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PC control

The New Automation Technology Magazine

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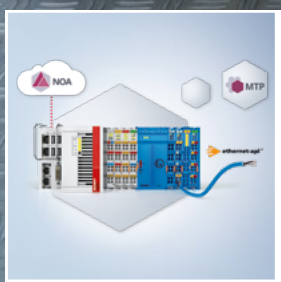

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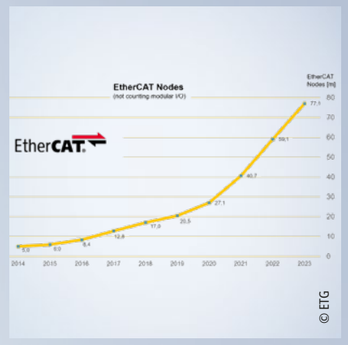

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The New Automation Technology Magazine

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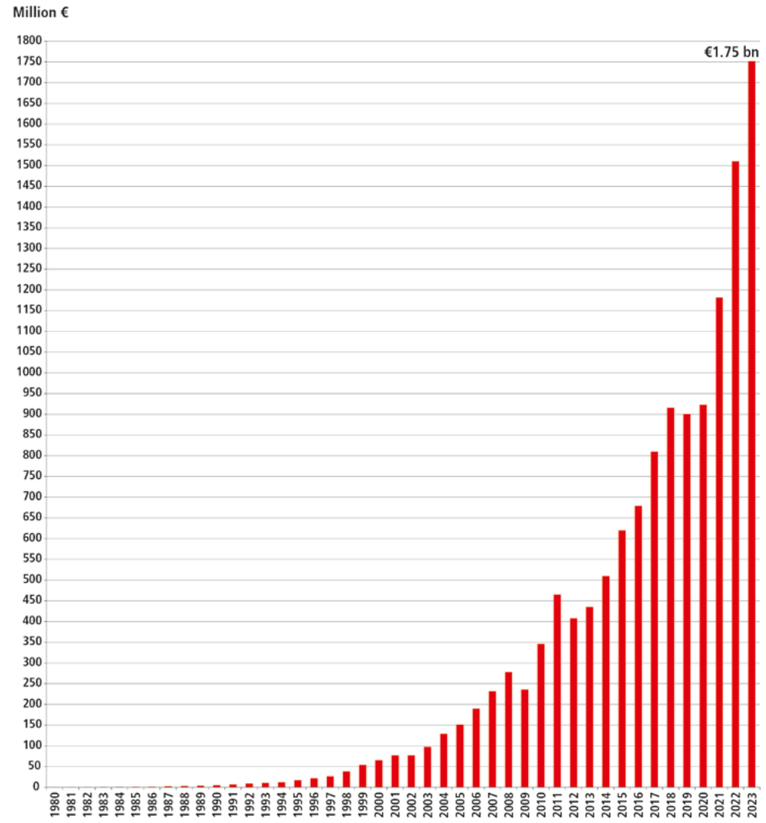
Hans Beckhoff,
founder and Managing Director

“We remain dedicated to our mission: we seek to evolve our portfolio every year and introduce revolutionary new technology every five to seven years.”



The sales curve at Beckhoff Automation continues to rise exponentially, with the Verl-based automation technology specialist recording an average annual growth of 15% since 2000.

Beckhoff Automation records a successful financial year for 2023

Beckhoff Automation successfully continued on its growth trajectory in 2023. The automation technology specialist was able to increase its sales to €1.75 billion. This represents an increase of 16% in comparison with the previous year’s sales of €1.515 billion. Currently, 5,500 employees worldwide (March 2024), including over 2,000 engineers, contribute to the company’s global success. Continuous innovation in all areas of automation and close cooperation with many global technology leaders are the keys to success for Beckhoff, the automation specialist from Verl.

“2023 was a challenging financial year,” explains Hans Beckhoff, Managing Director, adding: “The strong growth incoming orders from 2022 continued in the first few months of 2023 and led to a record order backlog and sales. However, incoming orders declined significantly as the year progressed. In the main, we can attribute this to the fact that our customers built up big stockpiles of products and placed mass orders in 2022 and at the beginning of 2023 in order to compensate for fluctuations in deliveries during the components crisis. They balanced this by ordering smaller quantities in the course of 2023. In addition, cyclical declines had an impact on some regions and industries.”

In the first quarter of 2024, Beckhoff observed stabilization in incoming orders with a slightly positive trend. “We anticipate a significant increase in demand in the second half of the year”, Hans Beckhoff states, adding, “In 2024, we will probably still see a significant decline in incoming orders and sales in comparison to 2023. We do not expect to see decent growth again until 2025. However, that doesn’t worry us. It will be the fifth sharp downturn that we will experience in our 44-year history. As a solid family business, we are well-prepared for this and will make the most of the resulting opportunities together with our customers!”

All Beckhoff products available ex stock again

Over the past two years, Beckhoff has made extensive investments in production, warehousing, and infrastructure, including increasing production capacity by more than 100%. In addition, the supply situation for components has improved significantly on the market. Hans Beckhoff stated, “Our goal was to do everything we could to assure reliable standard delivery times for our customers again by the end of 2023.” Beckhoff is currently able to supply almost all products ex stock again.

Innovations for automation

Beckhoff Automation has shown exciting innovations again during Hannover Messe 2024, such as industrial PCs with more CPU power, powerful control software for Windows and Linux, expansion of the Beckhoff Bus Terminal System, the MX-System, which can replace the control cabinet, new drive amplifiers and motors, new software-based safety CPUs, and deep integration of AI into the control and engineering functions.

A positive outlook for long-term development

Overall, Hans Beckhoff is positive about the future: “Automation is a basic technology that is used in all areas of society worldwide and it is a driver behind digital and ecological transformation. Constantly growing demand and the introduction of new product ranges and forms of technology should enable us to return to good, steady growth from 2025. Our software and PC-based control technology in combination with our powerful hardware for I/O, motion, vision, and AI, along with the expertise and commitment of our employees, have laid an excellent foundation for many successful customer applications. We are looking forward to taking on these challenges.”

More information:
www.beckhoff.com/company

Beckhoff China supports control technology laboratory at Changshu Institute of Technology

Industry, academia, and research are brought together

Changshu Institute of Technology is a regional full-time undergraduate institute located in Changshu City, Jiangsu Province. In addition to being the pilot university for the latest initiative organized by the Chinese Ministry of Education, evaluating teaching qualifications for undergraduate (bachelor's) programs, it is also renowned for its outstanding engineer education and training program, for incorporating information technology into education, and for the national New Engineering Research and Practice project. The control technology laboratory at the Faculty of Electrical Engineering and Automation, which is supported by Beckhoff, plays a huge role in this.

The Changshu Institute of Technology in the Chinese province of Jiangsu

Chen Jingbo, deputy dean of the Faculty of Electrical Engineering and Automation

The Department of Electrical Engineering and Automation at Changshu Institute of Technology is rising to meet the challenges of the future by dedicating itself to providing an engineering education that blends solid scientific foundations, comprehensive practical skills, broad expertise, and international competitiveness. As vice dean of the faculty, Chen Jingbo consistently pursues the philosophy of developing talent in line with the needs of the industry, prompting the addition of Beckhoff PLC technology courses to the automation curriculum in 2018. In 2020, the university founded the control laboratory based on Beckhoff technology and launched courses on TwinCAT 3 software. This practical approach will not only help to meet the future demand for skilled workers, but also create a solid foundation for students' professional development.

Collaborative syllabus combining academia and business

Changshu Institute of Technology draws on invaluable expertise across industry, business, and academia by incorporating Beckhoff China's knowledge into its university subjects, curricula, lesson design, practical training, and career guidance via the control technology laboratory. After intensive preparation and joint funding efforts, for example, teaching experiments based on the Beckhoff CX5130 Embedded PC were introduced within the soft PLC experiment courses. These include introductions to TwinCAT, programming exercises for traffic lights, running lights, and a 3-axis palletizer.

The content imparts knowledge and skills in embedded systems, PLC programming, and industrial automation. TwinCAT training courses allow students to learn the basic principles and methods of PLC programming, while programming tasks for traffic lights and running lights provide hands-on programming experience and an understanding of the role played by the controller in real-world applications. The course structure also includes a more complex undertaking in the development of a three-axis palletizer, which demands proficiency in multiple areas, including mechanical engineering, electrical control, and programming.

Tian Ran and Cao Jun (technical engineers at Beckhoff Suzhou) support teacher Shan Changkao from the Changshu Institute of Technology in class.

Experimental course content such as this helps students to connect theoretical knowledge with practical applications, developing both their hands-on capabilities and innovative thinking in the process. At the same time, these courses can also help students to understand the latest technologies and trends in the field of industrial automation and provide invaluable support for their future employment and career development.

A win-win all round

Beckhoff China actively participates in the development of course content and teaching activities at Changshu Institute of Technology and also helps outstanding students to secure internships and employment with its customers. This cooperation creates a win-win situation for everyone involved: the students, the companies, and the university. By working with Beckhoff, students have the opportunity to gain practical experience with specific automation projects and technologies, which gives them a clear advantage in the real world of work. Beckhoff also offers student internships of its own, not to mention exciting work and career opportunities.

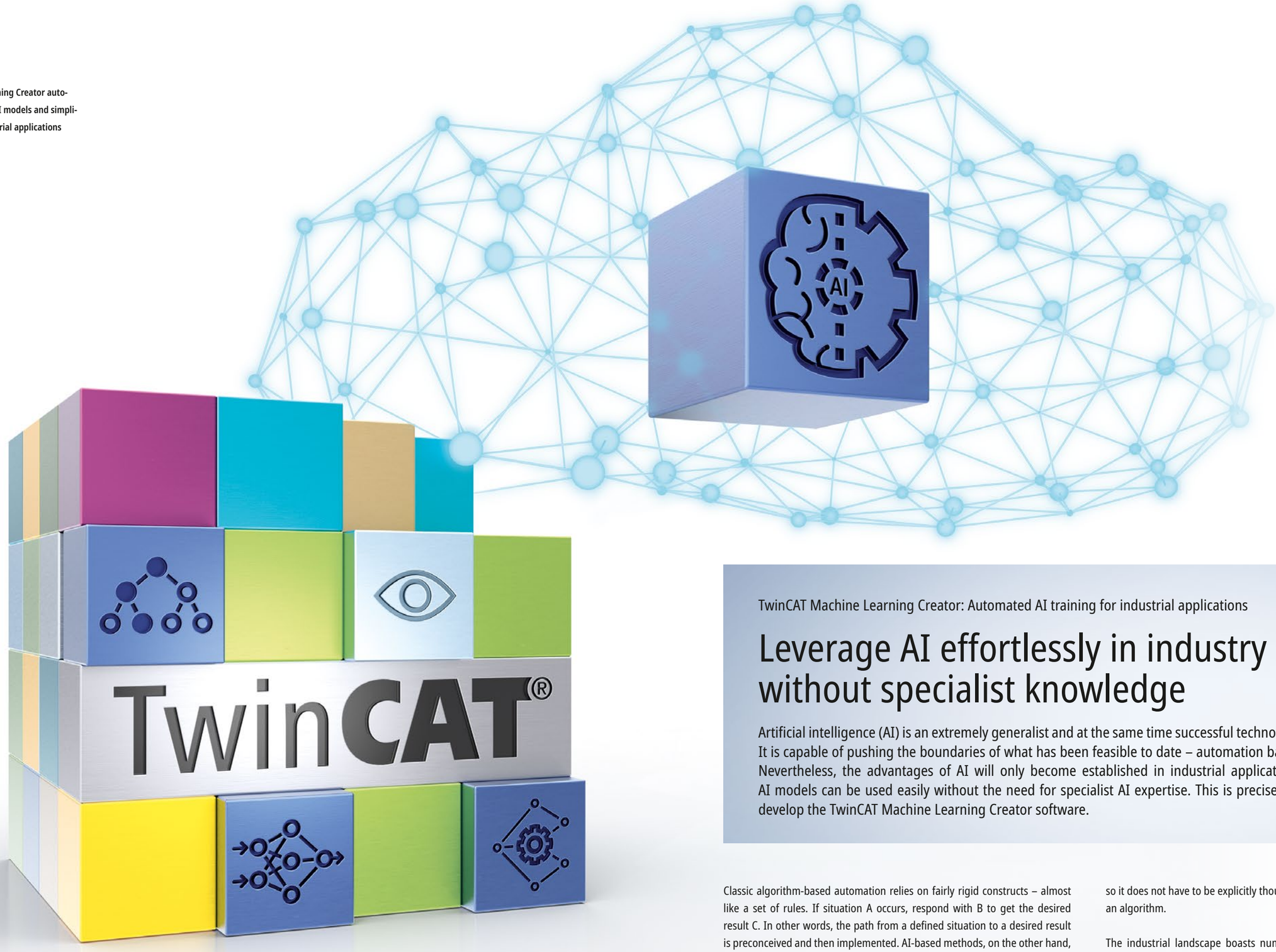
In China, for example, Beckhoff regularly recruits students from the Changshu Institute of Technology for internships in the Suzhou office, including Tian Ran and Cao Jun, who were offered permanent positions in 2022 on account of their outstanding performance. The resounding success of this program is also confirmed by Deng Fei, electrical manager at Kunshan Shengcheng Photoelectric Technology Co, Ltd., who notes that, "Graduates of Changshu Institute of Technology have already been familiarized with Beckhoff software and gained all-important hardware experience during their studies, so they are always sure to hit the ground running. Not only are they hard-working and responsible, but they also bring their own ideas and thoughts to the table. It is precisely this kind of attitude that allows them to apply their specialized knowledge adeptly in resolving real-world challenges on the job. They really have nailed the perfect combination of theory and practice!"

Chen Jingbo, deputy dean of the Faculty of Electrical Engineering and Automation, has personally observed the automation market in Suzhou and noted that an increasing number of companies are now using Beckhoff TwinCAT 3 software and keen to hire students with the relevant training. As the person responsible for teaching the PLC technology courses, Shan Changkao has a clear understanding of the advantages of PC-based control technology from Beckhoff: "With TwinCAT 3, Beckhoff offers all the functions of PLC systems on a single software platform and supports all common fieldbus systems on the market. This makes TwinCAT 3 an ideal platform for teaching and research for teachers and students alike." The university has increased its future investment in the Beckhoff PLC technology courses accordingly in a bid to further improve both the quality of teaching and the employability of its students. The cooperation between Beckhoff and Changshu Institute of Technology can be described as a win-win situation that brings numerous benefits for students, the school, and the company itself. This not only yields advantages for teaching, but also promotes cooperation between industry, academia, and research as well as driving innovative developments.

More information:
https://en.cslg.edu.cn
www.beckhoff.com/cx5130
www.beckhoff.com/twincat

PC Control 02 | 2024 products

TwinCAT Machine Learning Creator automates the training of AI models and simplifies their use for industrial applications



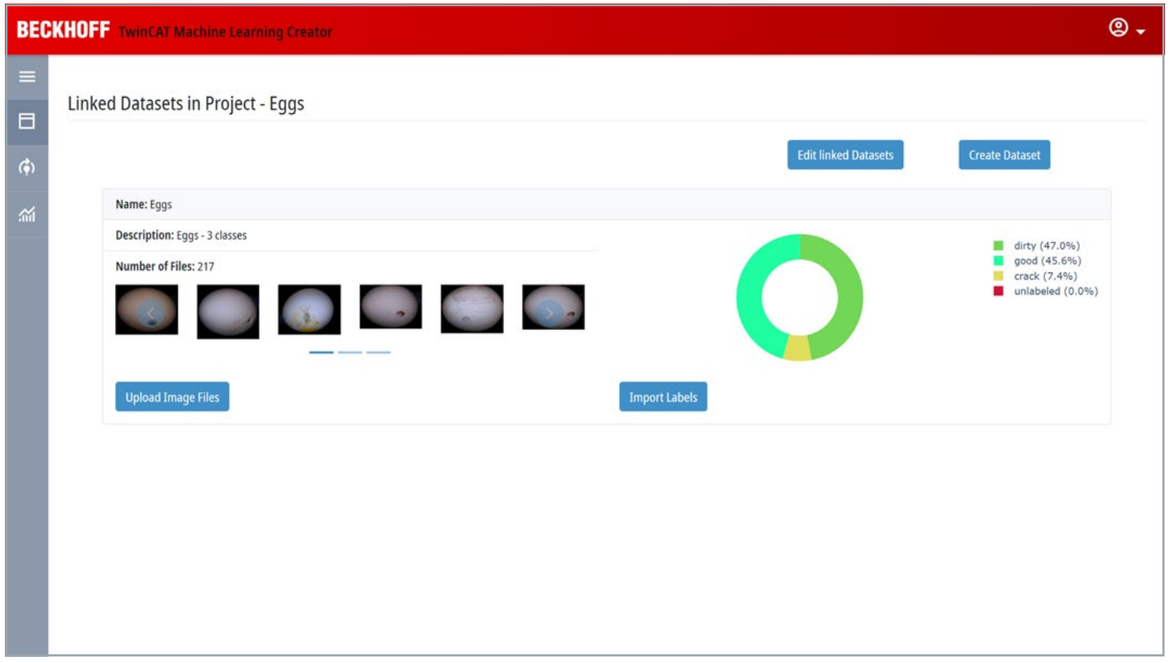
TwinCAT Machine Learning Creator: Automated AI training for industrial applications

Leverage AI effortlessly in industry without specialist knowledge

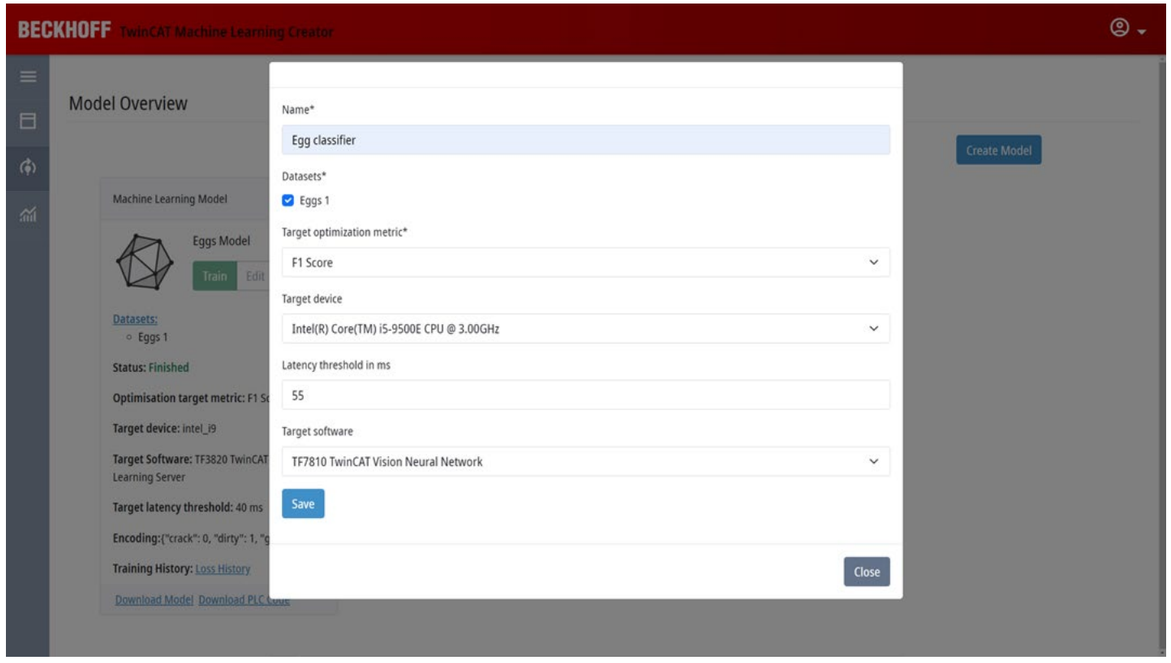
Artificial intelligence (AI) is an extremely generalist and at the same time successful technology for automating processes. It is capable of pushing the boundaries of what has been feasible to date – automation based on traditional algorithms. Nevertheless, the advantages of AI will only become established in industrial applications when the corresponding AI models can be used easily without the need for specialist AI expertise. This is precisely what prompted Beckhoff to develop the TwinCAT Machine Learning Creator software.

Classic algorithm-based automation relies on fairly rigid constructs – almost like a set of rules. If situation A occurs, respond with B to get the desired result C. In other words, the path from a defined situation to a desired result is preconceived and then implemented. AI-based methods, on the other hand, use examples to automatically learn the path from the situation to the result, so it does not have to be explicitly thought up by humans and transferred into an algorithm.

The industrial landscape boasts numerous potential AI applications, with AI-enabled visual inspection currently at the forefront. These include



Upload of an image classification dataset for categorizing eggs into “good”, “cracked”, and “dirty”



Training of the AI model

end-of-line inspections of manufactured products, the sorting of (often natural) products into quality or other property classes, and optical process monitoring and classification. Specific examples of this broad field of application include:

- performing final inspections of a metallic body with regard to its shape and/or surface quality
- sorting natural products such as fruit, wooden surfaces, and wool into different quality classes
- sorting waste for recycling
- monitoring process zones – e.g., during laser welding
- handling visual localization tasks, such as those designed to locate and grasp specific objects

AI-based methods for tackling these tasks exhibit a stand-out property in that, provided it has been properly trained, the learned algorithm is highly resilient to variances in the input data. This means that even within its limitations, a well-trained AI can also effectively handle unfamiliar situations. Whether it’s defects in manufactured products, anomalies in a laser welding process, or wood surfaces that never look quite the same – the algorithm has to be able to contend with all of these unknowns and more.

Given the immense potential at stake, the real challenge facing industrial companies today is the lack of skilled workers who can create AI models on an industrial scale. Data science and machine learning degree programs have now become commonplace at colleges and universities, yet the demand for AI experts far exceeds their availability on the current job market. What’s more, AI experts can only successfully solve automation challenges together with an automation or process expert. This is where Beckhoff comes in: The TwinCAT Machine Learning Creator automates sophisticated AI training processes, which directly empowers automation or process experts to create AI models themselves. This makes the potential of this technology directly applicable to everyone.

The Beckhoff AI ecosystem

Beckhoff offers a complete ecosystem for industrial AI applications with a clear focus on the execution of AI models directly on the industrial controller (in the PLC). Various sensors can be connected to the control system via the EtherCAT fieldbus and corresponding EtherCAT network devices. An extensive system-integrated range of vision hardware is also available, including industrial, robust cameras, industrial-grade lenses, and illumination devices. The sensor information is transmitted to a PC-based controller where it can be processed directly – including with AI. PLC-integrated execution modules for trained AI models are available for precisely this purpose in the form of TwinCAT Machine Learning Server, TwinCAT Vision Neural Networks, and TwinCAT Neural Network Inference Engine. These can access both the computing resources of the CPU and those of an optionally available NVIDIA GPU. The AI execution modules load trained AI models that have been stored in the open standard "ONNX". This gives the user the freedom to train AI models in any training environment and then execute them in the TwinCAT controller. With the C6043 ultra-compact Industrial PC, Beckhoff offers scalable hardware with an integrated embedded GPU from NVIDIA in line with industry standards. This makes the entire Beckhoff ecosystem optimally geared toward the integration of AI models into the machine’s control level.

Control-integrated AI models offer the advantage that their results can be used directly in the control system to perform actions. If, for example, a component is ejected, specially treated in downstream processes, or passed again through the process that has just been completed, the information can be calculated in the machine control system and used immediately. In addition, cost-intensive additional hardware devices with complex interfaces for control, independent maintenance and update schedules, and separate IT security protocols are no longer required.

Automated creation of AI models

In line with the philosophy of open control technology, Beckhoff has designed the existing PLC-integrated execution modules for AI models irrespective of the AI training environment used by supporting the ONNX standard. An ONNX file describes a trained AI model as a sequence of operators with associated parameters. These description files can be loaded with TwinCAT 3 Functions, such as TwinCAT Machine Learning Server, and then executed from the PLC; however, the relevant AI frameworks such as PyTorch or Scikit-learn, which are generally used to train AI models, are aimed at specialist AI experts who prepare training data in the Python programming environment, create AI model structures, and then train AI models.

With TwinCAT Machine Learning Creator, Beckhoff now offers a much simpler approach in the form of a web-based interface that guides you through the steps of data upload, model training, model analysis, and download. Target groups include automation and process experts without a specific background in data science, with the aim here being to standardize the training process for AI models.

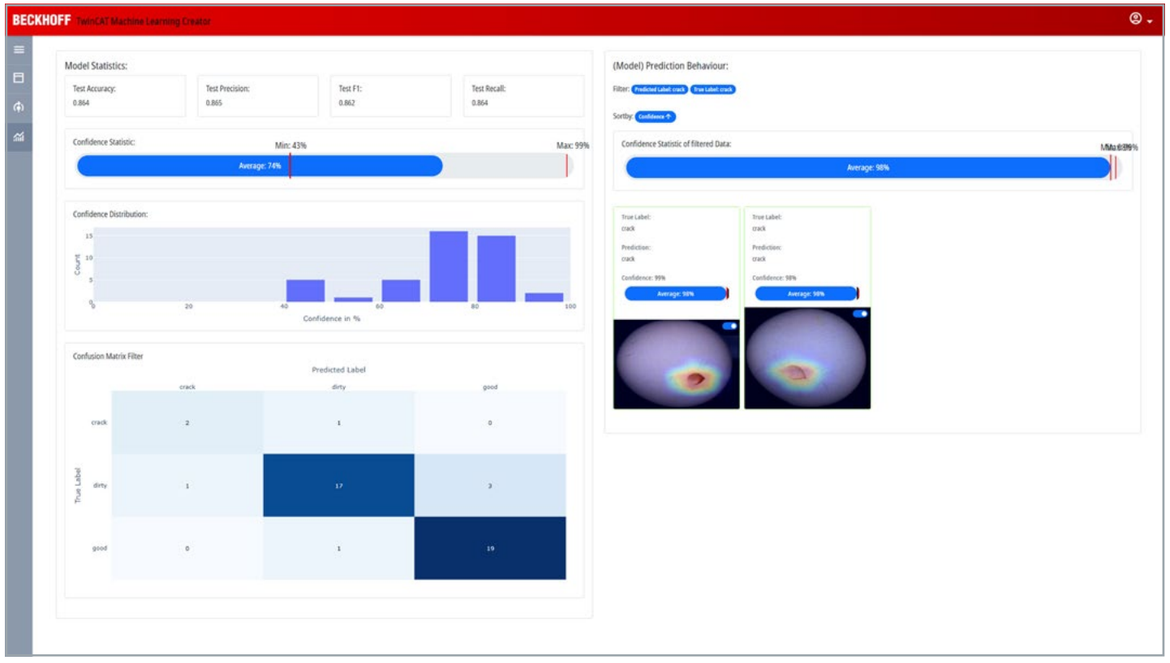
Features and benefits

The TwinCAT Machine Learning Creator
offers the following properties:

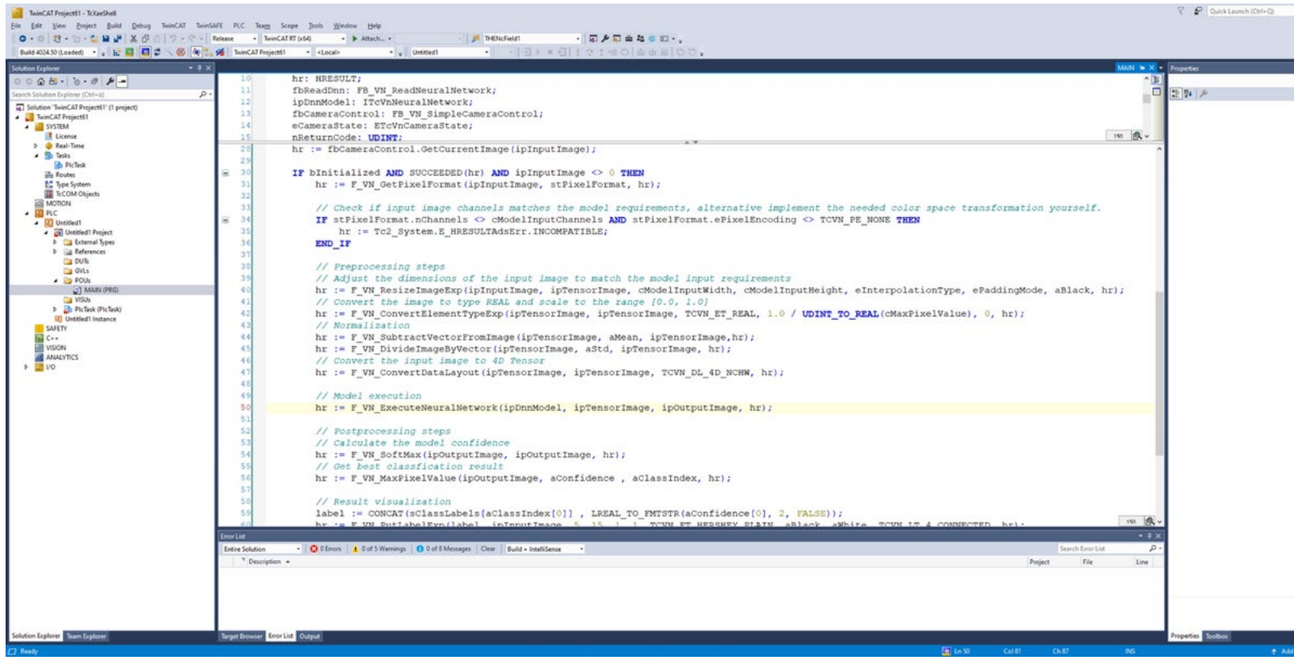
- simple model creation via no-code platform in TwinCAT
- latency-optimized AI models for real-time applications
- implementation of open standards, interfaces, and best practices
- provision of trained models in the open ONNX standard format
- transparency in the development, testing, and validation of AI models
- in-house standardization and further development of AI models
- ideal for AI-supported quality assurance in image processing

The automated model creation results
in the following application benefits:

- AI potential unlocked for all companies
- greater competitive edge through AI, even for smaller companies
- support in view of the increasing shortage of skilled labor
- minimized workload and error risk for AI experts
- application-specific data remains within the company and is therefore protected
- faster project development and return on investment



Analysis of the AI model



Download of the trained AI model

The data upload

The entire concept of machine learning revolves around learning by example. With this in mind, it is essential to have a clean, representative data set that can be used to learn the task. This usually requires an annotated data set: in the field of image classification, for example, this means that a certain number of sample images have already been classified by a human. As a result, each image has its own kind of label, which represents the desired result. The relationship between image and label is established by a label file, which, in the simplest case, is a table containing the file name and corresponding label.

The data upload is open and supports various image data formats and label file formats. This means that users are free to choose a labeling tool (if one is required). Work is currently in progress to use TwinCAT Analytics Data Scout as a labeling tool to achieve data integration from the TwinCAT controller to TwinCAT Machine Learning Creator.

The AI model training

The configuration of an AI training session is kept lean, which involves a model name being created and a data set (or several data sets) added to the training process. All other configurations are optional and allow the AI model runtime behavior on the TwinCAT controller to be specified if required. If a Beckhoff TwinCAT hardware platform and the TwinCAT software on which the AI model to be created is to be executed are specified, users can specify a maximum acceptable execution time for the AI model. This information is taken into account during the AI model creation process. If no maximum execution time is specified, optimization is based exclusively on AI model performance (generalization capability).

The model analysis

AI models, especially the deep neural networks (deep learning models) created with TwinCAT Machine Learning Creator, have very good generalization properties. This means that the expected performance of the models is also very good; however, neural networks are “black boxes” whose functionality can only be deciphered through specialized analysis methods, rather than directly. These methods are also referred to as “Explainable AI”.

The analysis methods for a trained AI model are diverse. The software automatically separates the uploaded data set into training data, which is used for model training, and test data, which is used for model analysis. The test data includes unknown cases for the AI model, where the result is known via the labels. This makes it possible to calculate statistical values and show how often a model is correct and how often it is not. A confusion matrix, for example, provides detailed information on how “true” labels and “predicted” labels are distributed. Confidence values can also be calculated for each model execution and displayed statistically. It is even possible to generate an attention map for each model execution, which shows which image regions were used for classification when superimposed over the input image.

The Explainable AI methods serve to increase the acceptance of the AI model. After all, only those who gain a more fundamental insight into how the trained model behaves will ultimately be prepared to use the models.

The model download

Once an AI model has been trained and is ready to be integrated into the machine control system, it can be downloaded from the platform as an ONNX file. This means that the AI model is not tied to execution in TwinCAT and can be deployed as often as required on any platform. Furthermore, the complete PLC code for TwinCAT can be downloaded from the platform in PLCopen XML format. This includes the complete process flow from image acquisition and image pre-processing through to AI model execution and post-processing. The transition from the training tool to the TwinCAT PLC is correspondingly seamless.

Another advantage of exporting an ONNX file from the training platform is the potential involvement of AI experts. These experts can use TwinCAT Machine Learning Creator to obtain an initial AI model quickly and in a standardized way. The result in ONNX format can then be imported into individual expert tools for continue working with it – for example, for additional analyses or further refinement of the model.

Dr. Fabian Bause, TwinCAT Product Manager, Beckhoff Automation

More information:
www.beckhoff.com/ai
www.beckhoff.com/te3850

MX-System helps tackle skills shortages and addresses DC power supply needs

The latest window profile processing machine from Schirmer Maschinen GmbH showcases the many impressive benefits of the MX-System.

As a replacement for the conventional control cabinet, the MX-System from Beckhoff offers some major efficiency advantages. It also provides a great deal of optimization potential in terms of the increasing shortage of skilled workers and the expanding presence of DC supply networks across the industry. This makes it possible to achieve greater future-proofing in industrial production, which benefits not only machine and system engineering companies, but also end users.

The MX-System is a uniform modular automation system that can be used to completely replace traditional control cabinets with function modules in many applications. This waterproof and dustproof system, which can be mounted directly on the machine, comprises a robust aluminum baseplate with integrated module slots, featuring EtherCAT for data communication and integrated distribution for different voltages. Its extensive portfolio of function modules includes the mains connection, drives, power supplies, industrial PCs, and I/Os. Boasting all of these features and more, the MX system easily covers the full range of functions of conventional control cabinets.

The function modules can be easily attached to the baseplate and simply screwed into place. This eliminates the need for any mechanical assembly of the control cabinet and its mounting plate, not to mention time-consuming manual wiring. All of this is directly reflected in the time required to set up the MX-System: including the necessary tests and checks, an MX-System can be set up in just one hour, in contrast to at least 24 hours for a comparable control cabinet. In this way, the MX-System also counters the shortage of skilled workers, as individual employees are less tied to a single task and can move on to the next project in no time. A further advantage is the straightforward pluggability of the function modules, which means they do not need to be connected by specialized electricians – a real bonus for companies lacking the necessary expertise in this area.

A notable application scenario involves the use of a higher-level DC power supply. The DC supply for complete production halls is based on the strategy of providing electricity from renewable energies (e.g., photovoltaics) in combination with storage technologies for machines and systems as a mains voltage of 600 V DC. The MX-System is already designed to be DC-ready in that it can distribute DC voltages and also be used directly for protective extra-low voltage power supply lines or modules for controlling synchronous and asynchronous motors. By facilitating the continuous use of DC voltage, it offers the major advantage of buffering the braking energy of the motors in the storage units of the DC networks rather than losing it through braking resistors. This possible use of the MX-System is already being implemented in a trial project.

More information:
www.beckhoff.com/mx-system

EL336x combines weighing function and sensor power supply in a single terminal

The EL336x EtherCAT analog input terminals offer compact and cost-effective implementation of high-performance weighing functions.

With its four EL336x EtherCAT analog input terminals, Beckhoff is offering a particularly compact and cost-effective solution for integrating weighing functions into control systems. The integration of the supply voltage for the load cells is particularly advantageous.

The EL3361-0100 and EL3362-0100 EtherCAT analog input terminals feature analog inputs for the direct connection of one or two resistance bridges (strain gauges) or load cells in a 4-wire or 6-wire connection system. The 10 V sensor supply is already integrated. The analog value resolution is 24 bits and 10 ksps. For more demanding applications, the EL3361 and EL3362 also offer a switchable sensor supply (5/10 V) and digital inputs (e.g., for tare) and outputs (e.g., for ready messages) that can be controlled either locally or via the controller.

The EL336x analog terminals are a welcome addition to Beckhoff's existing range of weighing technology, slotting into the portfolio above the EL3351 and alongside the EL3356 with additional functionalities. The ELM350x EtherCAT measurement terminals, which support freely adjustable filters, quarter/half bridge capability, and even higher sampling rates (also in connection with the TwinCAT 3 Weighing Library), are the ideal solution for the most demanding dynamic applications that require an even greater level of measurement technology.

More information:
www.beckhoff.com/el336x

A new generation of EtherCAT analog terminals

The new generation of Beckhoff analog I/Os starts with seven EtherCAT input/output terminals.

With a new generation of EtherCAT analog terminals in the compact HD (high-density) housing, Beckhoff is significantly enhancing the performance of the previous IP20 I/Os in this area. With up to eight channels and an impressive 16-bit resolution, the seven terminals cover a wide range of applications and offer excellent value for money.

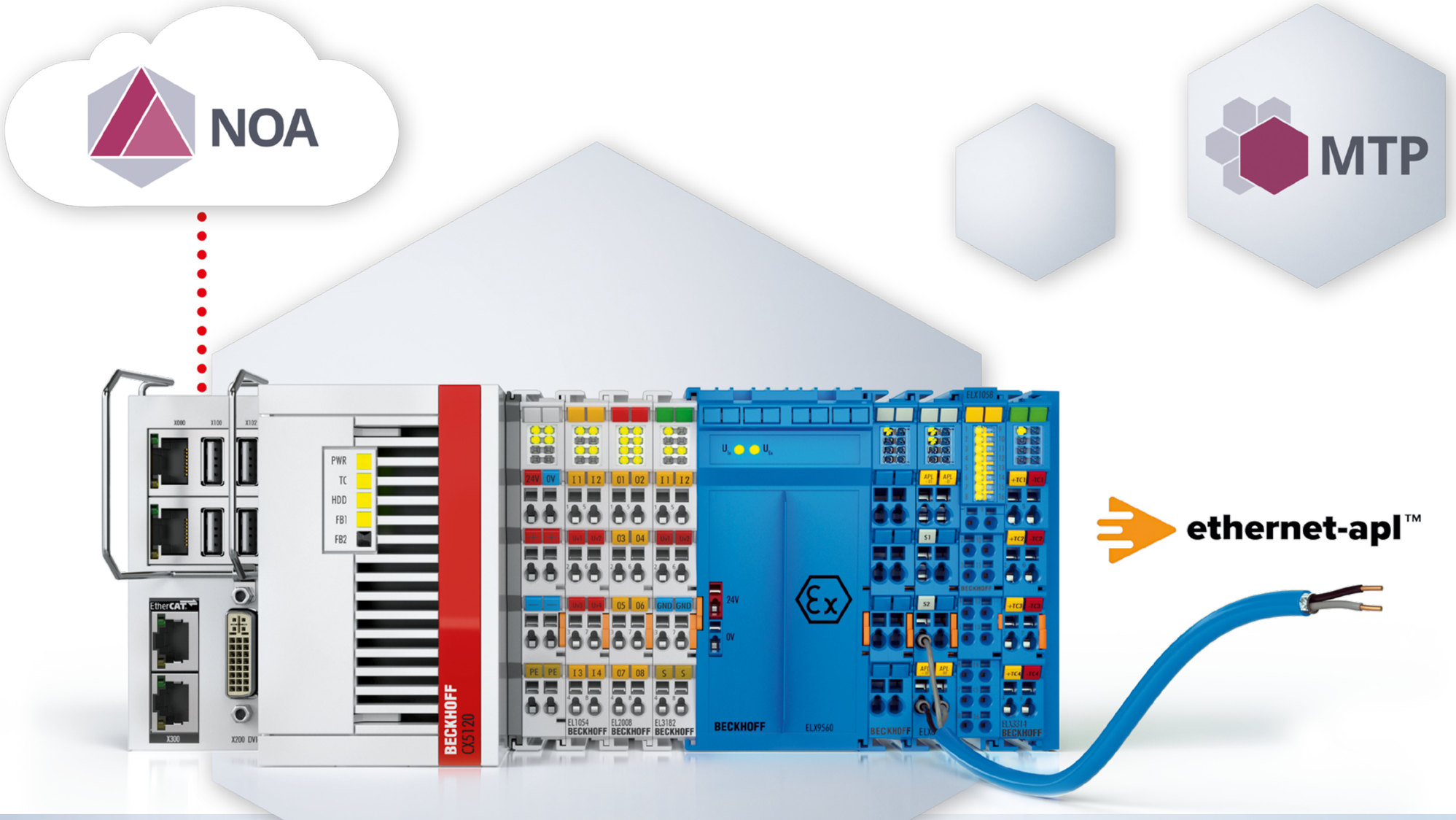
The new generation of analog terminals includes the EL4374, the first combined Beckhoff analog input/output terminal (10 V/20 mA or -20/0/+4 to +20 mA) compatible with a conversion rate of 2 ksps per channel. The two inputs and outputs can be individually parameterized for current or voltage operation via TwinCAT (via CoE). With a technical measuring range of ±107% of the nominal range, this terminal also supports commissioning with sensor values in the limit range and evaluation in accordance with NAMUR NE43. The outputs can provide up to 107% of the nominal value, and the high output power allows a load of up to 750 Ω at 20 mA.

The same features are offered by the EL3072 and EL3074 analog input terminals, which now have 16-bit resolution (previously 12-bit) as 10 V / 20 mA universal inputs. The EL3072 is equipped with two individually parameterizable inputs, while the EL3074 has four. Another new feature is the EL3078 version, which facilitates the use of eight channels in the same compact HD housing. The higher resolution and expansion to eight channels have also been implemented for the analog output terminals, namely with the EL4072, EL4074, and EL4078.

More information:
www.beckhoff.com/multi-io

Sebastian Böse,
Process Industry Management,
Beckhoff Automation

“Ethernet-APL opens up a whole world of possibilities for users. If this technology is to be implemented quickly, it is vital that it can be integrated into established installations, and the ELX6233 EtherCAT Terminal offers users the necessary flexibility, modularity, expandability, and security to achieve this.”



Digitalization for the process industry

Future-proof system automation with NOA, Ethernet-APL and MTP

In the world of process automation, reliable and efficient production processes lay the foundations for economic plant operation. Modern system concepts help to support maintenance and optimize process flows, and Beckhoff offers future-proof solutions for both existing and greenfield plants through its implementation of NOA, Ethernet-APL, and MTP.

Concepts such as Industry 4.0 and the Internet of Things focus on collecting all plant operating data and making this available to various applications. This data is evaluated in analytical tools to facilitate proactive action, such as early detection of failures in field devices. It can also be used to optimize processes and increase productivity.

Plant monitoring and optimization with NOA

The NAMUR Open Architecture (NOA) concept described in NAMUR Recommendation NE175 extends the automation architecture without altering the existing control system. NOA's core task is therefore to provide information from the field level to higher-level applications in order to monitor the field devices and optimize the process (monitoring and optimization – M+O). The type of data that is forwarded from the field level depends on the field devices used and the respective analysis tools. The focus here is on parameters that need to be read out cyclically which contain information on device status or process quality.

The world of process automation employs a wide range of protocols and communication technology. For the initial implementation of the NOA concept, Beckhoff opted for the HART protocol. This protocol is widely used and is implemented in many field devices from different manufacturers. Superimposing a digital signal onto the actual 4–20 mA measured value facilitates

the transmission of further data, such as the field device status. Furthermore, a second channel can be opened with minimal effort with the help of special feed isolators, which already form part of the automation architecture in many plants. This means that the connection to the field device is separated into a 4–20 mA signal, HART communication, and the supply voltage, which means that the established connection to the process control system is not interrupted. The data can therefore be received via the second channel and used for M+O.

Beckhoff offers a way to connect two field devices via the HART protocol in a very compact installation space in the form of the EL3182 analog EtherCAT input terminal. Combined with an embedded PC (such as a CX8110) and the TwinCAT automation software, a modular expandable edge device can be built without any specially developed hardware. The edge device has three main functions:

- receiving vitality data via the HART protocol
- converting and translating the data
- providing the information to higher-level analysis tools

Commands have to be sent from the edge device so that the vitality data can be read out via the HART protocol. The data that are read out and the commands that are used to store it on the field device depend on the device type (pH, oxygen, temperature, etc.) and manufacturer. Beckhoff has developed a database to store the necessary information for reading out the vitality data. The corresponding file is read into TwinCAT, thereby facilitating communication with all field devices stored in the database. When a field device is connected to the edge device, it is automatically detected, the relevant HART commands are sent, and the received data can then be converted using the stored translation tables and TwinCAT functions.

The vitality data that are stored in the PLC at that point must be made available for further analysis applications in the next step. NAMUR recommends using OPC UA for this. The Beckhoff portfolio offers several products, including the TwinCAT OPC UA Server. This is based on a stored information model and filled with vitality data directly from the PLC. This information model is based on the PA-DIM (Process Automation – Device Information Model), but it can also be extended with additional parameters by the user. Depending on the detected field device type, individual OPC UA nodes can be removed or added automatically.

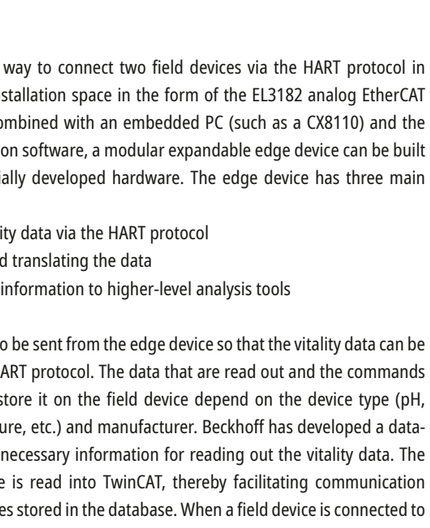
EP series IP67-protected I/O box modules can be installed directly in the field in order to capture diagnostic data that are acquired by additional sensors, for example for vibration or temperature measurement, along with data from established field devices. Several sensors are connected to one module and the signals are transmitted to the edge device collectively via one cable. This version cuts down on cable routing work while also reducing the space required in the control cabinet.

Complete data acquisition with Ethernet-APL

The NOA concept also offers advantages for greenfield plants: additional sensors can be added during the plant planning stage, thus providing more data for monitoring and optimization. New forms of technology such as Ethernet-APL make implementation simple.

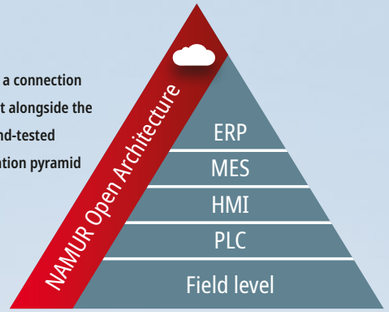
This new communication technology is based on the 10BASE-T1L Ethernet standard, which allows a maximum cable length of 1,000 meters and a transmission rate of 10 Mbit/s. Power and data are transmitted over the same pair of wires (Single Pair Ethernet) with Ethernet-APL. Power supply limits in all zones throughout the explosive atmosphere are defined by IEC specification 60079-47 (2-WISE). To simplify installation and improve the connectivity of the devices used, the project group has also defined port profiles in the TS10186 technical specification: In addition to information on the connection and segment class, a port profile also includes the Ex approval for the respective device connection.

The Ethernet-APL concept aims to implement the entire communication in process technology plants – from the field level to higher-level control systems – on an Ethernet basis. This focuses both on the pure process data and specifically on the status information of the field device. The increased transmission rate compared to fieldbus systems also allows web servers to be used for parameterization or downloading data sheets or certificates directly from the field device.

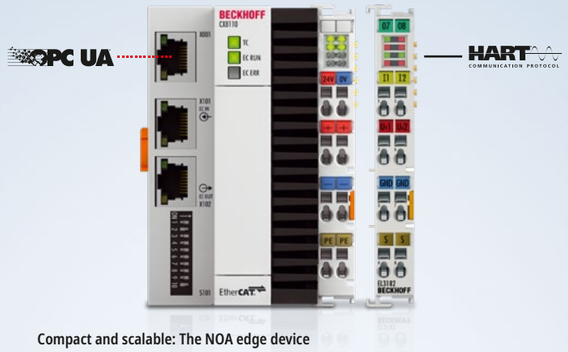


Lennart Winkler,
Process Industry Management,
Beckhoff Automation

> “Ensuring that data can be accessed from all plants remains one of the biggest challenges in the world of process automation. As process plants have developed into huge networks of interconnected systems, large parts of the information from field devices are inaccessible. NAMUR Open Architecture was developed to provide a standardized interface to all information from the field, allowing data to be accessed quickly and easily. Our compact and scalable NOA edge device upgrades old systems to assure future-proof operation.”



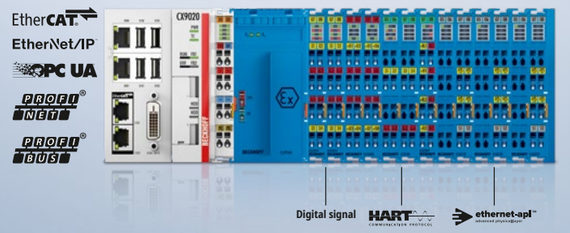
NOA as a connection element alongside the tried-and-tested automation pyramid



Compact and scalable: The NOA edge device

With the ELX6233 2-channel communication interface, Ethernet-APL field devices can be integrated into the control architecture on a compact, modular basis.

Ethernet-APL can be seamlessly combined with other communication standards in the modular EtherCAT Terminal system from Beckhoff.



The scalability of the ELX6233 provides efficient solutions for integrating Ethernet-APL field devices in small test setups, as well as for large process plants. As part of the EtherCAT Terminal system, the ELX6233 can be combined with other digital and analog I/Os so that standard electrical signals or communication protocols can be integrated in addition to Ethernet-APL. Direct connection to CX Embedded PCs also offers a whole host of advantages, one of which is allowing NOA applications to process data from the field and filter it before sharing it further.

Like many of the EtherCAT Terminals from the Beckhoff portfolio, the ELX6233 can be mounted in zone 2 hazardous areas and allows Ethernet-APL field devices to be connected from zone 0. The interfaces comply with the specifications of IEC 60079-47 and are in accordance with the SPAA port profile.

Ethernet-APL leads to further challenges in terms of IT and OT security due to end-to-end Ethernet communication. Unlike many PROFINET architectures, the controller is located directly in the EtherCAT Terminal and not in the higher-level controller. This design offers users the option to filter all data traffic through the terminal and install a firewall. Compared to a field switch, the terminal also cuts down on opportunities to gain unauthorized access to process data. This architecture even elicits further advantages in terms of the application’s performance. The point-to-point connection to the sensor eliminates the risk of overloading the network due to unwanted cross-traffic, which is a well-known problem in conventional PROFINET networks. System cycle times can also be reduced as EtherCAT facilitates a more compact data size for the process image compared to other fieldbuses.

How can users integrate Ethernet-APL into their plants and benefit from the many advantages it offers right now? One solution is to combine the new technology with proven standards such as the HART protocol. Existing plants can thus be successively digitalized with new APL devices and the barriers to a complete conversion can be overcome.

For these reasons and more, Beckhoff has already integrated Ethernet-APL technology into the modular terminal portfolio: The ELX6233 EtherCAT Terminal offers a 2-channel communication interface for Ethernet-APL. Contrary to the typical field switch concept, this creates an alternative for integrating APL field devices. The modular system allows the user to install the exact number of required Ethernet-APL channels in the control cabinet, saving valuable space and allowing the application to be expanded flexibly.

Users still face a number of challenges during implementation: APL-capable field devices are required to allow the aforementioned advantages to be exploited immediately across the board. However, as this technology is still in its early days, the market does not yet offer a broad portfolio. In established plants, there is also a lack of space for installing additional infrastructure components such as switches. Implementing Ethernet-based communication technology down to field level also requires new functions and policies for IT and OT security.

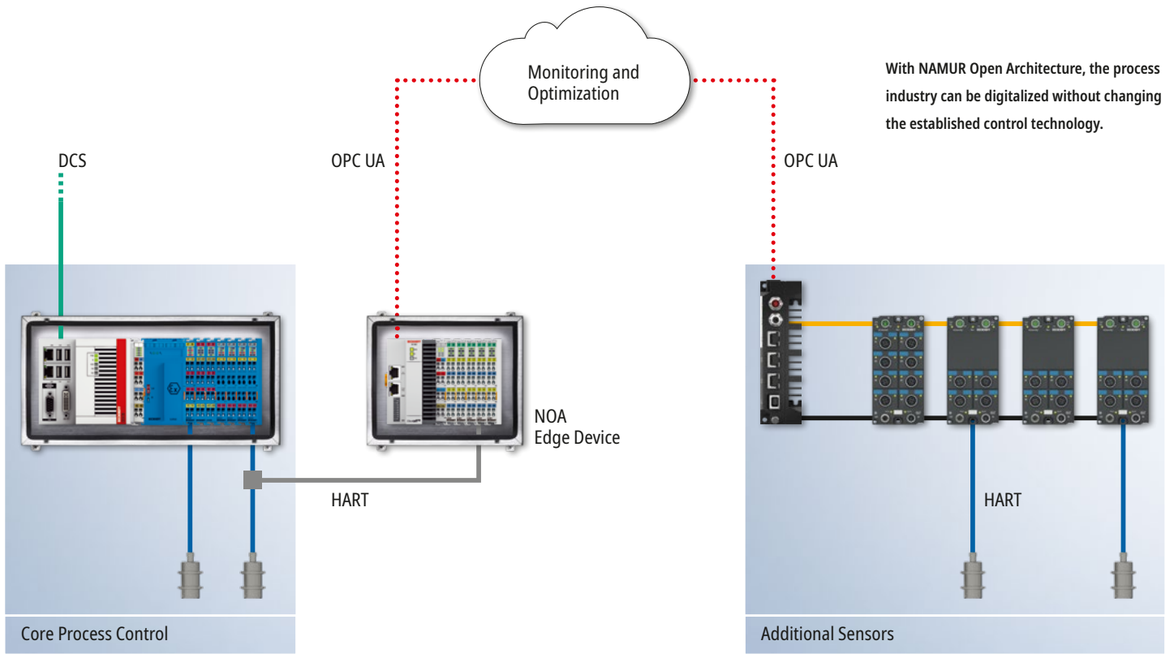
Franziska Rostan,
Process Industry Management,
Beckhoff Automation

> Increasing the availability, efficiency, and flexibility of plants is key when it comes to optimal plant operation. This requires innovative digital technology. Field device data must be transmitted quickly and in full, even in sprawling plants, to enable seamless monitoring and continuous process optimization. The system could also be modularized so that companies can respond to constantly changing market requirements flexibly. With PC-based control from Beckhoff and our products and solutions for NOA, Ethernet-APL, and MTP, you can meet these requirements and automate your plant to make it fit for the future."

TwinCAT MTP for consistently modularized systems

One of the emerging challenges for many industries in the process industry, such as the pharmaceutical industry, is increasing fluctuation across sales markets. This is accompanied by the need for a shorter time-to-market due to accelerated development cycles. Product life cycles are shortened accordingly, and these in particular require economically profitable and simultaneously individualized production of small batches.

An increasingly popular solution is designing plants to be modular, which provides the option to reuse the modules for different purposes. This involves breaking down the plant's entire process into individual sub-processes and mapping them using modules. Full plant modularity can then be achieved with a separate, decentralized controller for each module. The entire process can be remapped by subsequently integrating the individual modules into a higher-level control system (e.g., a DCS). As a result, the development work shifts from plant engineering to module engineering, enabling the plant to be flexibly modified with little effort, depending on current requirements. Additional modules can be added to the plant and modules that have already been integrated can be rearranged or removed. Complete reprogramming is not required, as most of the logic is encapsulated in the individual modules. The higher-level controller only handles the orchestration of the modules and the services they offer, and is therefore referred to as the process orchestration layer (POL).



With NAMUR Open Architecture, the process industry can be digitalized without changing the established control technology.

Laurids Beckhoff,
Process Industry Management,
Beckhoff Automation

> The modularity of the MTP (module type package) concept revolutionizes process plants design and offers advantages such as a rapid time to market, increased flexibility, and the ability to produce small batches economically. MTP's standardized interfaces simplify the plug-and-play integration of specialized modules into a process orchestration layer and enable seamless operation. TwinCAT MTP offers an environment for easy development of modules via automatic code generation. This approach minimizes the need for in-depth knowledge of the specification. In practice, it simplifies module development and makes the benefits of modularity accessible and efficient for professionals in the process industry."

In practice, the concept is implemented by a manufacturer-independent standard for the description of process modules: the module type package (MTP). Initiated by NAMUR and ZVEI, the MTP contains all the information needed to integrate a process module into a modular plant, including functions in the form of services, communication, and an HMI template. Interfaces defined in the MTP guideline enable plug-and-produce behavior, eliminating the work and costs associated with reusing a plant. This means modules are only developed once and can then be integrated into other plants independently of the controller manufacturer and POL.

MTP is seen as an essential component of digital transformation in the industrial sector. The general expectation is that using MTP will significantly improve plant KPIs. Experts predict that the time to market can be halved on average, engineering costs can be reduced by 70%, and flexibility can be increased by 80%.

Conclusion

With NAMUR Open Architecture and PA-DIM, the process industry is laying the foundations for standardized and structured mapping of heterogeneous systems in higher-level analysis tools. This means that existing plants can be digitalized right now and reap the benefits, including a reduction in maintenance costs.

The idea of a standardized data model such as PA-DIM is also an interesting topic for the future, independent of NOA. For example, system sections could be combined in gateway applications and forwarded to the DCS in defined information models. The DCS would therefore be independent of the sensor's process image, enabling smooth exchange for the field device across different manufacturers. Furthermore, control loops can be implemented on a decentralized basis to relieve the DCS and reduce data traffic.

A similar approach is pursued in the MTP concept, where the plant is structured on a modular basis. Each module is equipped with its own controller, which is integrated into the automation architecture via a standardized interface description. This allows the MTP to flexibly adapt production to the market situation by varying the modules used. Individual modules can also be replaced quickly and easily in the event of a fault, thus reducing downtime.

The modular approach is also continued in the integration of Ethernet-APL into the Beckhoff portfolio. Instead of large field switches, APL field devices are integrated using compact EtherCAT Terminals. These can be flexibly combined with other terminals – for example, for communication with digital sensors. Direct integration with a controller also offers further possibilities for gateway or edge applications. Ethernet-APL and NOA already work together seamlessly with the help of Beckhoff Automation Technology.

With TwinCAT MTP, Beckhoff automation software paves the way for increasing plant modularization in the process industry.

More information:
www.beckhoff.com/digitalization-process-industry

The base carrier support system (right) enables GKN Additive to connect all process steps involved in additive manufacturing in a fully automated manner.

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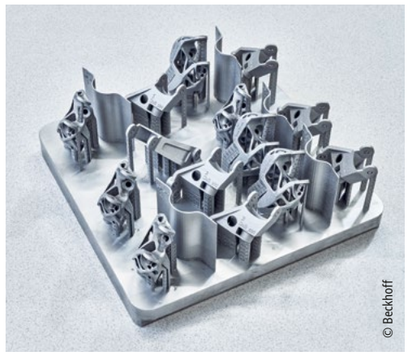
PC-based control automates container handling for 3D printing processes

Additive manufacturing on an industrial scale

The aim of the BMBF-funded IDAM project is to make it possible to use additive manufacturing for the series production of automotive parts. Its central component, the base carrier support system (BCSS), was automated by the companies Intec and Schmitz Spezialmaschinenbau with PC-based control from Beckhoff. The BCSS has enabled automotive supplier GKN Additive in Bonn to link together various production steps to create a fully automated pilot system for 3D printing metals.



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Components printed using the LPBF process on a square substrate carrier, which the base carrier support system transports between processing stations.

Additive technologies such as the LPBF process (laser powder bed fusion) are already being used in series applications, but only as individual processing stations. One of the reasons for this is that the working area of the machines must be hermetically sealed. This is due to the metal powders used in additive manufacturing, which are extremely fine and therefore “respirable”. For this reason, the metal powders and components are fed in and out in closed containers and this is predominantly done manually. “Our base carrier support system solves this problem and enables a fully automated process chain,” says Dr. Simon Höges, who is responsible for the Technology and Industrialization division at GKN Additive, highlighting the potential of the research project.

The company has been producing series parts for the automotive industry using additive manufacturing such as LPBF for some time now. In this process, metal powder is melted layer by layer with a laser at the exact point where the component structure is to be created. The advantages here are that no specialized tools are required and new designs can be implemented flexibly. “This is why we are working hard on scaling up the production processes to series production,” says Dr. Simon Höges.

“The BCSS is the missing link for the industrialization of additive manufacturing, especially with regard to the modularity and utilization of the processes,” emphasizes Reinhard Schmitz, Managing Director of Schmitz Spezialmaschinenbau. The BCSS connects the individual process steps and machines (3D printer, powder handling, and post-processing) to form an automated overall system. “Using many different manufacturers inevitably leads to different mechanical and electrical interfaces,” says Reinhard Schmitz, explaining the challenge for the mechanical design and automation of the BCSS. For example, the base carrier support system must be able to move cylindrical containers and carrier plates with a diameter of 330 mm as well as rectangular carrier plates and containers weighing up to 750 kg safely and precisely. The BCSS has a total weight of 1,500 kg and dimensions of 1,200 x 800 mm with a maximum height of 1,800 mm so that it can be combined with automated guided vehicles (AGVs) from as many suppliers as possible and can be moved to a wide variety of system modules.

Compact drive technology saves valuable installation space

These requirements had a massive impact on the space available for the control cabinet and the components used. “The control technology had to be as small, light, and powerful as possible and function without air conditioning despite its high performance,” emphasizes Achim Heimermann, Managing Director of Intec, Ingenieurbüro für Automatisierungstechnik. The high-performance computer, six axes for positioning the BCSS, five axes for the transfer/takeover functions, and the I/Os for the various sensors had to be integrated in a very small space, including compact AM8112 synchronous servomotors and EL7211 servomotor EtherCAT Terminals with STO, as well as an ultra-compact C6030 Industrial PC. “With the industrial PC, the compact servomotor terminals, and One Cable Technology (OCT) as the connection technology, Intec was able to save a lot of space,” says Wilm Schadach, head of the Beckhoff sales office in

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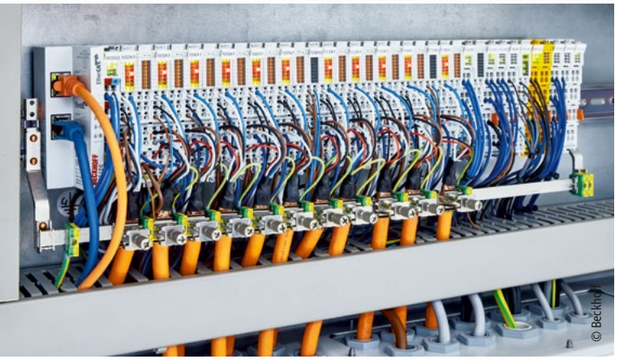
Wilm Schadach (left), branch manager at Beckhoff Monheim, and Erik Heimermann, managing director at Intec, were also involved in the BCSS project.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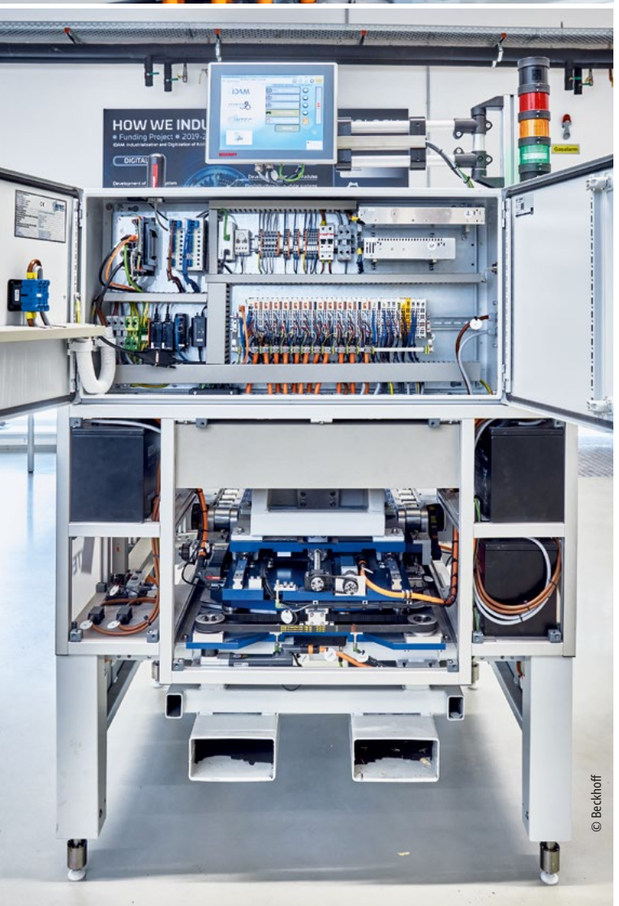
One Cable Technology, as the connection technology for the compact drive technology, enables space-saving and clear wiring.



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The rear of the base carrier support system: The compact drive technology (48 V DC) in EtherCAT Terminal format and the ultra-compact C6030 Industrial PC save valuable installation space and weight (top); eleven AM8112 synchronous servomotors (bottom) align the base carrier support system and feed and discharge the containers weighing up to 750 kg.

Monheim. “With systems from other manufacturers, we definitely wouldn’t have been able to set it up so compactly and connect it so easily,” confirms Erik Heimermann, also Managing Director at Intec.

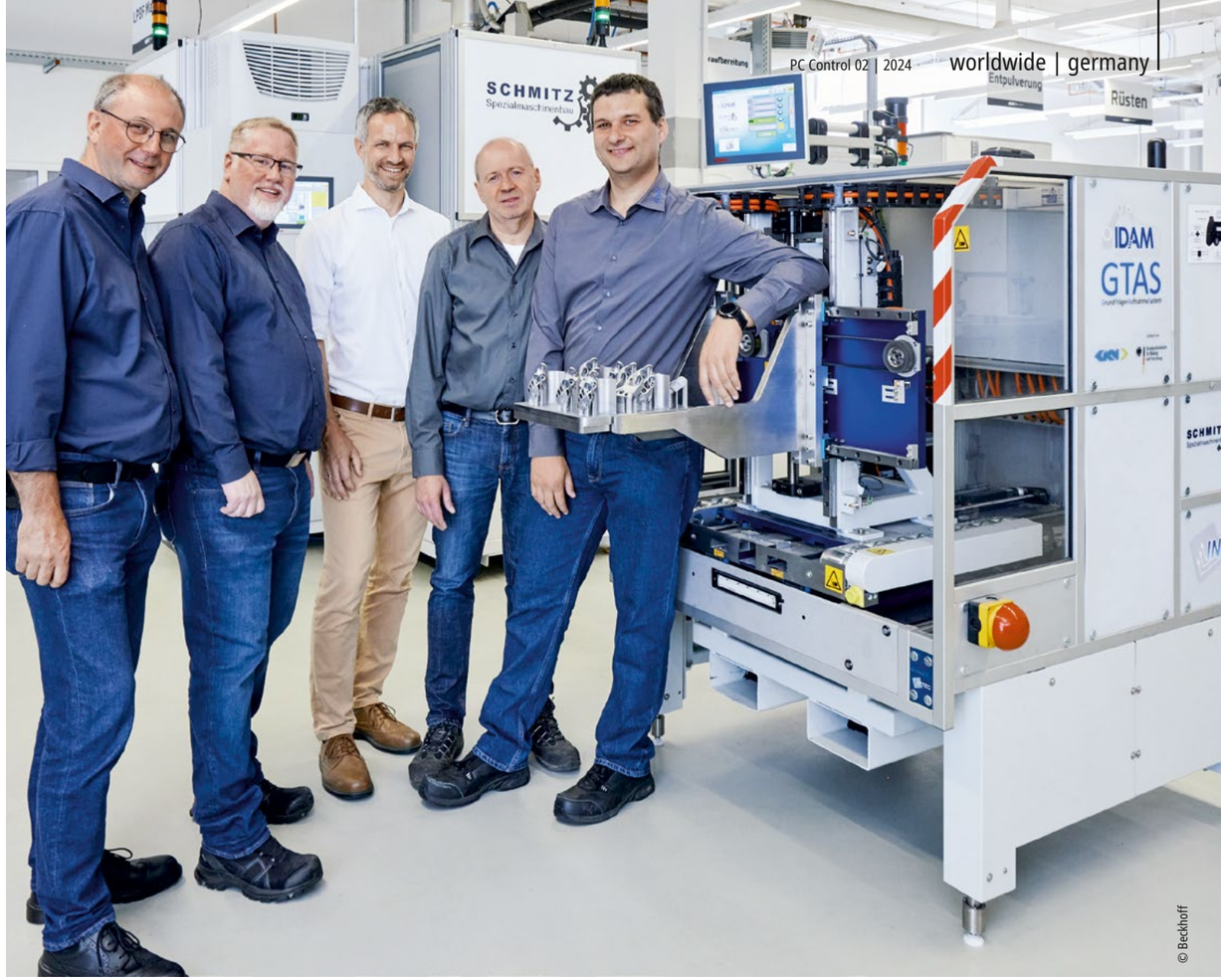
This has created space for a total of three rechargeable batteries with a capacity of 105 Ah – enough energy to ensure self-sufficient operation of the production lines at weekends, which GKN plans to implement in the future in conjunction with AGVs. “Currently, the BCSS is roughly positioned in front of the workstations manually using an electric pallet truck,” says Dr. Simon Höges. The fully automatic process then starts, beginning with the leveling of any unevenness in the hall floor using four adjustable feet. “The Beckhoff drives with integrated safe torque monitoring are essential for alignment and positioning in front of the individual modules,” emphasizes Stefan Hornberger, project manager at Intec. The torque monitoring of the adjustable feet is used to check whether all of the feet have been placed on the floor surface after alignment via an EP3752 EtherCAT Box with two 3-axis acceleration sensors and whether the four drives are each applying the same torque diagonally. Only then can the BCSS be confirmed as horizontal and stable, which means that the gripper can now move to the specified height to start the transfer sequences for the containers and substrate plates.

Openness and flexibility of PC-based control

With the compact drive technology from Beckhoff, the BCSS compensates for position deviations in front of the modules. “The accuracy is between 0.5 and 1 mm in terms of the height offset, lateral offset, tilt offset, and angular offset,” says Reinhard Schmitz. To achieve this precision, various sensors are used. These are read in via an EL6224 IO-Link terminal, for example. Two precise laser sensors with EtherCAT connection determine the angular offset between the BCSS and the machine module. “Intec can read in the XML description of the lasers via EtherCAT and access all parameters and user data directly in TwinCAT,” says Wilm Schadach, demonstrating the openness of PC-based control. At the same time, a camera and TwinCAT Vision are used to scan a QR code on each machine module to check whether the base carrier has been placed in front of the correct module and positioned correctly. To assist the operator of the electric pallet truck, the live image from the camera is displayed on the BCSS Control Panel (CP3912). Due to the installation situation, it is also necessary to control the camera lighting with an EL2502 EtherCAT Terminal and its PWM output. “The flexibility of PC-based control in one system – diverse I/Os, high-performance and open control, visualization, compact drive technology, vision, safety, and communication – has made the implementation of all these functions much easier,” says Stefan Hornberger.

Further proof of the openness of PC-based control can be found in the integration of a wireless game controller for setting up the motion sequences: Intec reads the communication data of the game controller into the system control via .NET, TwinCAT HMI, and TwinCAT ADS. This brings the operator closer to the action. Further configuration of the container transfer is then carried out on the control panel.

In automatic mode, the transfer cycle is converted depending on the distance determined after positioning and the process is started. The network of various system modules and BCSS is controlled by a central monitoring unit – the digital automation level. It initiates the transfer and takeover sequences via WLAN and monitors the process sequence. This higher-level coordination of the processes takes place on a C6025 ultra-compact Industrial PC, where the production data of all modules in a line is brought together via EtherCAT, OPC UA, or HTTPS. Dr. Simon Höges: “Intec also implemented the communication with our production planning software. This enables several orders to be processed fully automatically over a weekend.”



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The BCSS project partners (from left to right): Managing Director Reinhard Schmitz and Thomas Schmitz, formerly operations manager at Schmitz Spezialmaschinenbau, Dr. Simon Höges, GKN Additive, Achim Heimermann, Managing Director at Intec, and Stefan Hornberger, project manager at Intec (not pictured: Sebastian Blümer, GKN Additive)

More information:

www.gkn.com
www.intecweb.de
www.schmitz-spezialmaschinenbau.de
www.beckhoff.com/compact-drive-technology

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Mercedes-Benz uses ELM-series precision measurement terminals and TwinCAT software to analyze and optimize the driving dynamics properties of future vehicle generations on several test benches.

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EtherCAT measurement terminals in vehicle development at Mercedes-Benz

Flexibility and precision for optimum vehicle tuning

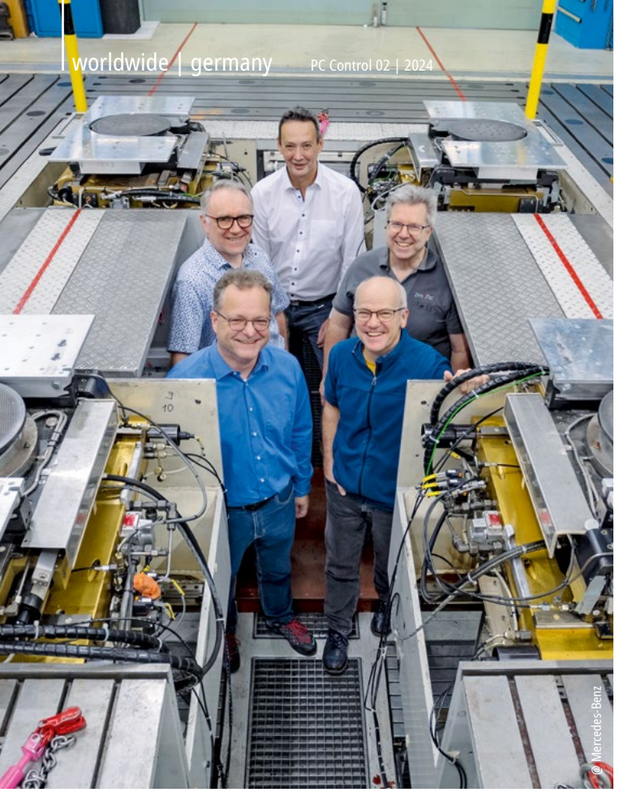
The chassis properties shape a vehicle's character and ultimately also the identity of a brand. That is why Mercedes-Benz leaves nothing to chance, checking the chassis properties on several test benches during development. Mercedes-Benz and system integrator DynoTec Prüfstandstechnik rely on EtherCAT, TwinCAT and the ELM-series precision measurement terminals from Beckhoff for retrofitting.

ELM3002 and ELM3502 EtherCAT Terminals acquire the signals emitted by the force sensors on the front and rear axle jacks. The displacement transducers with EnDat 2.2 interface are read in using an EL5032.

© Mercedes-Benz

At the Mercedes Technology Center (MTC) plant in Sindelfingen, Germany, car axles are examined with the highest precision on four test benches – in parallel with road tests and simulations. The aim is to validate processes, analyze any anomalies specific to vehicles and identify the components causing them. To do this, the developers measure the reactions of the vehicles when forces/displacements and torques are applied with high precision and in a reproducible manner. This allows the suspension, kinematics and elastokinematics of the chassis to be recorded quickly and reliably. In addition, this data can be described objectively in the form of characteristic diagrams, characteristic curves and characteristic data sets. Approximately 90 parameters are then compared with the digital twins of the vehicles. This protects both the development vehicles/prototypes as well as the digital development process in that important area known as the Mercedes-Benz driving characteristics. "That's why the test benches are an integral part of the Mercedes-Benz vehicle development process, where we ensure that parameters such as the component design, simulations, test benches and the performance on the road work together in harmony," emphasizes Uwe Lochner, member of the chassis analysis team at Mercedes-Benz in Sindelfingen.

To examine the chassis, the vehicle is set up on the test bench using the front axle jacks, then positioned and fixed over the four hydraulic jacks. The vehicle axles are then loaded and measured very precisely. "When we talk about precision, we mean measuring distances with 0.1 mm and angles at 0.1° and less than 2 Hz with high sampling rates," explains Walter Selg, Managing Director of DynoTec Prüfstandstechnik GmbH, the system integrator responsible for designing and implementing the retrofits. During the excitation process,



The brains behind the sophisticated retrofit of the driving dynamics test benches: Uwe Lochner, chassis analysis team at Mercedes-Benz and Dr.-Ing. Frank Dettki, head of the chassis analysis team at Mercedes-Benz in Sindelfingen (first row from left); Walter Selg and Rainer Fischer, Managing Director of DynoTec Prüfstandstechnik (second row from left); Dieter Völkle, Sales, Beckhoff branch in Balingen (third row).

a large number of sensors register the displacements, angles, forces, and torques. All data is acquired using PC-based control from Beckhoff, displayed live on a monitor at the test bench for the operator, and forwarded in parallel to a database system. "After the test run, all measured values are automatically processed and any limit violations are displayed in the results," adds Walter Selg. Using these results, Uwe Lochner and his colleagues determine whether they will release the vehicle for further testing or whether the vehicle requires further analyses or any mechanical modifications.

Retrofitting in several stages

Using a signal processing component developed by Daimler AG, the Hydromat, selected parts of the test benches were repeatedly updated. The Hydromat is a modular control system for sophisticated test benches with setpoint input, measured value processing, output stages and monitoring functions. Back in the early 2000s, the control functionality for the test benches was outsourced to an RCP (rapid control prototyping) system from dSpace. After internal development for the remaining Hydromat functions had been discontinued and it became as difficult to procure spare parts as with the control systems used to date, Mercedes-Benz commissioned DynoTec to design and implement an integrated automation solution for the test benches. There was one central premise for modernization: retaining the modular concept of the test benches.

"Our first approach was to find a series product on the market that featured as many Hydromat functions as possible," explains Uwe Lochner. In addition, they needed to replace the analog signal lines which measured up to 30 m in length. "We didn't find a series product to replace Hydromat, but we did find a promising open automation platform and ecosystem consisting of EtherCAT Terminals, controls and a development environment at Beckhoff," describes Uwe Lochner, recalling a visit to a trade fair. Another important criterion was the open nature of the EtherCAT protocol. This meant that they would not have to rely solely on Beckhoff for the components. There was also an EtherCAT interface to the RCP system.

Rainer Fischer, Managing Director of DynoTec, explains: "This gave us the opportunity to implement a test bench concept providing decentralized data logging and digital measurement signal transmission – with all possible advantages in terms of wiring and signal quality." When it came to verifying and validating this concept, DynoTec examined a number of issues:

- What is the ideal coupling method to integrate the RCP system (synchronous/asynchronous, master to slave, slave to slave, or distributed clocks)?
- How does the signal quality of AD/DA converters from different manufacturers compare to the current system?
- Which RCP system task runtimes result from the configurations?

The outdated, traditionally centralized PLC technology has now been replaced by decentralized control cabinets with EtherCAT Terminals mounted on the four jacks. The control cabinets contain the components for measured value acquisition and servo valve control for adjusting the jacks in the x, y, and z direction and for rotating them around the z axis. The PLC task and the associated HMI run on a CX5140 Embedded PC. The high-performance hardware allows the system status and error history to be visualized in detail on a CP2219 multi-touch built-in Panel PC. The measurements are performed and visualized on a C5240 19-inch slide-in Industrial PC. TwinCAT 3 HMI Server (TF2000) software supports the visualization functions. All computers in the test benches are linked to a higher-level operating computer via TwinCAT ADS. In the overall system, the Beckhoff control system acts as the master and triggers the RCP system via UDP communication to achieve a high level of time precision and control quality.

High resolution and sampling rates

The decisive factors for DynoTec and Mercedes-Benz were the high sampling rates offered by the ELM3xxx measurement terminals, the high speed of data transmission via EtherCAT, and the simple, compact and modular data logging directly on the four hydraulic jacks. "All in all, our standardized system technology integrating classic PLC tasks and sophisticated measurement technology ensures a significant cost advantage," summarizes Rainer Fischer. "This is true even when dealing with the high bandwidth and resolution requirements that test benches place on the measurement technology," adds Dieter Völkle, who is responsible for the project at the Beckhoff branch in Balingen, Germany.

During a test run, the system synchronously records up to 136 measurement channels at 5 ksps each (10 ksps optional). This corresponds to a total sampling rate of 680 ksps. In addition, there are 36 setpoint or output channels with 5 ksps each and around 300 channels with post-mortem diagnostic data, which are recorded at 100 sps. There is also a measuring box for external signals on each test bench. Each box has 16 analog inputs for special measurement technology and 16 analog outputs. These outputs can provide any measurement channel to synchronously record the outputs with the measurement technology installed in the vehicle, for example.

The measurements results can be visualized in detail with TwinCAT HMI.

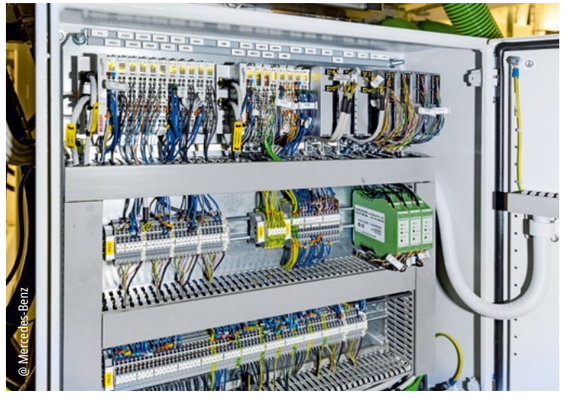
Space and time are always scarce on the test bench

The compact EtherCAT Terminals make it easier to log signals and reduce the space required. The control cabinets are now much clearer, facilitating rapid troubleshooting and fault rectification. What's more: "We were able to save one out of five computer control cabinets on the test bench," adds Uwe Lochner. In addition to space, the time factor is at least as important when it comes to testing vehicles. Here, too, the modular system structure of PC-based control offers a distinctive advantage – due to the repetition effect, the process of converting the other test benches was much quicker. "Compared to the first test bench, we were able to reduce the downtime by more than 30% when converting the last test bench," says Rainer Fischer from DynoTec.

Given that use of the TwinCAT Analytics Logger is planned as the next expansion stage, the measurement data from the four test benches can be conveniently accessed for post-processing in the future. The real-time data logger is easy to configure and streams all measurement data to a central storage location. This also simplifies post-processing across all test benches. With TwinCAT Analytics, it is possible to analyze both the historicized data and the live measurement data online.

For test bench specialist DynoTec, this project with its extremely demanding measurement technology and control tasks has proven that high demands can be met with EtherCAT measurement terminals and PC-based control. Walter Selg: "The scalable Beckhoff platform offers us the opportunity to handle projects of any size with a standardized system." In another project, DynoTec used the ELM3602 EtherCAT Terminals to implement one-third octave band analysis of triaxial IEPE vibration sensors with a sampling rate of 50 ksps.

At first glance, the test bench does not appear to offer an enormous amount of measurement technology: a total of 136 input channels with 680 ksps and 36 output channels with a sampling rate of 180 ksps.



More information:
www.dynotec-gmbh.de
www.beckhoff.com/measurement

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System for high-voltage direct current transmission

Model-based engineering and PC-based control for high-voltage direct current transmission

Transmitting high power efficiently over long distances

Whether from offshore wind turbines on the high seas to the mainland, from wind turbines in northern Germany to industrial sites in the south of the country, or from hydropower plants in Scandinavia to central Europe – high-voltage direct current transmission is used to transmit large amounts of energy over long distances. For its solution, Siemens Energy relies on MATLAB and Simulink from MathWorks and PC-based control from Beckhoff.

Following the dispute that arose between Nikola Tesla and George Westinghouse over the technology used to supply electricity to the USA in the 1890s, alternating current has become the most widely accepted system. However, the cables used to transmit alternating current over long distances act like a capacitor, which leads to transmission losses and a need for compensation through reactive power. When transmitting direct current, however, this reactive power requirement is negligible, i.e., the current can be transported with significantly lower losses. This is why direct current under high voltage is used to transmit high power.

The basics of direct current transmission

Put simply, this kind of transmission by means of direct current uses two power converters with a common DC link. Each power converter can transmit energy from the grid with alternating current to the DC link with direct current and also feed the energy from the DC link back into the grid as alternating current. This allows electrical energy to be transmitted in any direction between the two grid connections. Direct current with a very high voltage is used for transmission in the DC link, which is how the system got its name: high-voltage direct current (HVDC) transmission. Transistors – known as insulated-gate bipolar transistors (IGBT) – which act like valves are used to convert the current. These can allow the current to pass through or block it and thus generate the desired current curves using pulse patterns.

However, the power converter of an HVDC system is dimensioned differently to conventional converters. This is because modular multi-level converters (MMCs) consisting of hundreds of IGBTs are used and installed over an area of 10 to 15 hectares. The DC link uses a voltage between 100 and 800 kV and transmits power between 500 and 6,400 MW over distances of hundreds of kilometers.

New control concept for large power converters

As a manufacturer of systems for energy transmission and stabilization of the power grid, Siemens Energy will in future be putting its trust in PC-based control technology from Beckhoff. Embedded PCs and EtherCAT I/O terminals as well as TwinCAT automation software in conjunction with model-based design are being used for higher-level control and to protect large power converters. Among other things, these power converters form the basis of such HVDC systems, but are also used for systems to compensate for reactive power or to support and stabilize electrical energy grids (flexible AC transmission systems, FACTS).

In order to achieve a high level of reliability for such an important part of the energy grid, redundant systems are often used. The control and protection systems in hardware and software are permanently in a hot standby mode so that they can immediately switch to the redundant system in the event of any malfunction. To achieve this, redundant communication is established via several separate Ethernet networks using the TwinCAT Parallel Redundancy Protocol (PRP) in accordance with IEC 62439-3. This method enables communication to take place between the embedded PCs via the EtherCAT Automation Protocol (EAP) as well as with external systems such as circuit breakers via MMS and GOOSE in accordance with IEC 61850.

Fast response times and safe operation

The requirements for fast response times for higher-level current and voltage control are met using EtherCAT and high-performance embedded PCs. Based on the AMD Ryzen™ CPU in the CX2043 Embedded PCs, control tasks can be executed in TwinCAT with cycle times of 250 µs and minimal jitter. A total of up to twelve such embedded PCs are used per power converter, which exchange fast signals in redundant segments via the EL6695 EtherCAT bridge terminal.

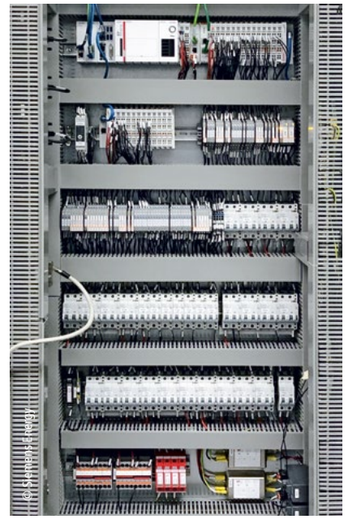
The TwinCAT/BSD operating system was chosen to ensure safe operation of the systems as part of the critical infrastructure. It offers a stable Unix platform for the TwinCAT 3 runtime, which also meets the growing security requirements. TwinCAT modules are then executed in the real-time environment of TwinCAT 3. TwinCAT modules developed directly in C/C++ are used for basic functions or special communication stacks. They make it possible to abstract the control software from the details of the hardware or communication via various protocols such as EtherCAT or IEC 61850. Specific functions and controls for the system are then configured using model-based development in MATLAB and Simulink and transferred to the embedded PCs using code generation.

Integrated and open software

Since these kinds of HVDC systems are not available for development and verification as a physical system, early testing via simulation is of central importance. In the past, these tests were carried out in various simulation environments, which required the control and protection software to be manually translated into each environment. This manual process was too error-prone and time-consuming to achieve comparable control behavior in all environments.

To enable a single source to be used for the software, Siemens Energy has been successfully using model-based design and engineering for the processes with the help of MATLAB and Simulink® for several years. The development of the control and protection software in Simulink and subsequent code generation with TwinCAT 3 Target for Simulink eliminates precisely all manual steps mentioned above, allowing the developers to concentrate on their core task instead. Running the same software in different simulation environments as well as on the final control hardware enables the behavior to be compared more effectively.

Another advantage is the time saved in the event of an error or when expanding the models. In the past, it was necessary to correct the errors in the respective target system or expand the functions there, but today this is done in the source model in Simulink. In conjunction with TwinCAT, the already tested software modules can then be ported to the powerful, highly real-time-capable embedded PCs with little effort and only need to be connected to the physical interfaces. As a result, both HIL (hardware in the loop) tests and tests involving the control cabinets to be installed in the real system later on can be carried out with the control system in order to deliver a control system that is optimally adapted to all scenarios in the power grid.



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Test cabinet containing the CX2043 Embedded PC and directly connected EtherCAT Terminals

More information:

www.mathworks.com

www.siemens-energy.com

www.beckhoff.com/wind

PC Control 02 | 2024 worldwide | canada

The Heat View system optimizes in situ heat treating for a range of applications, including shipbuilding, petrochemicals, mining, aerospace and more.

© Heat View Heat Treating Controls Ltd.

Portable PC- and EtherCAT-based controls for in situ heat treatment

Compact carrying case solution offers versatile use in the field

Heat treatment is traditionally used in the welding of pipelines to influence the material properties through controlled heating and cooling. A Canadian system integrator was looking for a flexible, compact system for controlling and documenting this process. With the space-saving EtherCAT Terminals and Industrial PCs from Beckhoff, the smallest version of the Heat View solution now even fits in a carrying case.

When system integrator Jeremy Breetzke started prototyping the Heat View Heat Treating System, he had no idea how many different applications and industries it would eventually be used in. Back in 2018, he simply saw a gap to fill. There was no compact, flexible option to control, monitor and provide reports during in situ heat treating in factories, plants or remote areas. So the owner of Grand Controls, Inc. based in London, Ontario, started working on a design. “The Heat View product grew so quickly that in 2021 we spun it off as its own company, Heat View Heat Treating Controls, Inc.,” Jeremy Breetzke says. Scott Fong is Group Director at KASI Technologies Inc., a company that sells and rents field heat treating equipment. So he knew the requirements for the new platform firsthand and supported the development process with technical input.

© Beckhoff

Using EtherCAT Terminals, the ConPak control solution incorporates a significant level of functionality and signal flexibility into a ruggedized, easily portable plastic case.

© Heat View Heat Treating Controls, Inc.

In the embedded version, the Heat View control system is operated via the built-in 7-inch touchscreen of the CP6606 Panel PC.

Heat View's ConPak product packages a stand-alone, 24-channel heating controller into a robust and compact carrying case solution.

© Beckhoff

The original use of the control system was to ensure that welded parts reached and held the correct temperature to avoid defects. This is critical when building oil and gas pipelines or refining infrastructure, for example, where failures can be costly and environmentally catastrophic. The system has been used for that purpose in aerospace, mining, shipbuilding, petrochemicals and more. But it has also been applied to power generation and high-velocity combustion. Once the work is completed, the unit provides the necessary quality control reports.

Covering all the bases with PC-based Control

The team of developers had several goals. First, the product had to be easy to transport and set up. Second, it needed to flexibly adapt to customers' requirements, such as accommodating different types of current transformer (CT) coils or communicating via various fieldbus protocols to existing equipment. Third, it needed to be easy to use with a more intuitive operator interface, whether the customer wanted a built-in control panel or simply to plug in a laptop. Jeremy Breetzke had been working with Beckhoff Canada since 2017 for applications with his system integration business, and knowing the flexibility of the EtherCAT and PC-based control technologies, they seemed like an ideal fit for these requirements.

The Heat View Heat Treating System comes in several form factors with options for customization. The most portable is the ConPak 24-channel heating controller, which is built into a rugged plastic case for easy setup and portability. In addition, the company provides an embedded controller for installation into new or existing equipment and generator panels.

From an automation technology perspective, both systems are very similar. Scalable, fully integrated control technologies from Beckhoff allow the company to use either a C6015 ultra-compact Industrial PC (IPC) or a CP6606 Panel PC when customers would like a built-in, 7-inch industrial touchscreen. "Both controllers run the same Windows version, along with TwinCAT 3 automation software, of course," Jeremy Breetzke says. "So the code that we wrote for the CP6606 was easy to port over to the C6015, and we could write custom code in C# and C++, which isn't possible on a traditional PLC."

By leveraging TwinCAT 3 from Beckhoff, the Heat View team benefited from a universal, end-to-end engineering and runtime platform for automation. TwinCAT integrates with Microsoft Visual Studio, which empowers engineers to program in a familiar, contemporary environment with the language that best fits their application. Jeremy Breetzke appreciated having Structured Text as a programming option, as well as the ability to deploy functions built into the libraries: "TwinCAT has a vast array of libraries that includes many function blocks that aren't very common with PLCs, such as file read and write," Breetzke says. "This makes code development much faster."

EtherCAT supports versatility

EtherCAT simplifies industrial networking significantly for Heat View. The wide variety of Beckhoff bus couplers and gateways to more than 30 common protocols ensures Heat View can connect to all kinds of modern control and SCADA systems.

Heat View uses various EL series EtherCAT Terminals for basic input and output of signals. However, even more specialized measurement modules retain the same compact 12-mm housing size. Thus, the compact EL2624 4-channel relay

© Beckhoff

Automation and heat treatment experts at the facility in London, Ontario: (from left) Dean Herron, Regional Sales Engineer at Beckhoff Canada, with the Heat View team of Ashley Dunn, Nathyn Smeets and owner Jeremy Breetzke.

output offers a relay contact up to 125 V AC or 30 V DC, with its long lifetime reliably cycling in the field for years. With four individually parameterizable analog inputs, the EL3174 EtherCAT Terminal supports signals ranging from -10/0 to +10 V or -20/0/+4 to +20 mA on each of the channels. This helps the systems adapt to changing customer requirements in terms of current transformers, according to Jeremy Breetzke."With most heat-treating control solutions, changing the CT type would require opening up the console, rewiring it and replacing all the CTs – or using very expensive ones that rectify the signal and feed it back into their controllers," he says.

Ideal for wide-ranging applications

"Sometimes, crews weld pipelines in remote areas where they camp and use generators for power. Other times, they're working on large facilities and move the setup around frequently," Jeremy Breetzke explains. "It's much easier to pull a 45-pound ConPak system out of your pickup and plug in four cables than transport traditional consoles that often weigh 800 pounds or more."

Currently, Heat View appreciates the ability to communicate quality control data to an operator's laptop using an Ethernet cable and the ADS protocol. Since TwinCAT engineering software is free to download from the Beckhoff website, customers can also easily install updates. The system's next step will involve additional IoT connectivity. Support for vertical communication protocols – such as OPC UA, MQTT and AMQP – will allow users to send reports and push updates from the cloud.

"We're monitoring so many different variables and mitigating faults to create a foolproof system. Our systems integrate elements of AI, so they can learn on the fly and detect problems while factoring in external variables," Scott Fong from KASI Technologies says. "These capabilities are game changers compared to what's on the market and the next-generation products we have in development will be even better."

More information:

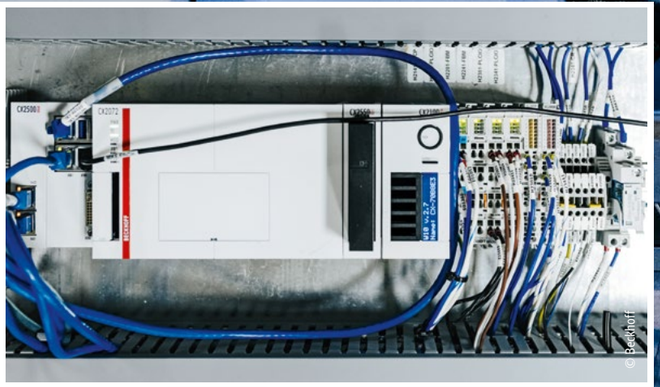
www.heatviewcontrols.com
www.grandcontrols.ca
www.beckhoff.com/c6015
www.beckhoff.com/cp6606
www.beckhoff.com/ethercat-terminal
www.beckhoff.com/twincat

PC Control 02 | 2024 worldwide | united states

EtherCAT and XTS in modular assembly platform for clean manufacturing

Intelligent transport system brings agility to product handling

Initially geared toward hygienic manufacturing in the life sciences market, the powerful FlexChassis® platform offers enormous potential for application in other industries. These include food and beverage, semiconductor, automotive, battery and e-mobility, e-commerce and more. Here, adaptive automation via the eXtended Transport System (XTS) from Beckhoff Automation is key, according to the experts at JR Automation.



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As a powerful many-core controller, the CX2072 Embedded PC provides sufficient computing power for the XTS and all other equipment in the system.

With flexible material handling using the XTS intelligent transport system, FlexChassis® helps customers focus on their core competencies rather than reengineer the automation aspects.

JR Automation®, a Hitachi Group Company with headquarters in Holland, Michigan, knows how to flex. From small beginnings, the machine builder and systems integrator has successfully developed into a company with more than 2,000 employees by delivering custom automated solutions for numerous industries. “We want to be good stewards of automation. That means helping our customers figure out where they want to go and providing the best technology solutions to get them there,” says Shawn Smith, Director of Sales at JR Automation. “One way we’ve done this is through our scalable, modular automation platform, FlexChassis, which speeds up customers’ time to market while cutting costs.”

The last few years have been challenging for manufacturers. And as pressure mounted in critical projects, the JR Automation team noticed how frequently reengineering slowed projects. Having to redesign a machine’s base and material handling technologies often took the equipment end user’s attention away from optimizing their own processes and products.

The FlexChassis platform, on the other hand, empowers manufacturers to start small with a system for product testing or proof of concept work. Then they can rapidly scale for series production with built-in OEE (Overall Equipment Efficiency) monitoring and quality control functionality. Going forward, they have confidence in the ability to add capacity, customize processes or retool.

Modularity meets customer needs

With standard modules measuring 1 by 1.5 m wide and 2.44 m tall, FlexChassis supports wide-ranging robotics and other bolt-on equipment for different applications. However, the JR Automation engineers didn’t want inflexible material handling to be a stumbling block to modularity, so they looked to adaptive linear transport tech that can accommodate constant change. That’s when they turned to the intelligent transport system XTS because JR Automation is part of the Beckhoff Integrator Group (BIG) and no stranger to Beckhoff technologies. “JR chose the XTS due to its speed and modular design that allows for multiple configurations,” says Mick Trompen, Chief Engineer, Life Sciences at JR Automation.

XTS consists of linear motor modules with integrated power electronics and wireless, magnetically connected movers on mechanical guide rails, all with multiple geometries to create any path and track length imaginable as a perfect match for the modular assembly platform. The movers can operate individually or in groups and in this way enable individualization of the material flow, e.g. by using multiple executions of slower process stations and skipping of stations for rejected products. In addition, the software-based changeover saves time during format changes and minimizes the mechanical conversion effort. The overall result is an extremely flexible workflow and high system throughput.

“The XTS motor modules’ simple configuration and track layout worked well for our concept,” explains David Shiles, Senior Controls Engineer at JR Automation. “We are taking on assemblies with more steps and at higher throughput rates than ever before.” Space savings also appealed to the team. The XTS technology’s compact and integrated design eliminates outmoded mechanical components such as belts, chains, indexing tables, etc. This typically shrinks machine footprints by roughly 50%.

Powerful control and communication

While XTS enables flexible product handling, many technologies come together in the FlexChassis to make a highly scalable solution. JR Automation sees possible process stations including everything from ultrasonic welding, snap fit and adhesive application to reagent fill/seal, drug handling and applying labels or decorations. Such a broad selection of robots, end effectors, tooling and sensors requires rapid communication via various industrial protocols and fast cycle times. Real-time communication with EtherCAT delivered the necessary speed and flexibility, David Shiles explains: “I prefer EtherCAT from a performance standpoint.” EtherCAT’s openness was critical, too, for adaptation to customer environments. The Beckhoff components offer support for communication via more than 30 common protocols.

High-speed EtherCAT communication is necessary for XTS and to coordinate with robotics and other tooling at high speeds. Here, a CX2072 Embedded PC from Beckhoff offers sufficient computing power with many-core Intel® Xeon® processors. “This is the only way to meet the necessary scan time of 250 µs to process the XTS data in addition to dedicating cores for PLC, servo control and machine vision,” Shiles says.

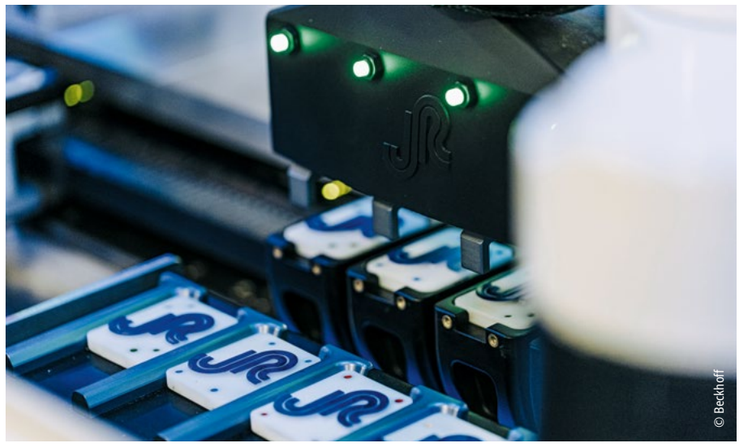
To program the wide-ranging functionality, the engineers relied on TwinCAT 3 automation software. The end-to-end engineering and runtime platform supports a vast range of programming standards and also transparent communication between the Beckhoff IPC and third-party PLCs for future extensibility. The high portability of code in TwinCAT also offered advantages to iterate faster.

Dynamic automation platform delivers results

FlexChassis offers customers faster time to market, high throughputs greater than 45 parts per min and low footprint requirements. Its clean manufacturing capabilities include HEPA filtration (air filter), support for various cleanroom classes and a stainless steel construction for hygienic applications. PC-based control also supports intuitive dashboards giving users easy access to all system data. “IoT and track and trace are very important functions that are native to the FlexChassis system for downtime management, quality management and OEE,” explains David Vitale, Chief Engineer, Digital Solutions at JR Automation. “Performance data is gathered from the system utilizing a local Beckhoff embedded PC through our MES functions. Currently, these are stored on local databases, but they can be hosted in the cloud or elsewhere as desired.”

TwinCAT empowered JR Automation engineers to rapidly commission the first FlexChassis system, which served as a demo for customer meetings and trade shows. The XTS platform sped this development through an intuitive configurator for hassle-free setup, a suite of powerful diagnostic tools and visualization tools for enabling rapid development, whether in simulation or on real hardware. The no-cost TwinCAT engineering environment was another huge benefit, according to Applications Engineer Chris Moritz. “It’s amazing how Beckhoff handles TwinCAT licensing for development work,” he says. “I originally wrote the XTS software used for a project in 2020 when we had to work from home because of COVID. Because I could simulate substantial portions of the machine without needing to buy hardware or software, I hit the ground running once the components arrived with minimal debug time.”

JR Automation developed the FlexChassis® system as a modular automation platform to boost speed to market for tailor-made customer systems.



XTS movers can work synchronously or asynchronously, which is highly beneficial when processing multiple parts at the same time, for example, in the 4-up station shown here.

The project experts (from left): Angela Farina (Regional Sales Engineer, Beckhoff), Shawn Smith (Director of Sales, JR Automation) and Graeme Peek (Application Engineer, Beckhoff).

“JR Automation and Beckhoff both started in 1980. We’ve been able to evolve together over the years and develop our technologies to be the tip of the spear for our customers,” Shawn Smith concludes. “It’s rewarding to have a partner like Beckhoff. We’re really excited about what’s next and how we will stretch the limits of automation together.”

More information:
www.jrautomation.com
www.beckhoff.com/xts

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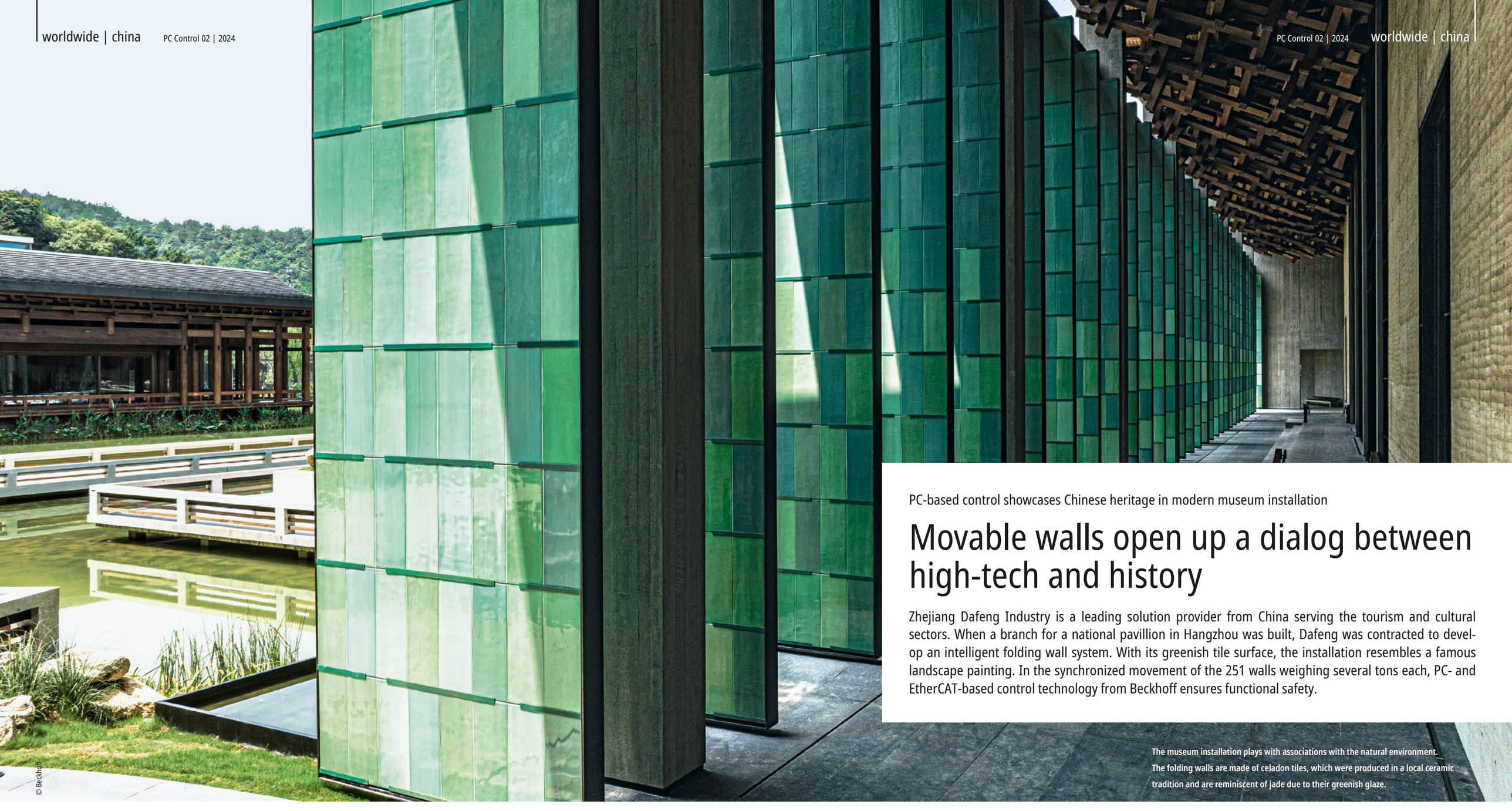

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The museum installation plays with associations with the natural environment. The folding walls are made of celadon tiles, which were produced in a local ceramic tradition and are reminiscent of jade due to their greenish glaze.

PC-based control showcases Chinese heritage in modern museum installation

Movable walls open up a dialog between high-tech and history

Zhejiang Dafeng Industry is a leading solution provider from China serving the tourism and cultural sectors. When a branch for a national pavillion in Hangzhou was built, Dafeng was contracted to develop an intelligent folding wall system. With its greenish tile surface, the installation resembles a famous landscape painting. In the synchronized movement of the 251 walls weighing several tons each, PC- and EtherCAT-based control technology from Beckhoff ensures functional safety.

The pavillion serves as a hub for preservation, exhibition, research and exchange. It combines the functions of a library, museum, art gallery, archive and exhibition hall. The newly constructed building complex is nestled among the mountains. The most eye-catching feature of the architecture is a folding screen consisting of movable wall elements that can open or close the exhibition space to the outside. To that end, the wall elements can be either folded like the panels of a traditional folding screen or positioned next to each other to form a flat surface like a painted partition wall. Following the design concept, the installation resembles the famous Chinese painting “A Thousand Miles of Rivers and Mountains”, which shows a blue-green landscape panorama over a width of more than 50 m. Therefore, the 251 folding screens of the entire installation were built using approximately 70,000 pieces of celadon tiles that were handcrafted to unique specifications in traditional kilns. Celadon is a form of ceramic typical of this region, which resembles jade with its greenish glazing and was very popular during the culturally significant Song dynasty (960 to 1279). The painting is also attributed to this period. The smooth opening and closing of the high and heavy walls is ensured by a PC-based control system from Beckhoff, creating a visual link between cultural history and state-of-the-art automation.

Stability, precision and safety

The construction phase of the pavillion began as early as 2020. However, the progress of realizing the celadon wall installation stagnated due to the high control requirements, as the largest wall type measures 2.1 m x 10.4 m, and at a thickness of 22 cm, weighs four tons. The machinery not only had to be able to safely support these walls, but also ensure the jerk-free movement and translation along a track system designed for that purpose, as otherwise the walls would shatter due to their high inertia.

“In machine building, we mainly deal with materials like steel. Until then, I had never worked with ceramics,” says Huafeng Yan, chief engineer for the development of the celadon folding wall at Dafeng. Furthermore, the enormous

When closing the walls, two axes for translation and one axis for rotation must be controlled with high precision so that the gaps between them do not exceed 1 cm.

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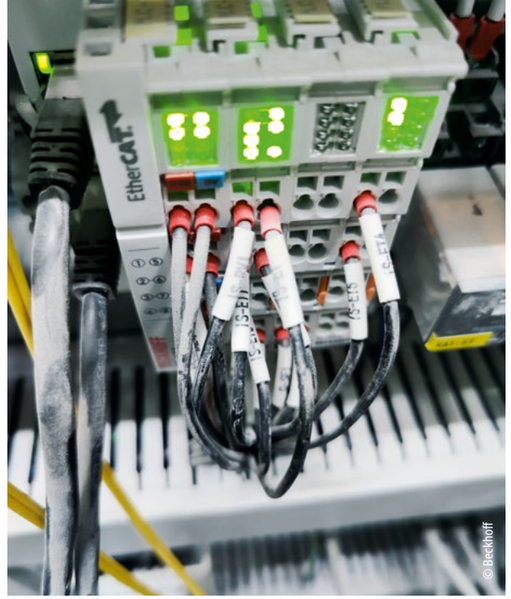


EtherCAT plays a central role in controlling the drive technology. The distributed clocks function enables system-wide synchronization of all wall panels in the installation

A CX2040 Embedded PC with a quad-core Intel® Core™ i7 processor offers high computing power for controlling the many servo axes in the installation.

weight of the celadon tiles resulting from the high density of the material, also means that the mechanical errors in positioning must be small. When the folding screens rotate to align in the same plane, the distance between them must be strictly controlled within 1 cm. Larger gaps between the screens would detract too much from the resemblance of the installation to the painting “Thousand Miles of Rivers and Mountains” after which it was named.

The system developed by Dafeng integrates motion control, logic control, safety monitoring, and real-time synchronization technologies. It embeds various algorithms implementing anti-vibration and acceleration functions including parabola overlay, which ensures that the celadon folding screens can run smoothly through 16 motion profiles. According to Dafeng, the safety control system of the system has achieved SIL 3 certification, the highest safety standard of the European Union. ”We have reached a world-leading level for technical implementations in the cultural sector,” says Hufeng Yan.

Powerful PC-based control system

At the core of the control system is the CX2040 Embedded PC with an Intel® Core™ i7 CPU, 4 GB of main memory, and Windows 10 operating system. This PC-based control platform offers excellent computing performance and, with the TwinCAT 3 automation software, enables flexible engineering in compliance with IEC 61131-3. According to Huafeng Yan, the mixed use of the programming languages Structured Text (ST), Function Block Diagram (FBD) and Ladder Diagram (LD) greatly facilitated the development of customer-specific algorithm and logic programs. In addition, the motion functions could be developed rapidly using the TwinCAT 3 Motion Control library based on the PLCopen specifications.

Each celadon folding wall is controlled via up to three servo axes, with two axes controlling translation and one axis controlling rotation. With a total of 251 individual walls, each controller therefore needs to control the synchronization of more than 100 axes. To meet these requirements, Dafeng uses TwinCAT NC to specify corresponding slave positions through a complex cam table, and to plan suitable interpolation positions and speeds. A high-level monitoring software, developed using C#, enables the fast and efficient exchange of very large data volumes via the TwinCAT ADS protocol.

Precise servo control via EtherCAT

EtherCAT is established as the fastest Industrial Ethernet technology because compared to traditional fieldbus systems, it offers exceptionally high data transfer rates. The celadon wall installation benefits from this with a correspondingly high level of precision. All servo axes are controlled via the distributed clocks function, to synchronize all nodes in the network, with a jitter well below 1 µs throughout the system. Three servo drives are required to control each celadon wall, which are connected via a network cable to one port of an 8-port EtherCAT junction CU1128. Furthermore, the system provides a hot-connect feature allowing for convenient insertion and removal as well as replacement in the event of a fault without interrupting operations.

For reliable and safe operation, the wall installation uses TwinCAT 3 EtherCAT Redundancy (TF6220). This EtherCAT cable redundancy integrates the entire system into a large closed control loop, where any physical or connection failure at one node does not affect the operation of the other devices in the network. This setup prevents the impact of transient electromagnetic interference on the system and greatly reduces the risk of downtime.

Integration of science, technology and culture

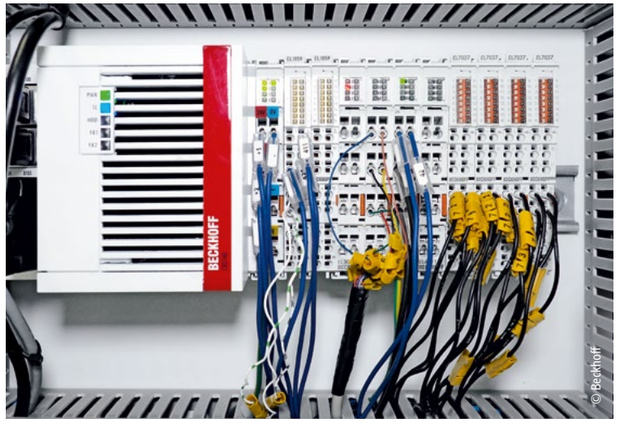
The celadon folding screens can be freely opened and closed at any angle to create an elegant visual experience in different scenarios. At the same time, the highlight of the national pavillion protects the public with its high level of security. Huafeng Yan sees the success of the project above all in the deep integration of technology and culture: “The outside world generally regards stage machinery as part of the manufacturing industry. And in fact, the trend that digital technology and cultural innovation are empowering the traditional manufacturing industries is becoming more and more evident! The experience of participating in the construction of the national pavillion, will undoubtedly be a remarkable highlight in the history of our company.”

More information:
www.chinadafeng.com
www.beckhoff.com/twincat

PC-based control in the post-processing of 3D printed parts

Ready for series production through continuous fiber injection

The limiting factors for 3D printing on an industrial scale are the limited choice of materials and possible print sizes using them. Here, CFIP (Continuous Fibre Injection Process) provides a remedy because it facilitates the use of affordable lightweight materials. By injecting endless fibers, the process developed by Reinforce3D from Spain, increases the stability of 3D printed parts. Flexible PC-based control technology simplified the automation of the novel process in the compact Delta machine.



The Beckhoff control solution based on an CX5140 Embedded PC and a range of EtherCAT Terminals easily fits into the compact control cabinet of the 3D post-processing machine.

Building on a research project, Catalonia-based start-up Reinforce3D brought a highly innovative technology for reinforcing 3D printed parts by injecting continuous fibers to maturity.

In general, there are four fundamental stages in additive manufacturing: design, 3D modeling, printing and post-processing. Regardless of the manufacturing technology used, the last step is especially important, as it gives the printed parts the desired surface finish. Moreover, many post-processing techniques are also used in order to enhance the physical and mechanical properties of the parts. CFIP (Continuous Fibre Injection Process) is a new post-processing technology that can potentially be a new milestone in the additive manufacturing industry. In the patented process developed by the start-up company Reinforce3D, 3D-printed parts are reinforced by the subsequent injection of continuous fibers. The advantage lies in increasing the mechanical performance while maintaining any lightweight properties.

Originally, Reinforce3D was a project within the Eurecat technology center, located in Catalonia, Spain. Together with Eurecat and former development leader Marc Crescenti, investors BeAble Innvierte Kets Fund (BIKF) launched a start-up in 2022, to further develop the CFIP technology. Under its CEO, Blanca Garro, the company succeeded in bringing its technology to maturity in a short period of time. In 2023, new head of automation Marc Roselló started to develop the Delta machine, which could be presented in that same year during the Formnext trade fair in Frankfurt. The objective of the young enterprise was to remove the boundaries for post-treatment accepted as standard until then.

Strengthening 3D printed parts from within

Instead of strengthening parts during the manufacturing process, as is common in conventional 3D printing, CFIP is improving part properties in a subsequent step. Specifically, this method involves injecting continuous fibers into pre-designed tubular cavities in the parts to drastically improve their strength. A key point to achieve this enhancement is the usage of continuous fibers instead of using short fibers because these will increase stability exponentially rather than gradually. In addition to strengthening parts, continuous fibers enable the integral bonding of different components by injecting fibers through the joints. The fiber continuity from one end to the other results in

Reinforce3D relied on the industrial expertise of Beckhoff to develop a technology that facilitates the transition from prototyping to volume production.

© Beckhoff

stronger bonds than those obtained with traditional joining methods, such as using adhesives. The fibers are carried by a liquid resin that seamlessly bonds with the 3D printing material after setting, creating a new physical interface and increasing the structural strength and mechanical properties of the part significantly as a result.

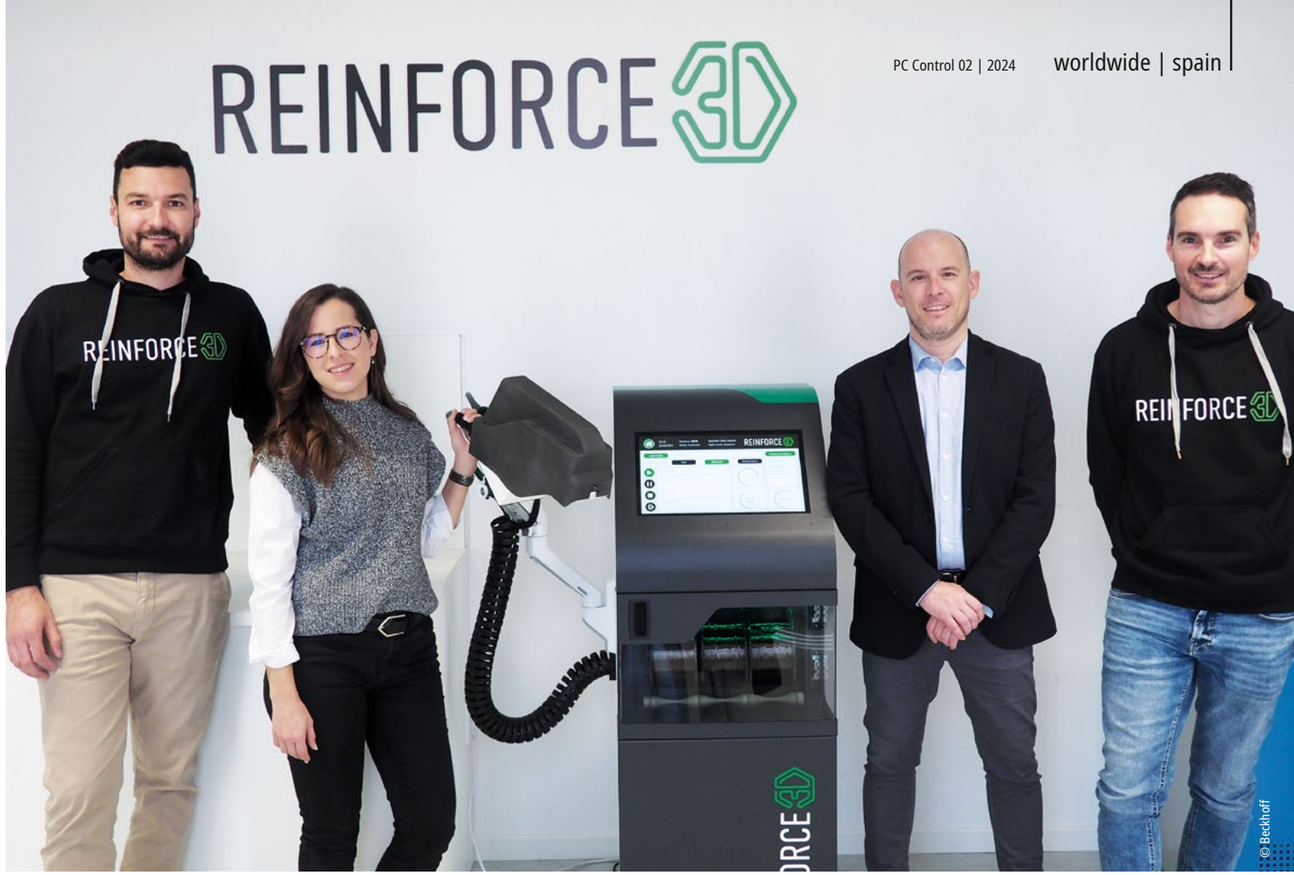
In addition to carbon fibers, CFIP can also be used with glass and aramid fibers. Moreover, Reinforce3D plans to expand its range of materials to include natural fibers in the future. Another advantage of the versatile method is its compatibility with a multitude of additive manufacturing methods. Therefore, users can turn to 3D printing technologies that are more suitable for volume production, such as well-known commercially available systems that work with thermoplastic polymers. Even when using these comparatively inexpensive materials, the user can achieve very good results by reinforcing the lightweight materials subsequently. In addition to plastics, the technology also works with a wide range of additive manufacturing materials, including metals and ceramics.

Unique new process and customized controls

As Marc Crescenti, CTO at Reinforce3D, explains: "CFIP is a completely new technology and Reinforce3D is exploring unknown territory, so we were looking to develop a machine that is sufficiently reliable to offer the best-possible user experience but flexible enough at the same time, so it can evolve together with the development of CFIP. After evaluating all options available, we concluded that Beckhoff provided the best solution for this application."

The hardware core of the control solution is formed by a CX5140 Embedded PC. The powerful and compact computing device proved to be an ideal fit for this application, which demanded a balance between computing power and size. Marc Roselló emphasizes the significance of its flexibility, as the CX5140 can be easily upgraded for future needs with regularly available new processor generations. The fact that the machine design can remain unchanged is a user benefit in terms of simplicity and sustainability, according to the head of automation.

For the intricate task of fiber injection, the implementation of precise stepper motor control was paramount. This was achieved using four EL7037 1-channel motion interfaces from the EtherCAT Terminal portfolio for compact drive technology. Marc Roselló, head of automation, highlights: "This choice simplified the cabling



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Proud of the innovative solution (from left): Marc Roselló, Head of Automation, and Blanca Garro, CEO, both Reinforce3D, with Octavi Martí, Sales Beckhoff Spain, and Marc Crescenti, CTO and Co-Founder of Reinforce3D.

significantly, compared to external stepper controllers solutions. Additionally, it facilitated the design of a compact control cabinet, seamlessly aligning with the design concept of the Delta machine."

Another critical aspect of the fiber injection process is controlling the injection force to prevent material jams within the randomly formed part structures. Feedback is achieved through connecting a load cell to the EL3351 analog input terminal for direct connection of resistor bridges. This system-integrated measurement technology eliminates the need for an external amplifier, ultimately reducing complexity, conserving space and minimizing cabling efforts. Furthermore, various digital and analog I/O modules are used to integrate multiple process valves and a diaphragm pump into the control loop for resin supply.

Efficient implementation with TwinCAT

The driving force behind the successful development of the precision control solution lies not only in its hardware components but also in the software suite TwinCAT from Beckhoff, says Marc Roselló. He attests to the high user convenience and power of the automation software, particularly in conjunction with the EtherCAT stepper motor controllers. TwinCAT 3 NC PTP has proven invaluable for realizing software-based point-to-point motion control, he adds. Marc Roselló elaborates: "The engineering interface, software architecture and usability of TwinCAT have supported us throughout the familiarization period. It is straightforward, requires minimal effort, and ultimately facilitates the implementation of our core expertise."

Highlighting the learning path, he emphasizes the wealth of training resources available with Beckhoff, coupled with the continuous support provided by Beckhoff. The unwavering availability to assist in overcoming emerging challenges has proven to be a key factor for the successful implementation.

More information:
www.reinforce3d.com
www.beckhoff.com/twincat

The Italian robot manufacturer Lesta relies on TwinCAT 3 and drive technology from Beckhoff to implement a wide variety of painting systems.

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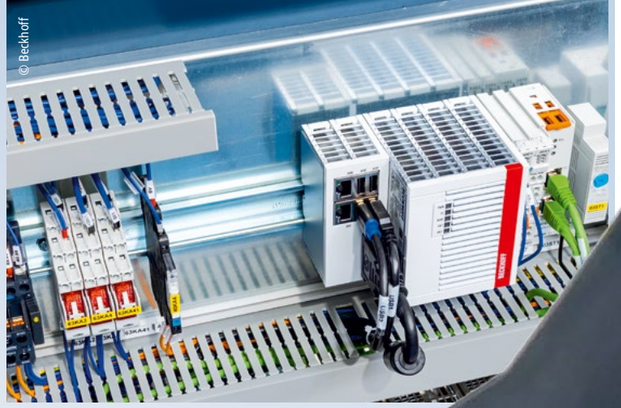

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A CX5140 Embedded PC with an Intel Atom® quad-core processor calculates movement for all robot axes while simultaneously handling visualization.

PC-based control and drive technology in robotics

Premium finish with professional finesse

A perfect surface finish is the most obvious sign of a high-quality component. Achieving this consistently throughout series production is a challenge many manufacturers face, and this prompted Lesta srl, an Italian company, to develop its innovative painting robots. Flexibly automated with PC-based control from Beckhoff, these robots are suitable for use in a wide range of painting tasks, making a crucial contribution to optimizing the surface-finishing process.

Founded in 2010 in Dairago near Milan, Lesta, a robot manufacturer, specializes in industrial robot-based painting systems. Around 700 Lesta robots are currently in operation, with the company's head of automation, Fabio Ferrario, noting that, "Around 100 systems are added each year across a wide range of industries." The spectrum ranges from metal, wood, plastic, glass, and ceramics producers through to applications in the textile and food industries. To cater to the different target markets, the robots are available in several variants, including with ATEX and UL Hazardous Location approvals.

Lesta has also developed auto-learning, anthropomorphic robots, such as the Lebot MV A5 and MV A6. These models are capable of recording the previously

manually taught movements of all axes in real time and then accurately reproducing them in automatic mode. The painter moves the robot arm with the motors switched off thanks to a pneumatic compensation system that is virtually resistance-free and weightless. As the pneumatic weight compensation remains active during operation, the motors only have to exert minimal force. This reduces the required motor power, its size, and the masses being moved, which in turn benefits the overall dynamics.

PC-based control makes a difference

For Fabio Ferrario, the company's continued strong growth clearly demonstrates the acceptance of the robots: "We have always had a widely recognized excellent reputation in the mechanical sector, but what truly sets us apart is the exceptional performance of our PC-based control systems." When it comes to the development of the automation and control application, Lesta relies on TwinCAT 3. TwinCAT 3 is flexible and open and this, along with the broad product range from Beckhoff, has proven to offer crucial advantages.

One such advantage is the way Lesta is able to build on the TwinCAT libraries and combine them with its own expertise, which includes specific coordination of the interpolated movement of the robot axes. "TwinCAT 3 allows us to build an effective high-performance system based on Beckhoff products, which we can expand at any time with third-party components or additional algorithms if required," states Fabio Ferrario.

Flowing movement like a real painter

Depending on the application, Lesta robots feature between five and over a dozen interpolating axes. Fabio Ferrario explains, "The challenge lies in getting the robots to replicate the smooth, fluid movement of a painter perfectly." However, achieving a uniform surface coating on workpieces requires more than just precise positioning. This is why engineers and technicians at Lesta use TwinCAT 3 PLC/NC PTP (TC1250) and TwinCAT NC Camming (TF5050) to optimally replicate the movements of a painter. Manual teaching of the anthropomorphic robots is also integrated into TwinCAT, while the safety functions are implemented via TwinSAFE. Lesta exclusively uses the .Net framework from Microsoft for visualization purposes. The HMI application runs in parallel with the control task on the same computer – a CX5140 Embedded PC with an Intel Atom® quad-core processor. The visualization and control application are linked via the ADS protocol, and a CP2915 multi-touch built-in Control Panel is used as the HMI hardware.

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The AX8000 multi-axis servo system and the EtherCAT Terminals from Beckhoff make for a compact and clearly arranged control cabinet.

© Beckhoff

Fabio Ferrario, head of automation at Lesta: "We chose Beckhoff because PC-based control supports perfect and effective integration, programming, and flexible configuration of our robot models."

When it comes to implementing the motion sequences generated in TwinCAT, Lesta relies on the AX8000 multi-axis servo system, as this can implement sophisticated motion profiles with high dynamics while maintaining a smooth, precise performance. Fabio Ferrario sees further advantages in the compact dimensions and in One Cable Technology (OCT) for connecting the AM8032 and AM8043 servomotors. These not only save space in the control cabinet, but also reduce material costs and installation time. "We typically only need to spend a week at the customer's site, which covers everything from the installation to commissioning of the painting station," explains Ferrario. "By Friday, the customer is already set up and ready to go."

Scalability as a competitive advantage

It makes no difference whether a project involves a 6-axis robot or a 12-axis gantry crane variant, a powder or wet coating system: all variants are based on a master configuration with functions activated according to the robot type. This flexibility is attributed to the open and easily scalable platform from Beckhoff. As Fabio Ferrario highlights, "There is no doubt that the scalability of our systems is a key USP that sets us apart from our competitors." The painting systems are often integrated into the customer's network to exchange data with other system components or factory management systems. What's more, the availability of the OPC UA communication standard in TwinCAT assures the necessary connectivity and makes the Lesta machines Industry 4.0-ready.

Looking ahead to future developments, machine learning is a hotly debated topic. Lesta anticipates that this technology will lead to further increases in productivity and quality, such as the automatic generation of painting strategies and routes. Here too, Fabio Ferrario relies on the Beckhoff automation and control platform, which can simply be updated as required on account of its openness and scalability. After all, machine learning and deep learning are already available as TwinCAT functions.

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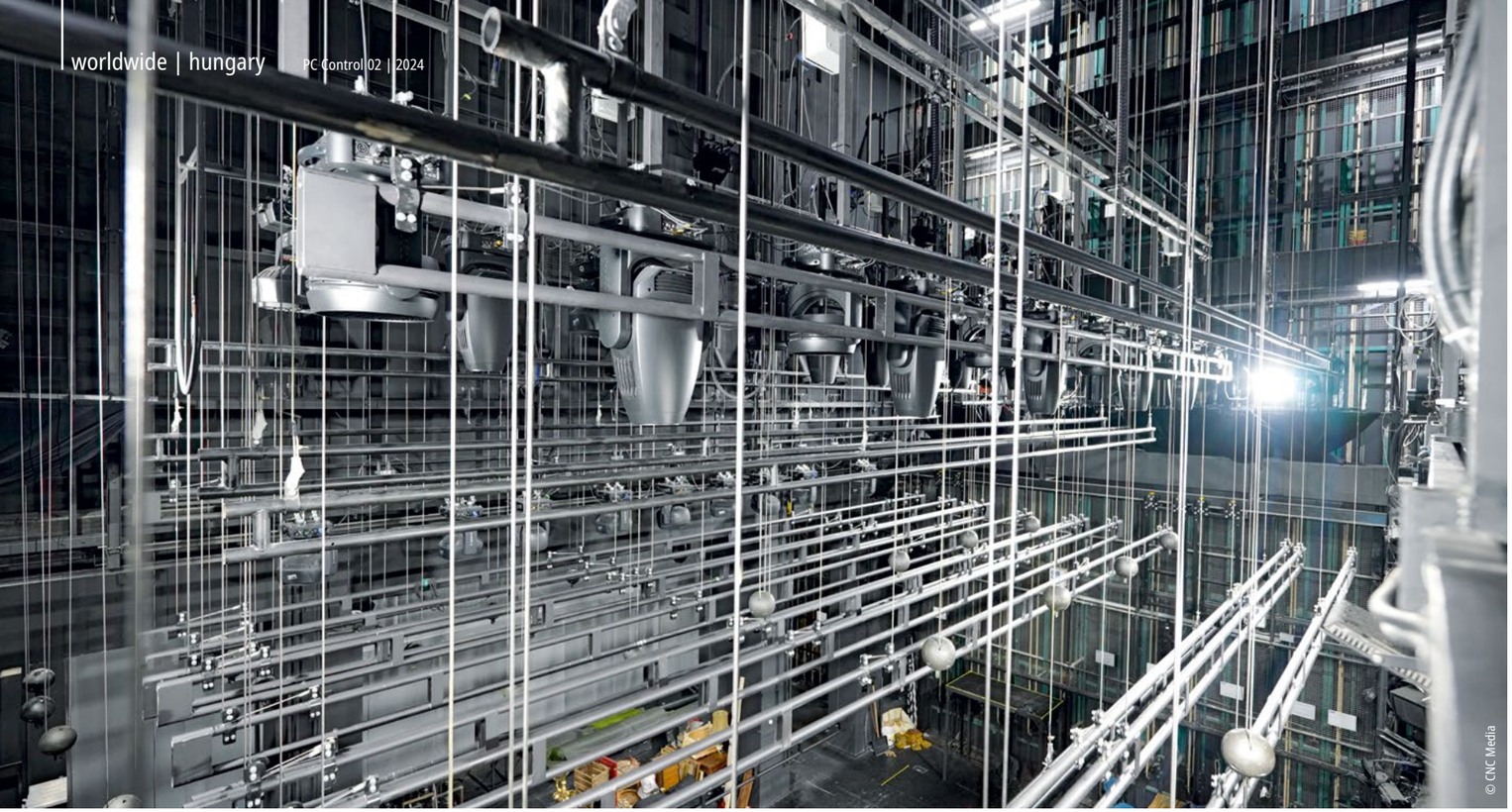
Lesta uses a CP2915 multi-touch built-in Control Panel to operate the painting systems.

More information:
www.lesta.it
www.beckhoff.com/motion



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All scenery elements are moved synchronously to defined positions via TwinCAT NC PTP according to previously configured motion profiles and scenarios.

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The extensive stage technology of the Szigligeti Theater in Szolnok, Hungary, is automated and monitored using components from Beckhoff.

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Support engineer János Bódvai and marketing manager Éva Porgánszki (both Beckhoff Hungary) alongside Attila Lukács, Gergely Major, and Attila Major from Gépbér-Színpad (from left to right)

PC-based control automates stage technology in historic theater

Lifting and moving scenery safely and precisely

Gépbér-Színpad from Hungary has been developing and implementing solutions for theater and stage technology for more than two decades – most recently for the retrofit of the Szigligeti Theater in Szolnok. Project manager Attila Major has put his trust in PC-based control from Beckhoff to control and monitor the stage floor and upper machinery.

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Section of a control cabinet containing the components for controlling and monitoring four of the total of 64 drives

The Szigligeti Theater is one of Hungary's best-known theaters. Opened in 1912 and in operation ever since, a complete renovation was carried out in 2021. Gépbér-Színpad Ltd. was commissioned with planning and designing all of the stage technology for this project. Attila Major explains: "The design of the theater technology posed a challenge in several respects." Firstly, the designers and engineers had to adapt to the historic building structure. Secondly, where moving scenery is involved, incredibly stringent safety requirements need to be met as people are in close proximity with the structures. The entire automation technology was therefore designed to meet the necessary specifications for stage technology in accordance with EN 17206:2020 and EN 62061. According to Attila Major, no other theater in Hungary has this level of safety technology. János Bódvai, support engineer for Beckhoff Hungary, adds: "We were delighted that we were able to make our contribution to the extensive automation of the stage technology with PC-based control." This includes:

- 18 pieces of equipment for moving scenery weighing up to 250 kg at a speed of up to 1 m/s
- 44 point hoists distributed over four rows
- a 5-part moving system for the orchestra pit
- a revolving stage with a diameter of 9.5 m and variably integrated performer descent platforms
- a hoist for lifting the scenery and props to the stage level

Flexible control and communication

To engineer and program the stage technology used to move the point hoists and scenery, Beckhoff recommended Drivecontrol, s.r.o., a Czech company, and its iTEMS (Intelligent Technology Motion System) control system based on TwinCAT software. The safety-oriented control section was equipped with EtherCAT TwinSAFE Terminals as hardware, including 64 EL1904 digital input terminals, 64 EL2904 digital output terminals, and one EL69xx TwinSAFE Logic. The signals from the SIL 3-certified rotary encoders used by Gépbér-Színpad for the drive axes are read in via a total of 64 EL5001 EtherCAT encoder interfaces (SSI). For the standard control range, there are another 128 EL1008 digital input EtherCAT Terminals and 64 digital output EtherCAT Terminals (each 8-channel).

When setting up the communication architecture, project managers Attila Lukács and Gergely Major were able to take advantage of the freedom that EtherCAT's topology offers: Two CU2508 real-time Ethernet port multipliers, one CU1128 8-port EtherCAT junction, 16 EK1101 EtherCAT Couplers with ID switch, and a total of 64 EK1122 2-port EtherCAT junctions were used to create a variable topology with eight fundamentally independent EtherCAT branches. "If an error occurs in one branch, the other EtherCAT segments are not affected," says Gergely Major.

Reliable control components with long-term availability

"The control technology must not cause any performance to be canceled," emphasizes Attila Lukács. With this in mind, a second C6920 compact Industrial PC has also been installed in the central control cabinet, which the theater technician can switch to immediately. As the technical infrastructure of a theater has to function flawlessly 24 hours a day, seven days a week, the reliability of all the components used was an important criterion when selecting them. The long-term availability of the control components was also a factor. After all, the stage technology needs to be maintained and modernized over the next 25 years.

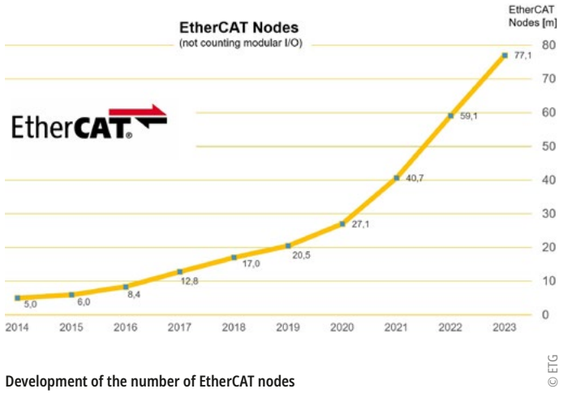
Attila Major states that further advantages of PC-based control are the fact that it is easy to integrate the stage technology with the AV and media technology as well as the building management system, plus the fact that remote maintenance is possible. Gépbér-Színpad technicians can provide the theater operator with immediate support in the event of a malfunction, although this has not yet been necessary. "The stage technology has been working smoothly for over a year now – to the satisfaction of everyone involved," says Attila Major.

More information:
www.gepberszinpad.com
www.drivecontrol.cz/en
www.beckhoff.com/entertainment-industry

EtherCAT: 77 million nodes in total, including 18 million in 2023

The strong growth of EtherCAT continues: the EtherCAT Technology Group now counts a total of 77 million EtherCAT nodes worldwide, with 18 million added in 2023 alone.

"The number of new EtherCAT nodes added in 2023 is impressive. We had assumed that chip sales would fall drastically after the end of the semiconductor crisis, as everyone had stockpiled significantly more chips than were needed in the short term," explains Martin Rostan, Executive Director of the ETG. "In addition, the market as a whole cooled down last year. Nevertheless, EtherCAT growth continues without interruption."



Development of the number of EtherCAT nodes

The figure is based on the EtherCAT chips sold throughout 2023, not including chips for individual I/O terminals. For example, an I/O station with 50 EtherCAT Bus Terminals only counts as a single node. Counting chips does lead to a certain time lag, as not every chip immediately becomes an EtherCAT device. However, it is more accurate than other methods. Chips with multi-protocol capability are counted according to their EtherCAT use: these quantities are therefore only included proportionally. Anyone who thinks that the ETG figures have been generously calculated for marketing purposes is wrong: on the contrary, the counting method is comparatively cautious, but the figures are very accurate.

The ETG was reluctant to publish node numbers until last year. One reason was that the number of devices based on FPGAs can only be estimated, in contrast to chip sales. These used to account for a higher proportion of implementations. In the figures now published, FPGAs only account for 10%, so that a certain amount of blurring here has no significant impact on the overall figure.

The ETG's membership figures also continue to grow. With over 7,600 member companies from 74 countries, the ETG remains the world's largest fieldbus user organization. Despite the current challenging economic conditions, membership growth has even accelerated in the past 12 months, with the ETG reporting over 500 new members in 2023.

EtherCAT ITW World Series 2024 with record participation

Five weeks, five regions: The EtherCAT International Technology Week (ITW) World Series 2024 embodies a milestone in terms of collaboration, knowledge exchange and dynamics within the EtherCAT developer community in Europe, China, America, Japan as well as Korea with nearly 1,000 participants.

The EtherCAT International Technology Week, a training event from the EtherCAT Technology Group (ETG), brings together developers of EtherCAT MainDevices, SubDevices, Configurators, codes and tools to acquire detailed and practical EtherCAT development know-how in numerous, regionally customized webinars. The content covers important topics such as implementation, certification and release processes for EtherCAT devices.

During the webinars, ETG's EtherCAT experts share their experience and expertise to practically address the challenges of EtherCAT device development. The interactive format allows attendees to get involved during the presentations.

In addition, special question and answer sessions after each webinar encourage in-depth discussion and a lively exchange of knowledge.

Janett Eibisch, member of the ETG tech team who organizes the EtherCAT ITWs, is delighted with the success of the event: "We really appreciate the response and active participation in this event, as it underlines the global reach of EtherCAT technology and the strong spirit within our community. This time, almost 1,000 developers attended, a number that shows us that there is great interest in this type of development support. We have definitely made an impact with the event format."

The international ETG team during the recent Global Strategy Meeting

ETG meets for its Global Strategy Meeting

International ETG team finally met in person for the first time since 2018.

Recently, the international ETG team gathered for its Global Strategy Meeting. In addition to presentations by representatives from ETG offices worldwide, there was also time for lively discussions and personal team building. In attendance were team members from marketing and technology from ETG's global offices in Germany, USA, China, Japan and Korea. It was the first face-to-face meeting of the entire ETG team since 2018.

ETG distributes 4,000th EtherCAT Vendor ID

With the assignment of the 4000th EtherCAT Vendor ID, the EtherCAT Technology Group once again underlines the outstanding diversity of EtherCAT manufacturers.

The Vendor ID is mandatory for manufacturers of EtherCAT devices and enables those devices to be uniquely identified and assigned worldwide. Accordingly, each EtherCAT device must bear its manufacturer's unique Vendor ID. The ETG alone assigns EtherCAT Vendor ID numbers and provides precise guidelines for their use. This ensures uniform and reliable interoperability of EtherCAT products in accordance with the EtherCAT specifications, and it is verified by testing with the official EtherCAT Conformance Test Tool.

Oliver Fels, who is responsible for Vendor IDs at ETG, explains: "Every manufacturer of an EtherCAT device must be a member of the ETG and have a valid Vendor ID. This must be implemented in every EtherCAT device before it is launched on the market. Users of EtherCAT devices such as machine builders, OEMs or system integrators do not need a Vendor ID."

Oliver Fels is responsible for Vendor IDs at ETG.

The allocation of an EtherCAT Vendor ID is free of charge, as is ETG membership. This underlines the openness of the technology. ETG members can apply for the Vendor ID online via the EtherCAT Technology Group website.

More information:
www.ethercat.org

PCcontrol
The New Automation Technology Magazine

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