Group (ETG) has become the largest fieldbus user organization in the world with more than 3,850 member companies from 62 countries. Established in November 2003, with 33 founding members the number of member companies grew continuously in the following years. In 2008, ETG celebrated one new member per working day, while in June 2016 ETG was able to report that 500 new members had joined over a 12-month period. The basis for the great success is, apart from the outstanding performance of EtherCAT, the numerous events organized by ETG worldwide, with roadshows, tradeshows, workshops, Plug Fests and others. In addition, teams of ETG representatives in Germany, USA, China, Japan and Korea assist the member companies with high level EtherCAT support every day – services that are well-received!

500 new members within 12 months: With more than 3,850 member companies from 62 countries, the ETG is the world’s largest fieldbus user organization.
Open, flexible, modular: the automation toolkit for the shipbuilding industry from Beckhoff

Beckhoff will present its universal automation toolkit for the shipbuilding industry at the SMM 2016 trade fair in Hamburg, Germany. Due to its openness, modularity and scalability, PC-based control can be used in the most diverse areas for control tasks, including in passenger ships, for example. In addition to the lighting, heat regulation, ventilation, air conditioning and individual room control, users can add measurement technology, condition monitoring and pump control flexibly and cost-effectively with Beckhoff control components.

IoT and Industrie 4.0 for the metalworking industry

The future of machine tools in the metalworking industry is being shaped by Industrie 4.0 and Big Data solutions. As a specialist in PC-based CNC solutions, Beckhoff will demonstrate at AMB 2016 in the company’s booth how you can design your machines to be essentially future-proof. The fast, open and highly scalable CNC solution from Beckhoff is Industrie 4.0-ready and integrates solutions today for predictive maintenance and process optimization in the cloud.

PC-based control optimizes your packaging machine

The packaging industry is continually facing new challenges: these include custom packaging and variable lot sizes due to changing consumer preferences and rapid production changes. With PC-based control, Beckhoff offers a universal control and motion platform for highly-flexible and efficient packaging machines. Discuss your innovations and application challenges with the Beckhoff team at FachPack 2016.
Discover the advantages of Wind 4.0

At WindEnergy in Hamburg, Germany, Beckhoff will present TwinCAT 3 Wind Framework; through this alternative energy solution, Industrie 4.0 is making inroads into the automation of wind turbines. The software package contains functions and tools for object-oriented and modular engineering, secure horizontal and vertical communication and optimized data preparation. The TwinCAT Wind Framework includes all the essential functionalities of automation software for wind turbines and offers support for efficient development, commissioning and operation.

Simple, open, standardized: Industrie 4.0 for assembly and handling technology

At Motek 2016, Beckhoff will demonstrate simple and standardized implementation of cloud-based automation concepts in assembly and handling technology using TwinCAT Analytics and TwinCAT IoT. Applications such as Big Data, data mining and condition monitoring form the basis for new automation solutions that will significantly increase the competitiveness of machines and products. Further highlights of the Beckhoff trade show booth are EtherCAT P, the one cable solution for the field level, and a live application of the XTS linear transport system with Cloud connection.

Advantages quadrupled for plastics machines

At this year’s K show for the plastics industry, Beckhoff will present practice-proven automation solutions with which companies can secure their competitive lead in several ways. New products for IoT and analytics applications enable you to implement future-proof Industrie 4.0 machine and plant concepts. The turnkey software for hollow-body blow molding assists users with ready-to-use program modules for wall thickness control. Beckhoff XFC technology, which enables high-precision switching from the injection phase to the holding pressure phase, provides the maximum performance for maximum quality with minimum use of energy.

State-of-the-art control technology for sheet metal processing

Beckhoff’s trade show booth at EuroBlech 2016 answers questions about the future of sheet metal processing: How can machining processes be optimized by utilizing cloud services? How can you reduce the cabling of your press line by 50 % with new technology? How can you guarantee your customers maximum intellectual property protection? How can you make your punching and nibbling machine even faster? How can you bend edges instantly? Concrete solutions to these questions can be found at the Beckhoff booth.
Trade shows 2016

Europe

Germany

SMM
September 06 – 09, 2016
Hamburg
Hall B6, Booth 218
www.smm-hamburg.com/en

AMB
September 13 – 17, 2016
Stuttgart
Hall E2, Booth 200
www.messe-stuttgart.de/en/amb

FachPack
September 27 – 29, 2016
Nuremberg
Hall 3A, Booth 331
www.fachpack.de/en

WindEnergy Hamburg
September 27 – 30, 2016
Hamburg
Hall B6, Booth 319
www.windenergyhamburg.com/en

Motek
October 10 – 13, 2016
Stuttgart
Hall 8, Booth 108
www.motek-messe.com

K
October 19 – 26, 2016
Dusseldorf
Hall 11, Booth G21
www.k-online.com

EuroBlech
October 25 – 29, 2016
Hanover
Hall 27, Booth D89
www.euroblech.com/english

FMB
November 09 – 11, 2016
Bad Salzuflen
Hall 20, Booth E14
www.messe-stuttgart.de/en/fmb

SPS IPC Drives
November 22 – 24, 2016
Nuremberg
Hall 7, Booth 406
www.messe-stuttgart.de/en/spsp

Switzerland

Sindex
September 06 – 08, 2016
Bern
www.sindex.ch

Denmark

Automatik
September 13 – 15, 2016
Brøndby
Booth B-1058
www.automatik16.dk

FoodTech
November 01 – 03, 2016
Herning
www.foodtech.dk

Finland

PacTec
September 20 – 22, 2016
Helsinki
www.messukeskus.com/sites3/PFGPtec/en

FinnBuild
October 12 – 14, 2016
Helsinki
Hall 6
www.finnbuild.fi

Sweden

Scanautomatic
October 04 – 06, 2016
Gothenburg
Hall B, Booth 808: 52
www.scanautomatic.se

France

Emballage
November 14 – 17, 2016
Paris
www.all4pack.fr

Smart Industries
December 06 – 09, 2016
Paris
www.smart-industries.fr

Romania

IEAS
September 20 – 23, 2016
Bucharest
Hall Unirii, Booth A24
www.ieas.ro/en
Turkey
Robot Investments Communication Forum and Exhibition
September 29 – October 01, 2016
Istanbul
Booth A4
www.robotyatirimlari.com

United Kingdom
PPMA Total Show
September 27 – 29, 2016
Birmingham
Hall 5, Booth B100
www.ppmatotalshow.co.uk
LuxLive
November 23 – 24, 2016
London
Booth P8
http://luxlive.co.uk

Africa
South Africa
Electra Mining Africa
September 12 – 16, 2016
Johannesburg
Hall 7, Booth A18
www.electramining.co.za

Asia
China
China Brew & Beverage
October 11 – 14, 2016
Shanghai
www.chinabrew-beverage.com
China Wind Power
October 19 – 21, 2016
Peking
www.chinawind.org.cn
Prolight + Sound Shanghai
October 26 – 29, 2016
Shanghai
www.prolight-sound-shanghai.hk.messefrankfurt.com
Industrial Automation Show
November 01 – 05, 2016
Shanghai
www.industrial-automation-show.com

North America
Canada
ATX Montreal
November 30 – December 01, 2016
Montreal
Booth 1615
www.atxmontreal.com

USA
Industrial Automation North America
September 12 – 17, 2016
Chicago
Hall East, Booth 4905
www.imts.com/iana
Pack Expo
November 06 – 09, 2016
Chicago
Hall North, Booth 6125
www.packexpointernational.com
Fabtech
November 16 – 18, 2016
Las Vegas
www.fabtechexpo.com

South America
Brazil
ISA Expo Campinas
September 13, 2016
Campinas
www.isacampinas.org.br

Further information:
www.beckhoff.com/trade_shows