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The New Automation Technology Magazine

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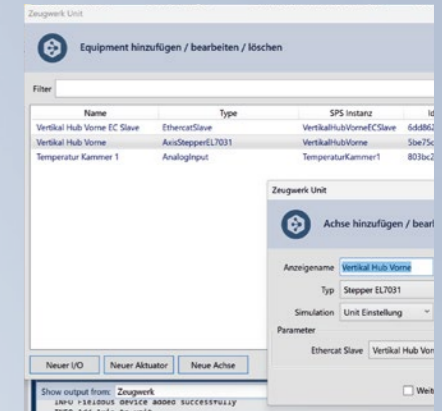
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Beckhoff Automation expands in Rheda-Wiedenbrück, Germany

Extra room for growth

The Verl-based company is planning to move into a new central warehouse in the Aurea industrial park in Rheda-Wiedenbrück near its headquarters to expand its logistics capacity. The strong sales growth in recent years and the positive outlook for the future mean that Beckhoff needs to expand its warehouse capacity extensively and sustainably.

In addition to its construction projects near its corporate headquarters in Verl, Beckhoff is planning to build a logistics and production facility of around 70,000 square meters in neighboring Rheda-Wiedenbrück. About 25,000 square meters of the hall will be fitted with high-rack shelving. The building is being developed by real estate investor and builder Dietz AG in coordination with Beckhoff and will be leased by Beckhoff on a long-term basis. "We are pleased to have Dietz AG, a competent partner with a great deal of experience in the field of logistics, at our side. We are currently in the joint planning phase. The building will be completed, and we will move into it by the end of 2025," reports Hans Beckhoff, managing director and owner of Beckhoff Automation. The space was brokered by logistics real estate consultant Logivest.

Central shipping from the end of 2025 in Rheda-Wiedenbrück

The Beckhoff central shipping department will be relocated to the new property. This department will be supplied with finished products from all Beckhoff production areas. "All European customers receive their ordered products directly from the central warehouse. Outside Europe, our branches and distributors are supplied from the central warehouse," explains Johannes Beckhoff. Frederike Beckhoff adds: "We usually offer our customers fast delivery of products directly from the warehouse, with the shortest delivery times. This requires storage capacity, which we are providing with the new central warehouse which allows for potential growth over the coming years."

Beckhoff Automation is a family-owned company that is growing: with additional capacity for a new central warehouse in Rheda-Wiedenbrück. Together, Hans Beckhoff (r.) and his children Frederike (m.) and Johannes (l.) take care of the expansion of the company.

Planning continues for new buildings in Verl and Rietberg

In parallel, Beckhoff continues to plan the expansion and new construction of its production facilities in the emerging Varesell intermunicipal industrial park, which will be directly adjacent to the company's current headquarters in Verl-West. The planned administrative campus is also set to be built on Gütersloher Strasse. "With the new property in Rheda-Wiedenbrück, we are now gaining considerable additional space to complement our production as well as administration campuses in Rietberg and Verl. This will also help us to further develop our company at the East Westphalia-Lippe site in the future. We will only be able to meet the ever-increasing demand for automation if we have the space we need to do so," Johannes Beckhoff continues.

Automation technology assures progress and prosperity for society

Beckhoff was founded in 1980 and has grown continuously ever since. Since 2000, the company has increased sales by an average of 15 percent every year. In 2022, Beckhoff generated sales of 1.515 billion euros with its workforce, which now numbers around 6,000 worldwide. Beckhoff intends to continue on this growth trajectory in the future. The chances for this are good, because high-tech automation concepts are needed in order to meet the needs of the growing world population in a resource-saving and sustainable way, and Beckhoff achieves this with its products. State-of-the-art automation technology from Beckhoff is used in almost all industries: classical mechanical engineering, wind turbines and battery cell production, the process and entertainment industry, and intelligent building automation are just a few examples.

More information:
www.beckhoff.com



Hendrik Wüst, Chief Minister of North Rhine-Westphalia, in the primary manufacturing (PCB assembly) department at Smyczek, a Beckhoff Automation Group company.



Hendrik Wüst, Chief Minister of North Rhine-Westphalia, came to Beckhoff Automation in Verl on August 30, 2023, to learn about PC-based control technology and how it forms an excellent foundation for new future technology, allied with artificial intelligence.

Industrial AI applications from Verl

NRW Chief Minister Hendrik Wüst visits Beckhoff Automation

As part of his summer tour, Hendrik Wüst, Chief Minister of North Rhine-Westphalia, visited Beckhoff on August 30, 2023 to learn about the industrial application options for artificial intelligence and the significance of automation for current sociopolitical challenges.

Automation's central role as a fundamental cross-cutting technology for the manufacturing industry was emphasized by Hans Beckhoff, Managing Director: "Automation plays a vital role in this era of transformation, as production processes need to be optimized so that less material and energy are consumed while productivity is simultaneously increased."

Automation: Engineers must save the world with high-tech solutions

Current sociopolitical challenges clearly show how important automation technology is for virtually everyone. Both climate change and our political dependence on fossil fuels are prompting the drive to find alternative concepts for energy generation, storage, distribution, and much more besides. What's more, creative technology has to be used to develop new solutions for dealing with limited raw material availability. "As we say at Beckhoff, 'Engineers must save the world!' Our mission is to develop products and automate production processes so that they consume less raw materials and less energy than they

did previously and make all manufacturing processes more efficient," explains Hans Beckhoff.

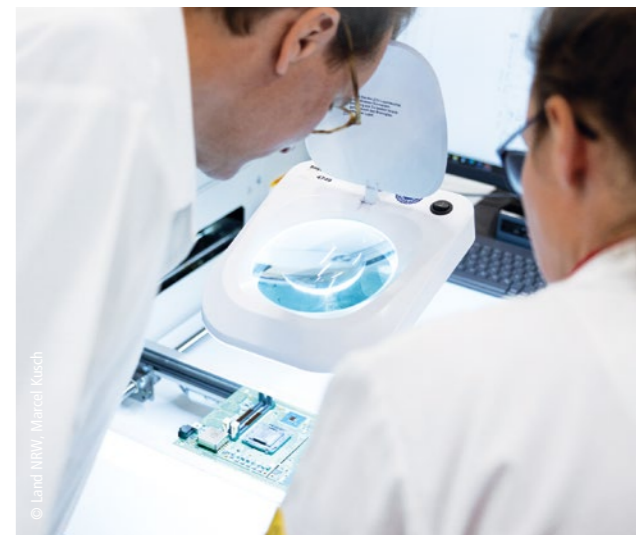
High-tech solutions are a crucial factor in the emergence of new and sometimes revolutionary automation in two respects. Beckhoff PC control technology integrates IT and automation into a powerful platform, thus combining the best of both worlds in a high-performance control system right on the machine. This formula for success has become popular with users worldwide and constitutes an excellent foundation for new future technology, allied with the implementation of artificial intelligence.

Beckhoff drives these developments with over 500 development engineers and manufactures the resulting automation technology products, such as industrial PCs, drive amplifiers and motors, I/O systems, cameras, and much more in Germany, with 90% of production being completed locally in Ost-westfalen-Lippe.

Beckhoff Automation with AI

The concept of AI is already firmly anchored in many areas of Beckhoff automation technology. In fact, TwinCAT Speech was introduced as early as 2018 as a speech input and output tool powered by deep learning technology. Just a year later, an integrated machine learning solution seamlessly became part of the TwinCAT automation software, providing machine builders with the optimal foundations for enhancing machine performance. Beckhoff also uses this solution in-house to handle tasks such as highly complex path calculations in the XPlanar motor drive system for floating product transport within machines and systems. The latest example of industrial AI implementation can be found in TwinCAT Chat, which was presented at Hannover Messe 2023. This tool allows large language models such as ChatGPT to be used for more efficient control programming.

Hendrik Wüst, Chief Minister of North Rhine-Westphalia, inspects the cutting-edge production technology in primary manufacturing for Beckhoff control technology electronics at Smyczek.



The IEC honors Prof. Dr. Frank Schiller with the 1906 Award

Every year, the International Electrotechnical Commission (IEC) honors experts with the 1906 Award for special achievements in international standardization projects. Prof. Dr. Frank Schiller, a safety specialist at Beckhoff, was one of 38 German prizewinners honored with the award in September.

Only five experts worldwide in each field are nominated each year. Prof. Dr. Frank Schiller received this year's award in the "Industrial-process measurement, control, and automation" (TC 65) category. He was honored for his commitment as a functional safety expert over the past ten years, in particular to safety communication. As head of the German DKE/UK 914.1 committee, he plays a key role in working on the profiles for functionally safe communication systems.

The award recognizes his developed new model for calculating the quality of safety communication, which includes many types of faults previously only considered special cases and can be applied by simple modification of previous calculation methods. Furthermore, it enables safety to be verified, even if security algorithms are used. Prof. Dr. Frank Schiller has thus made an important technical contribution to the IEC 61784-3 series on safe fieldbuses and their latest developments with extended models and equations. His contribution is critical to establishing the scientific basis for the current content of IEC 61784-3.

"I'm very proud to receive this year's IEC 1906 Award; it's a real honor. The award recognizes my work within the IEC and acknowledges my efforts in the field of safety communication. Only five experts in my field are nominated each year worldwide, and that makes this award all the more significant for me. I am grateful for this award and will continue to work passionately on the global development of international safety standards," Prof. Dr. Frank Schiller commented.

More information:
 IEC Award 1906: www.iec.ch/awards
 Safety over EtherCAT: www.ethercat.org/safety
 TwinSAFE: www.beckhoff.com/twinsafe



Prof. Dr. Frank Schiller, safety division expert at Beckhoff, is pleased to receive the IEC 1906 Award 2023.



Some 41 school leavers are embarking on their professional future at Beckhoff in Verl, welcomed among others by Frederike Beckhoff (second from left), assistant to the management.

Beckhoff journey begins for 41 apprentices and 30 students



A total of 30 first-year students were welcomed to the start of their work-integrated study program at Beckhoff by staff members including Frederike Beckhoff (second from right) and Dr. Ursula Frank (left), Project Manager R&D Cooperations.

For 41 apprentices and 30 students, August 2023 marked the start of an exciting professional career at Beckhoff, the automation specialist from Verl. Including this new intake, the company currently employs a total of 117 apprentices and 101 students.

Beckhoff provides recent school leavers with excellent preparation for their chosen future careers in the world of technology. "As the global leader in PC-based control technology, we offer young individuals a dynamic work environment filled with exciting prospects," says Frederike Beckhoff, Assistant to the Management at Beckhoff. She adds, "Our commitment to training on the job, a successful approach we've maintained for over thirty years, is evident in the substantial number of apprentices we engage. Consistent on-the-job training has proven to be a very successful training model for more than thirty years. By actively participating in live projects from day one, our apprentices become integral members of their teams and are able to experience for themselves exactly what their work achieves."

After successfully completing their training, junior employees are offered exciting long-term career prospects and the opportunity for specialization across all areas of the company. "The dual training program provides the ideal foundation for a successful professional future, serving as a valuable alternative to traditional university studies. Not only that, but the ability to count on well-trained and highly motivated talent from within our own company is a key success factor for Beckhoff, which is why we are so keen to invest in them," emphasizes Frederike Beckhoff.

The company offers apprenticeships in nine different fields (m/f/x each): electronics technician for automation technology, electronics technician for industrial engineering, electronics technician for devices and systems, industrial

electrician specializing in devices and systems, mechatronics technician, IT specialist for application development, warehouse logistics specialist, industrial management assistant, and media designer for digital and print media.

Starting out on the work-integrated study program
 For more than 10 years now, Beckhoff has been working in collaboration with Bielefeld University of Applied Sciences at the Gütersloh campus to provide work-integrated engineering training to young people with a passion for technology. Some 30 first-year students were welcomed by Frederike Beckhoff at the Verl headquarters at the end of August. "With the practice-integrated degree courses, we and all other participating companies can train the next generation of skilled workers to a high level, right here on site. This is hugely important for Gütersloh's technological businesses," emphasizes Frederike Beckhoff.

The consistently high number of students and the future-oriented focus of the Gütersloh Campus of the Bielefeld University of Applied Sciences serve to highlight the success of this training model. Involving students early in engineering workgroups, as well as engaging them in concrete projects and work processes, creates a real sense of accomplishment for these young individuals. Similarly, the opportunity to take on responsibility from day one makes them feel valued and bolsters their confidence to tackle challenging tasks. With intensive support provided by personal mentors throughout, standards remain high for the duration of the study program.

Beckhoff offers study places on five different degree programs: Mechatronics/Automation, Industrial Engineering, Product Service Engineering, Digital Technologies, and Digital Logistics.

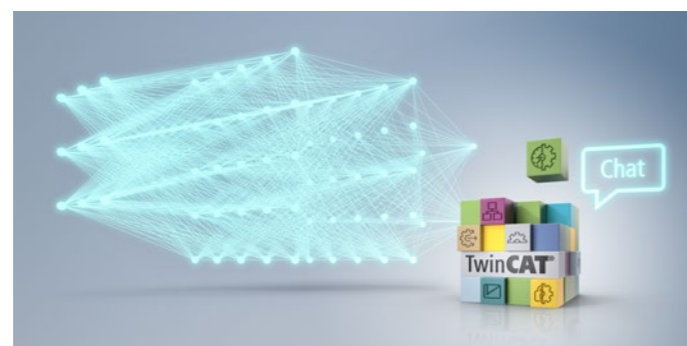
More information:
www.beckhoff.com/students



Beckhoff at SPS 2023

From November 14 to 16, 2023, Nuremberg's SPS (Smart Production Solutions) exhibition will open its doors once again. Beckhoff will be taking the opportunity to showcase its full spectrum of smart and digital automation with PC-based control. In addition to a host of product innovations and exciting technology demonstrations, the pluggable MX-System solution for control cabinet-free automation and industrial AI usage, e.g. with TwinCAT Chat, are set to be highlights of the Beckhoff trade show presence at Booth 406 in Hall 7. The event will also be covered by the popular Beckhoff Live + Interactive live-stream, which will be broadcast daily from 10:00 a.m. right from our booth.

More information, tickets, live TV:
www.beckhoff.com/sps



Introduced brand new this spring, TwinCAT Chat will now also be at the SPS to experience how Large Language Models, such as ChatGPT from OpenAI, enable more productive control programming with AI-assisted engineering.



The exceptionally flexible ATRO modular industrial robot system allows users to configure the right robot kinematics for any application – with an internal media feed for data, power or fluids and endlessly rotating axes.



As a modular system for totally control cabinet-free automation, the MX system cuts down engineering, assembly, installation and maintenance effort, thus enabling highly efficient processes for manufacturers and operators of machines and systems.



XTS and XPlanar are solutions for intelligent product transport – as a linear system or for floating 2D transport with up to 6 degrees of freedom – and enable flexible motion profiles and new types of machine concept.



With the comprehensive vision hardware spectrum to supplement TwinCAT Vision software, a complete image processing solution is available that is EtherCAT-based and system-integrated, providing users with significant competitive advantages.

Secrets to success: innovation, reliability and excellent support

What are the secrets to success for Beckhoff Automation? Technological innovations, high levels of reliability, and great support. In an exclusive interview with Ronald Heinze, editor-in-chief of Open Automation, Managing Director Hans Beckhoff provides insights into current economic developments and introduces a whole range of new products as well as further developments that will be presented at the SPS 2023 trade show.



Hans Beckhoff, owner and managing director of Beckhoff Automation:

“For 2023, we expect another successful fiscal year with growth up in the double digits.”

In today's era of technological innovation and digital transformation, companies that specialize in automation and innovative solutions have become true leaders in the industry. Beckhoff Automation is one of these pioneers, setting itself apart with its outstanding achievements and long-term success. With a remarkable history dating back to 1980, Beckhoff has revolutionized the way we look at automation and control systems.

“It's difficult to make predictions in times like these,” says Managing Director Hans Beckhoff, but he is pleased that there is likely to be positive business growth to report for Beckhoff Automation in 2023. He forecasts that sales trends will be up in the double digits, but also points out that incoming orders have decreased drastically and that he expects development to be significantly weaker next year. For Beckhoff, this is an international phenomenon, not something specific to Germany.

Hans Beckhoff goes on to explain that the previous sharp rise in incoming orders led to a bubble in the order backlog, as is typical, but this is starting to fall back again this year. There are various reasons for this drop in orders, including shorter delivery times and a reduction in stock levels as customers had built up reserves due to parts shortages – a global effect, according to Hans Beckhoff. He is convinced that this will be offset in the first quarter.

When it comes to the various industries, the managing director explains that most customers in machine building are optimistic about the future. The process industry is also showing positive signs for Beckhoff, especially in new areas such as the hydrogen economy, where the company engages in many projects. However, Beckhoff is seeing a reluctance to invest in the building automation market.

The Chinese market, which is very important to Beckhoff, is expected to show less growth in 2023 than in the past. “We believe in China and want to continue investing there,” he continues. “Up to now, we have produced all our products for the Chinese market in Germany. Now we are planning to manufacture directly in China as well.” Certain Beckhoff products are due to start being produced locally next year. Hans Beckhoff is an advocate of the notion of “change through trade” and sees China as an industrialized country with a huge domestic market. The company is preparing for the increasingly fierce Chinese competition and

has launched special development projects for products on the Chinese market. Hans Beckhoff expects this competition to be exciting and is optimistic about future prospects in China.

A combination of success factors

It is rare to find an automation company that can show such sustained success as Beckhoff Automation. But what is the secret to this success? Physics graduate and company founder Hans Beckhoff's answer is fascinating: “We are a technology company and our technical ‘revolutions’ are the reason we are where we are today. What's more, automation is a compelling matter – it's highly technical, yet extremely human. Good cooperation between suppliers and users is just as crucial when it comes to advancing innovative technology together.” For Beckhoff, its long-term relationship with many customers is another key to joint market success.

Over the years, Beckhoff Automation has launched an impressive series of technological revolutions every five to seven years. These milestones include PC-based control itself, TwinCAT, bus terminals, EtherCAT, embedded PCs, XTS, XPlanar, and the current MX-System. Hans Beckhoff is extremely enthusiastic about these achievements: “Each of these technological innovations has brought us new customers. Our customers appreciate the fact that they can always rely on innovations from our company. If an electronics supplier does not promote development, this blocks innovation and hinders its customers' market success. We want to encourage our customers to drive technology forward with us and therefore come out on top in the market.”

However, the managing director emphasizes that it is not enough to offer great technology – you also need to be able to sell it successfully. Beckhoff Automation has therefore also developed a global customer-focused sales organization supported by local engineers. Around 2,200 of the company's more than 6,000 employees now work in sales or sales-related areas.

In short, the secret to Beckhoff Automation's success is the combination of technological innovation, a high level of reliability, and first-class customer support. Hans Beckhoff adds: “When it comes down to it, we combine traditional family values with openness. We advocate an open and fair way of working with one another.”



Hans Beckhoff:

“Good cooperation between suppliers and users is crucial when it comes to advancing cutting-edge technology together.”

In addition, the entire company is committed to making the world a better place through technology. “Our motto is: Engineers must save the world,” emphasizes Hans Beckhoff. The company takes this principle very seriously, because only through technological innovations will it be possible to create a sustainable world in which prosperity is possible for everyone.

Continuous expansion of customer service

Beckhoff Automation’s international sales network is constantly being expanded. New sales offices were recently opened in Lithuania and Estonia to strengthen the company’s presence in these regions. However, due to political developments, the subsidiary in Russia had to be closed. According to Hans Beckhoff: “We have opened additional sales offices in various countries and as sales numbers increase, so does our international workforce.”

The next expansion plans are now directed at the African continent. At the moment, Beckhoff is only represented with subsidiaries in Egypt and South Africa, which have significant machine building industries. “We plan to expand our presence in Africa by opening more subsidiaries,” explains Hans Beckhoff.

The ambition to drive automation technology forward is evident again this year at the upcoming SPS trade show, where many new products and innovations from all of the company’s product areas of the company will be on show.

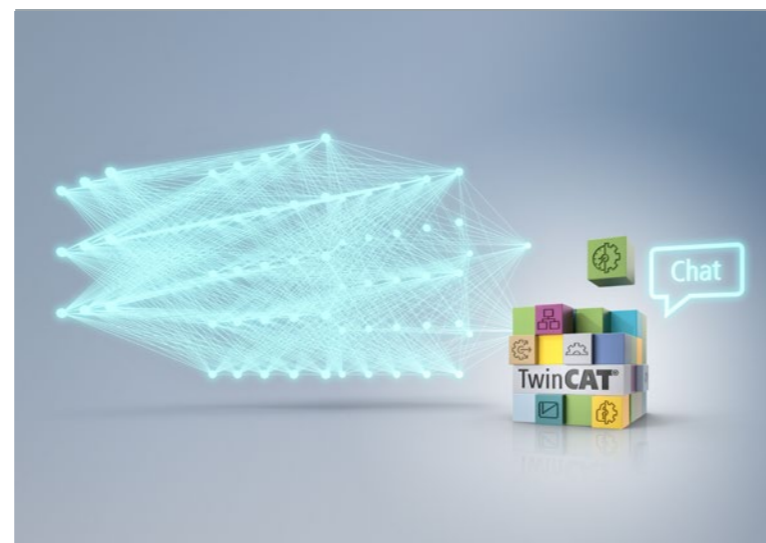
Automation software with relevant further developments

One highlight at the SPS trade show will undoubtedly be the numerous TwinCAT innovations. “We will present the highly anticipated Build 4026, which brings a wealth of new performance features, an optimized internal structure, and

innovative control features,” announces Hans Beckhoff. There is a big focus on the user mode runtime for Windows, which allows multiple runtime versions to be run simultaneously on a single PC, making it particularly useful for system simulations.

“We are also presenting the next generation of our motion control software, which will offer multi-core and multi-tasking support and bring with it a 30% increase in performance,” he enthuses. He adds: “Once again, we are pushing forward the limits of performance. As a result, applications in which 100 axes and more are correlated and moved in hard synchronization are possible –

TwinCAT Chat opens up a new world of chatbot possibilities for control engineering.



completely effortlessly. This innovation shows the full strength of calculating all motion sequences centrally.” And that’s not all – the new performance package can be used in parallel with existing TwinCAT Motion solutions.

“TwinCAT CNC, which is increasingly being used in machine tools, is also doing very well,” emphasizes Hans Beckhoff. “This was also demonstrated at the last EMO in Hanover.” More and more machine tool manufacturers are using TwinCAT CNC, including for traditional metalworking machines. TwinCAT 3 CNC Milling now provides a comprehensive package of different CNC cycles for three-axis milling and drilling for this purpose. It facilitates programming for these machines by encapsulating the required processes in parameterizable and reusable modules. The new CNC cycle package supports a variety of different drilling strategies, ranging from simple centering and deep hole drilling to helical milling, tapping, and thread milling. These can also be combined with the included cycles for drilling patterns to facilitate efficient programming for multiple drilling in various arrangements.

TwinCAT is the universal platform from Beckhoff for all aspects of automation technology and the company will exhibit both minor and major advances in nearly all areas at SPS, including TwinCAT HMI. “For this, we are presenting an audit trail that meets the requirements of FDA 21CFR for applications in the pharmaceutical and food/beverage sectors,” the managing director continues. “However, this can also be used in other industries, for example, to securely log changes to machine parameters.”

The use of AI

Hans Beckhoff tells us about the ongoing improvement of the integration of Large Language Models (LLMs) such as ChatGPT in TwinCAT. This also opens up new areas of application: For example, it can now be used to create TwinCAT HMI projects automatically. The usability and features for PLC programmers have been significantly improved. “We have further optimized and refined the integration of ChatGPT into engineering,” explains Hans Beckhoff.

He emphasizes that the outcome of a ChatGPT response depends largely on the wording of the question, which is known as prompt engineering: “It’s about

TwinCAT 3 CNC Milling Base simplifies the programming for drilling and milling machines into a comprehensive cycle package with parameterizable and reusable function blocks.



incorporating targeted information into the question. To make this easier for our users, we’ve included pre-written commands and questions in ChatGPT.” This approach is constantly being developed.

Specifically for machine learning, the C6043 ultra-compact Industrial PC is equipped with state-of-the-art Intel® Core™ processors and an external, factory-fitted GPU/graphics card with highly parallelizing GPU/graphics chips. According to Hans Beckhoff: “This can be used to implement highly complex AI tasks; our GPU-based solution is about 18 times faster than a conventional Windows computer.”

Control cabinet-free automation: samples now being delivered

“For our MX-Systems for control cabinet-free automation, we will be presenting the three-row system design with a corresponding baseplate as the basis at this year’s trade show,” Hans Beckhoff tells us. Specific function modules include the main switch with an infeed of up to 125 A, the supply module with 600 V DC and up to 40 A, and the axis module with a nominal current of 28 A. “At the trade show, we will demonstrate how a large control cabinet can be divided into several MX-Systems, among other things,” he explains. “Earlier this year, we introduced the option to integrate pneumatic modules from Festo and SMC, as well as 48 V power supplies with 40 A and connections for AMI, XTS, and ATRO,” he adds.

“We are also thrilled that we can now deliver samples of our control cabinet replacement system to customers,” underlines Hans Beckhoff. “The EMO trade show in particular, which has just ended, has once again highlighted the huge amount of interest in this system. Machine tool manufacturers also recognize this disruptive innovation and what it can mean for their machines.”

IPCs at the heart of the PC-based control philosophy

Together with associated software, industrial PCs in different shapes and forms are at the core of a wide range of diverse automation tasks such as control of machines, processes or logistics systems, networking of system components, data acquisition, or image processing. IPC company Beckhoff provides industrial PCs and panel PCs for all applications. It’s probably the only company out there

The MX-System has a highly modular design and can now be even better adapted to the respective application with the three-row baseplate and corresponding function modules.



to launch innovations for industrial computers this consistently. And 2023 is no exception.

Hans Beckhoff starts his list of IPC innovations with a promising announcement: "With the introduction of the new CPU generation on Intel Atom® Elkhart Lake motherboards, we will significantly increase the performance of our compact embedded PCs." These motherboards will serve as the standard for small controllers from now on and Elkhart Lake will be the new Atom® platform for CX, IPC, and MX. The performance is expected to increase by 20 to 30% compared to Apollo Lake. These computers will have two or four cores and offer significantly improved graphics.

For IPCs, the phased introduction of the next CPU generations will be completed at the beginning of 2023. By the end of 2023, almost all IPCs and panel PCs will be equipped with a new motherboard generation.

One real highlight is the Speed Shift technology, which is available for all IPCs with Intel® Core™ i-CPUs from the 11th to 13th generation. "Speed Shift makes it possible to switch one or even two processor cores from their master clock to the turbo clock frequency in real time," explains the physics graduate. "This is a really good feature of our products. The result is the ability to run individual fast programs on the appropriate core."

The compact C60xx industrial PC series has a new addition in the form of the C6043 model. This is not only equipped with 12th and 13th-generation CPUs but will also feature an MXM slot for integrating corresponding GPUs/graphics cards. The aim is to integrate GPUs/graphics cards ex factory, which is particularly beneficial for machine learning and XPlanar applications. The company owner claims: "The C6040/43 series boasts exceptional performance in a very compact design, while offering excellent value for money. High speeds for demanding industrial applications!"

Hans Beckhoff:

“At the SPS trade show, we will be presenting the MX-System with a three-row baseplate for the first time and demonstrate how a large control cabinet can be divided into several MX-Systems.”



Moreover, series production of the CX5620 Embedded PC with a 2-core AMD R1000 CPU running at 1.2 GHz and the CX5630 with a 2-core AMD R1000 CPU running at 2 GHz will start in October. These embedded PCs come above the Atom® series in terms of price and performance, in the same sort of ballpark as the CX2033, according to Hans Beckhoff.

Expanding the signal variety in the I/O range

The extensive Beckhoff I/O portfolio includes products for all application areas and environmental conditions. Beckhoff Automation will also present an impressive range of innovations in this area. "We now offer the PS97x1 DC/DC converters specifically for battery-powered systems in the 24/48/750 V range that can be converted to 24 V," Hans Beckhoff tells us. The company is also introducing the cost-effective EL4374 analog EtherCAT multi-functional terminal, which offers two analog inputs and outputs each with 10 V/20 mA.

"We are constantly expanding our range of EtherCAT plug-in modules and terminals, especially in the TwinSAFE SC portfolio," says Hans Beckhoff. "With this TwinSAFE single-channel technology, it is possible to use standard signals for safety tasks." The EJ5101-0090 plug-in module, for example, is specially designed for 5-V differential encoder signals. The EL3314-0092 terminal makes it possible to connect thermocouples with galvanic isolation between the channels. In addition, speed measurement has been integrated into the EL5001-0090 (SSI master) and EL5031-0090 (EnDat 2.2 interface) terminals.

In the IP67 range, the EP6224-0092 TwinSAFE SC Box module – a 4-channel IO-Link master – deserves a special mention. The new IP67 products include the EPP6224-0522 EtherCAT P Box, which is a 4-channel IO-Link master with timestamp and eight digital I/Os. "The precise EtherCAT timestamp can be used when synchronizing sensors via IO-Link," emphasizes Hans Beckhoff. The new EP3751-0260 digital I/O box has an integrated gyroscope. Besides the low-noise 3-axis accelerometer, its additional sensor (acceleration, direction of

rotation) makes it possible to detect complicated movements, for example for AGVs, cranes, and robotics. "This is another step toward integrating modern sensor technology into the industrial environment," adds the physics graduate. As the successor to the EP9300-0022, the EP9320-0022 I/O box acts as a gateway to PROFINET networks, thereby supporting the openness of PC-based control.

IT/OT convergence: understanding manufacturing and machines better

"The introduction of IoT and Industrie 4.0 represented a groundbreaking decision," Hans Beckhoff points out. The activities related to this, some of which are state-sponsored, have massively advanced the integration of IT and automation technology. This feels like home ground for Beckhoff Automation, having had PC-based control technology in its product range since 1986. "So this development was not necessarily new for us," he adds. "Integrating IT and automation has been standard practice at our company for a long time now. Nevertheless, this development has shown positive results." Nowadays, seamlessly connecting IT and automation is considered to be the cutting edge.

IoT has undoubtedly also made a positive contribution to business growth at Beckhoff. "Our smaller IPCs in particular are often used as IoT gateways," says Hans Beckhoff. He sees great potential for IoT applications in the actual production control logic: "Providing macroscopic modeling data for optimization is a promising approach. However, this data usually comes as aggregated data from the control and is not derived directly from the individual sensor, from the PC in our case, which can therefore easily take over the edge function."

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More information:

www.beckhoff.com/sps



AL8000 linear motors with One Cable Technology

Motion innovations at SPS

Beckhoff will present a wealth of exciting new products in the Motion division. These include the ASI8100 stepper motors for NEMA 17 protection, which have integrated electronics. "These stepper motors complement our AMI8000 integrated servomotors and are priced lower," the company leader explains. "With their EtherCAT P connection, they can be seamlessly integrated into EtherCAT-based systems."

Hans Beckhoff also tells us about the new AM83xx-series water-cooled motors with up to 274 Nm standstill torque. "These powerful motors allow two to three times more torque than convection-cooled variants," he states.

The new AX8820 regenerative power supply unit for 7 kW is being introduced for the AX8000 and AX5000 Servo Drives. By connecting these units in parallel, up to 21 kW of power can be achieved and stored in the DC link. All necessary inductors and filters are already integrated. "The regenerative power supply is sinusoidal and significantly reduces grid distortion," explains Hans Beckhoff.

Another highlight is the new AX8128 axis module with silicon carbide power amplifier. The modern power amplifier technology reduces power losses and therefore enables an extremely compact design with a module width of only 60 mm. With a nominal current of 28 A and a peak current of 50 A, this drive system offers impressive performance.

The AL8000 linear motors are now equipped with an integrated OCT (One Cable Technology)-compatible EnDat 3 encoder. "The encoder head is pre-aligned and mounted directly on the coil unit, and an OCT cable connects the linear motor and sensor to the amplifier," notes Hans Beckhoff. As a result, only one cable is required for the power supply, the feedback system, and the thermal sensor.

New tiles will be presented for the XPlanar system, including the APS4244 XPlanar tile measuring 320 x 320 mm, which enables 2-track operation for APM43x0 XPlanar movers and therefore cost savings in this mode. New is also the APS4242 XPlanar tile for 1-track operation of the APM43x0 XPlanar mover. These new tiles offer improved precision through higher sensor density, reduced minimum mover spacing due to the optimized coil design, and integrated Safe Torque Off (STO). In addition, the powerful integrated power supply provides greater dynamics.



Interview with Martin Rostan on 20 years of EtherCAT and the EtherCAT Technology Group

Powerful and future-proof technology plus an active community

EtherCAT offers numerous technological advantages, but it has also benefited immensely over the past two decades from the disclosure of the protocol and the foundation of the EtherCAT Technology Group (ETG) related with it. In the following interview, Martin Rostan, Executive Director of ETG, describes the most important aspects of these two sides to the EtherCAT success story.



Martin Rostan, Executive Director of EtherCAT Technology Group:

“While the technology and its user benefits are certainly in the foreground, the extraordinarily dedicated team of the EtherCAT Technology Group also contributed strongly to the success of EtherCAT.”

20 years of EtherCAT – how did it actually start back then?

Martin Rostan: Beckhoff had already launched the Lightbus in 1989, an optical fiber-based bus system for fast communication with input and output modules. The Lightbus had a transmission rate of 2.5 Mbit/s and already used the principle of processing on the fly. At the end of the 90s, considerations began to develop a next generation of this fiber optic technology with a higher transmission rate. The project name was FLB (Fast Lightbus). With 50 Mbit/s, this would have been significantly faster, but somehow we felt that something was still missing. This came with the idea of combining the Lightbus principle with Ethernet.

What is so special about the principle of processing on the fly?

Martin Rostan: Instead of sending a telegram to each network node in each cycle and receiving a telegram from each node, a single, correspondingly longer telegram is sent through all nodes and processed by them on the fly and thus almost without delay. Each node reads the output process data intended for it and inserts its input data into the same telegram. Since the network nodes have been informed beforehand where the respective process data is to be found in the frame, no node-related address information has to be carried along. Thus a bit remains a bit and does not become a whole frame. And this is how we achieve maximum efficiency: Typically, over 90% of the entire telegram is used for process data. So we use the bandwidth most efficiently – and since the same frame is used for input and output data, we usually even double the available bandwidth. This is why EtherCAT achieves such high performance.

Keyword “performance”: EtherCAT is often referred to as the fastest fieldbus solution. But why is that so important?

Martin Rostan: For every control engineer, it is obvious that shorter cycle times mean better control quality and thus ultimately lead to better product quality: this applies to all applications with a motion control component, but also to measurement tasks. Thanks to PC-based controllers, computing power is no longer a bottleneck – now the bus system is usually the limiting factor, and exactly for this reason, the performance of the bus system has become increasingly important. Anyone who combines a control system that can handle cycle times in the sub-millisecond range with a bus system that cannot keep up is doing something wrong. It is less obvious how much all applications with so-called transition conditions benefit from the shorter cycle times with EtherCAT and thus from faster response times: Even if the controller only has to wait a few milliseconds at a time for a sensor signal confirming that a part has arrived or a target position has been reached before moving on to the next process step: reducing these small waiting times is worthwhile and leads to measurably better efficiency and more machine throughput.

That’s some sophisticated technical reasoning: do users go along with it?

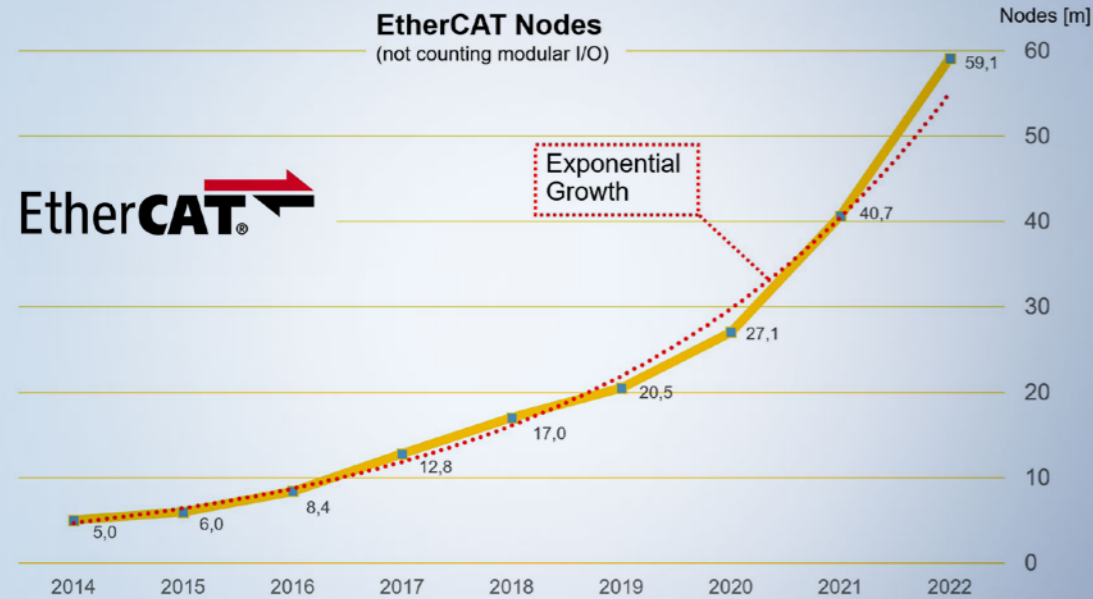
Martin Rostan: It’s true that with EtherCAT, we go much deeper into the technical argumentation than is usual with most fieldbus organizations. But that is exactly our approach: convince users with convincing technology. And that is what gives engineers particular pleasure. When we presented EtherCAT for the first time at Hannover Messe in April 2003, we were not able to score points with a large user organization, nor was Beckhoff at that time already one of the large suppliers of automation solutions. And so we explained the special features of our new technology and initially won over those users who were quickest to recognize the benefits of the exceptional performance of EtherCAT.

And then founded the EtherCAT Technology Group with these users?

Martin Rostan: Correct. Of the 33 founding members of the ETG, half were users, not manufacturers of automation systems, and they were usually considered technology leaders in their industry. In other words, companies that were used to be convincing with convincing technology. Of course, it also helped to overcome the chicken-and-egg problem to start with users right away.

The chicken-and-egg problem?

Martin Rostan: Yes, that’s exactly one of the challenges when introducing a new technology: the vendors only implement the technology when users ask for it. And users can only be won over when there are suppliers for the corresponding devices. Another challenge was that we did not have any cost-effective EtherCAT chips at the beginning, but had to work with FPGAs, which were still very expensive initially. An EtherCAT interface still cost a lot of money at that time. With the availability of the first EtherCAT ASICs in 2006, however, the problem was solved quickly. In the meantime, these chips are available from 13 different manufacturers and the interface costs are lower than those of



In 2022, 18.4 million EtherCAT chips were sold, bringing the total number of EtherCAT nodes – not counting bus terminals – to 59.1 million with exponential growth.

classic fieldbus systems, not to mention other industrial Ethernet solutions. And with EtherCAT, one standard Ethernet port in the controller is sufficient, which has helped us a lot in spreading the technology.

Speaking of popularity: on the occasion of 20 years of EtherCAT, the ETG has published figures for the first time, and they differ significantly from the known market studies. Why?

Martin Rostan: Precisely because we have now published our figures for the first time. We were reluctant to do so for two reasons: initially, FPGA-based devices dominated, and we did not know their quantities. And we could not yet count or leave out the modular devices, i.e. the EtherCAT terminals – after all, it would be misleading to count a modular I/O station with 50 electronic terminals as 50 EtherCAT nodes, even if these are actually 50 EtherCAT nodes. In the meantime, however, these bus terminals use special chips, and we assume the share of FPGA-based devices to be less than 10 percent, so that the fuzziness in our numbers does not matter. And so we arrive at almost 60 million EtherCAT devices, without counting the bus terminals. And that should mean market leadership.

And with over 7,000 member companies, the ETG is also the world's largest fieldbus association. How has this come about?

Martin Rostan: While the technology and its user benefits are certainly in the foreground, the extraordinarily dedicated team of the EtherCAT Technology Group has also contributed strongly to the success of EtherCAT. After all, the tech team not only coordinates the technical working groups, writes specifications

and represents EtherCAT in the various standardization bodies, but above all supports our members in implementing the technology. This means tech support and workshops as well as regular interoperability meetings, so-called plugfests, which we hold worldwide. Our members highly appreciate the quality of our implementation support, and also actively contribute to it in the very comprehensive developer forum in the members' area of our website. The marketing team is equally committed to organizing high-quality trade show booths and technology seminars, which we have now held in over 50 countries. At the beginning, I would not have thought that 1,000 member companies would be possible to achieve – and so far, growth is still not slowing down. Meanwhile, almost 500 new member companies are joining every year.

And this is all organized from Germany?

Martin Rostan: Although the headquarters of the EtherCAT Technology Group is in Nuremberg, Germany, we have offices in China, Korea, Japan and the USA, which operate pretty independently and support the members locally. Over 3,000 member companies from Asia show that EtherCAT is also a leader on this continent. And with over 1,000 members in the Americas, the ETG is the fieldbus association with the largest membership there as well.

There is a lot to celebrate. And certainly one or the other special EtherCAT application is part of it.

Martin Rostan: Yes, of course, some EtherCAT applications are particularly rewarding. For me as a sailor, the high-tech yachts of the America's Cup are among them, all of which use EtherCAT. And since I am an aerospace engineer,

Martin Rostan:

“The performance of EtherCAT is often highlighted, but the special functional principle offers far more advantages – from automatic addressing of network nodes to highly accurate synchronization capabilities without the need for special hardware through to special diagnostic features.”

EtherCAT in space excites me. EtherCAT has already been used on the ISS and was selected for the robot arms on the Lunar Gateway space station. But EtherCAT also rides on tractors and helps with experiments that have won Nobel Prizes in physics.

Was EtherCAT selected for these applications only because it is so fast?

Martin Rostan: No. The performance of EtherCAT is often crucial, but our special functional principle has many more advantages. For example, we can automatically address the network nodes during startup, which greatly simplifies commissioning. We can synchronize the nodes with high precision, even without special hardware in the controller. EtherCAT users do not need any IT know-how or specific switches, and therefore do not have to buy, install and configure them, nor are they limited by cascaded switches. Therefore we can therefore create line topologies with almost any number of nodes, but also branches, tree topologies and rings for line redundancy, and that without special redundancy nodes. And we have built special diagnostic features into the EtherCAT chips that help us not only to reliably detect bit errors and even loose connectors, but even to localize them. All this saves a lot of time and money.

How do the other industrial communication systems respond to the EtherCAT success story?

Martin Rostan: Yes, with Gigabit and TSN technologies the competition is trying to catch up with our performance advantage. But anyone who can do the math quickly realizes that the EtherCAT functional principle cannot be beaten



even with Gigabit: EtherCAT will continue to perform better even at 100 Mbit/s when realistic scenarios are compared. And for applications that actually require more bandwidth, the EtherCAT G technology extension is available. The more robust 100 Mbit/s technology, however, will not be replaced by EtherCAT G, but instead only supplemented. I assume that even in 15 years 95% of the EtherCAT devices will use 100 Mbit/s. This maintains the stability of EtherCAT: we have always only enhanced EtherCAT, we never changed it.

And how do you see the next 20 years for EtherCAT?

Martin Rostan: 20 years ago I boldly predicted that 10 years later EtherCAT would be number 2 in the market. Another 10 years later we are even further ahead. And I don't see any development that should change that. With EtherCAT G, we are enhancing our technology for application areas that require even more bandwidth and we are making EtherCAT future-proof. And when I look at the membership growth of the EtherCAT Technology Group: the end of the line is obviously far from being reached.

The interview was conducted by Stefan Ziegler, Editorial Management PR, Beckhoff Automation

More information:

www.ethercat.org

Interview with Thomas Rettig on
20 years of EtherCAT development

Technology, ease of use, and investment security as factors for success



The 20-year success story of the EtherCAT technology developed by Beckhoff continues and has established itself worldwide as a high-performance standard for real-time Ethernet communication.

Thomas Rettig, Senior Management Control System Architecture at Beckhoff, and EtherCAT Technology Expert at ETG:

“With Beckhoff’s extensive experience in other fieldbuses and communication systems, the stage was set 20 years ago for the development of a very stable protocol.”



The 20-year success story of EtherCAT is based on more than simply technical performance: Other major contributors include continuous further development without technological disruptions, user-friendly operation, and optimal diagnostic capabilities. As Senior Management Control System Architecture at Beckhoff, and EtherCAT Technology Expert at ETG, Thomas Rettig was happy to share his valuable insights and perspective in the following interview.

Thomas, looking back on two decades of EtherCAT development, how long have you been involved in this area at Beckhoff and what have been your main areas of focus over the years?

Thomas Rettig: I started at Beckhoff in 2002, originally as a hardware developer in FPGA/ASIC development. My role back then was to define and implement a new industrial bus system, which was initially known as Fast Lightbus. But as EtherCAT quickly established itself as a market standard thanks to its technical advantages and open protocol, I began to shift my focus toward technology management, implementation support, and training for both Beckhoff and ETG members in around 2008. Since 2015, I have been a product manager for EtherCAT technology, which includes EtherCAT development products such as EtherCAT Slave Controller ASICs and IP cores, software tools, and evaluation boards. Other aspects of my job involve looking at and evaluating new technologies for control architectures. These include new developments in the IEEE regarding Ethernet physical layers, and the properties and possible applications of the 5G mobile communications standard.

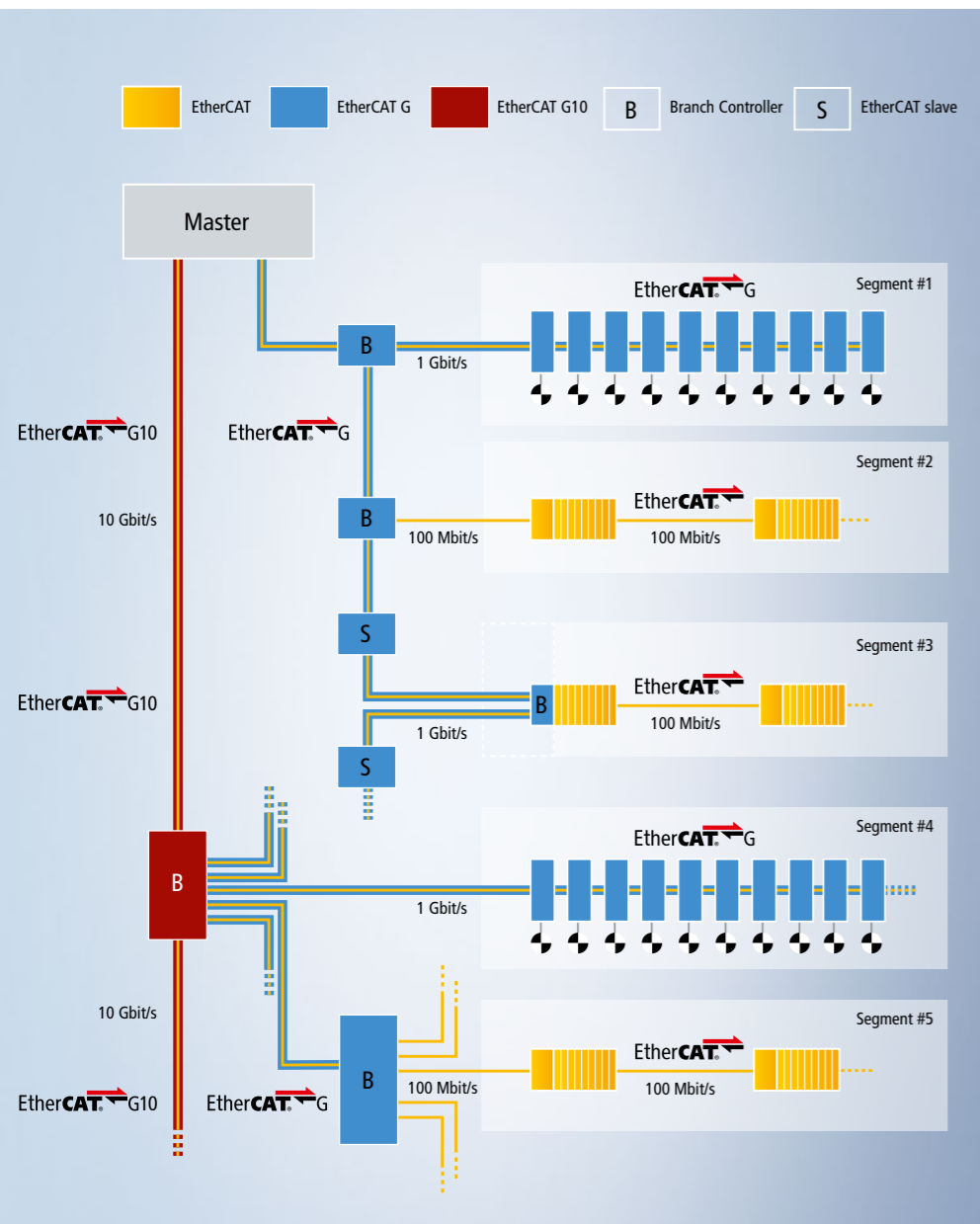
What technological features have proven to be core elements of EtherCAT through all these years?

Thomas Rettig: I would have to start with the capacity for telegram processing on the fly, which is one of the fundamental principles of EtherCAT technology. This is the only way to ensure that the high bandwidth of Ethernet can be effectively harnessed, typically requiring just one telegram for the many small information units from the numerous automation devices in a system – over 65,000 of which are possible in an EtherCAT network. Right at the heart of this is the Fieldbus Memory Management Unit (FMMU), which was developed by Beckhoff as one of the essential features of EtherCAT. This unit transforms an EtherCAT network into a single 4 GB address space. The mapping and subsequent organization of data from individual devices within this address space take place as part of the configuration process during network startup. These details are then written directly into the EtherCAT Slave Controllers of the

devices by the EtherCAT master. This saves up to 30 percent of the computing power on the master, which would otherwise require software to perform the copying operation. Another central feature of EtherCAT can be found in the distributed clocks, which introduced a defined and automatically synchronized system time for the communication system. Added to this are the advantages of the highly flexible, freely selectable network topology, which does not require any switches and is therefore associated with very low latency times. What’s more, it has virtually no effect on communication performance, regardless of whether the network is used as a long line or in a branched tree structure.

What other features do you see as development highlights of the last 20 years?

Thomas Rettig: The integration of functionally safe communication using the Safety over EtherCAT (FSoE) protocol was a sensible and necessary extension within the EtherCAT system. What’s more, the integrated approach, ‘lean’ protocol, secure logic, and safe actuators allow for the seamless integration of safety sensors such as light grids or laser scanners into the network, all while keeping system costs low. A functional standard controller does not have to be extended for safety purposes since it only needs to copy the FSoE data containers. As part of the ‘black channel’, it forms part of the communication layer that is considered non-safety-relevant. For motion applications, adapting the CiA402 drive profile to short-cycle, time-synchronous operation and the advanced features of EtherCAT provides significant advantages in terms of control quality in the (coupled) drives. Another significant development step was the introduction of the EtherCAT P one-cable solution, which integrates data and two independent 24 V DC power supplies into a standard four-core Ethernet cable. This technology was further expanded with the Beckhoff hybrid connector technology, allowing for additional higher voltages and currents within the same cable alongside an EtherCAT P core.



The branch concept allows EtherCAT, EtherCAT G, and EtherCAT G10 segments to also be operated in a mixed configuration, resulting in maximum communication efficiency within the overall system.

What EtherCAT features are worth highlighting in terms of engineering?

Thomas Rettig: The automatic scanning of the network and its topology including address assignments are major advantages from a user's perspective. When setting up a network, each connected device can be easily identified, and the additional information about the implemented and connected ports in each of these devices makes it possible to establish the network topology. Customers have reported that it took them a week to set and verify the IP addresses of all devices in large installations equipped with other bus systems. With EtherCAT, on the other hand, it was all done in a single click. The data storage on the

EtherCAT master also has a positive effect. Each time the system starts up, the application-specific configuration parameters are written from the master to the devices. This simplifies the process significantly in the event of a device replacement, as the system checks and detects whether the replacement device is of the same type and then automatically configures it correctly during startup.

Which properties enhance diagnostic capabilities?

Thomas Rettig: EtherCAT offers outstanding diagnostic functionalities at both hardware and software level. This allows for precise error localization in every cycle, narrowing down troubleshooting to a specific device or cable. There are telegram-specific cyclic error messages such as the working counter and lost frame counters, which help to monitor not only data consistency within the telegram, but also the data integrity of the telegram itself. For subsequent error cause analysis, the lost link counters indicate how often the link was lost at a port, and RX error counters show how often an error in a telegram structure was detected at a port. These counters are available in the hardware registers of EtherCAT Slave Controllers of the devices. Further errors are logged in the device firmware, which indicate information such as incorrect configurations by the master or the loss of synchronization with the EtherCAT master, leading to an error in the EtherCAT State Machine of the device. These errors are immediately reported to the master through status information and can optionally also be read via a diagnostic history object for further error analysis.

With a base protocol that has always remained the same, continually expanding while remaining 100% backward compatible, how has it been possible for EtherCAT to achieve such remarkable continuity over the past 20 years?

Thomas Rettig: With Beckhoff's extensive experience in other fieldbuses and communication systems, the stage was set right from the start for the development of a very stable protocol. In terms of protocol design, forward-thinking considerations have made it possible to accommodate future backward-compatible extensions.

Also, the smart division between hardware and software implementation has made it easier to introduce extensions without changing the protocol.

Future-proofing is crucial, especially when using a core technology like EtherCAT. What are the key factors that will continue to ensure this with EtherCAT?

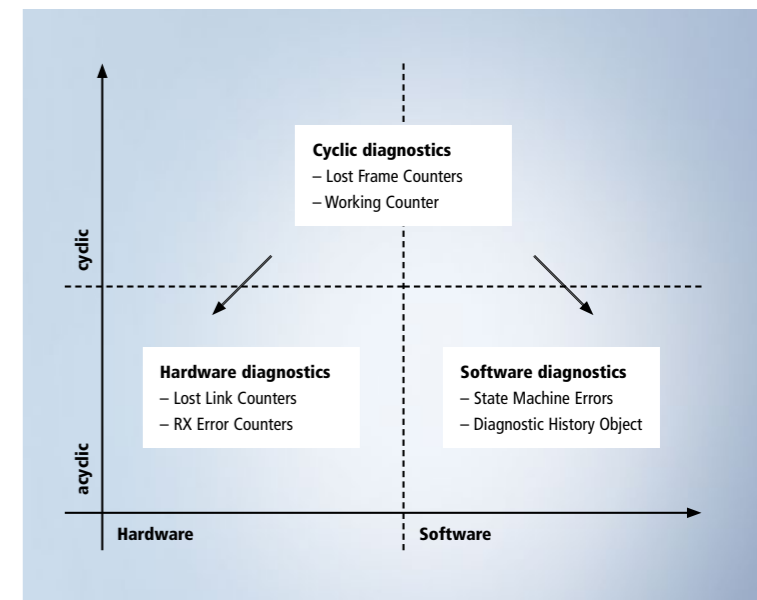
Thomas Rettig: With EtherCAT G, the next fully backward-compatible technology expansion is already on the horizon. This is set to address future high-end requirements without rendering the existing diversity of devices obsolete. As a result, customers can count on a high level of investment security, not least considering that the established EtherCAT technology based on 100 Mbit/s still provides sufficient performance for up to 99% of all use cases even today, 20 years after its introduction. EtherCAT is still the fastest Industrial Ethernet technology on the market, even compared to other 1 Gbit/s communication systems. Also, in addition to Beckhoff, there are now 12 other manufacturers of EtherCAT Slave Controller chips offering a wide range of options, with more joining the list. Many of these reputable manufacturers recognized very early on that EtherCAT is one of the most important technologies in the industrial automation landscape. It is also worth noting that Beckhoff will soon be launching a new EtherCAT Slave Controller ASIC (100 Mbit/s), based on the latest semiconductor technology and produced in more crisis-resilient areas. This demonstrates that, even after 20 years, Beckhoff continues to invest heavily in this core technology to ensure maximum supply security for both the company itself and its customers.

Future security also includes ongoing development and innovation. What main topics are the EtherCAT developers currently working on?

Thomas Rettig: I should definitely start by mentioning the new EtherCAT Slave Controller ASIC yet again. In addition to this, we are also expanding our IP core product range for FPGAs and expect to introduce an IP core for EtherCAT G next year. After experiencing delays due to the universally acknowledged component shortages, we are now so close to implementing the technology for the EtherCAT G Branch Controller in the form of the EtherCAT G Coupler EK1400. The pilot customer phase is set to commence no later than Hannover Messe 2024.

What exactly is behind the branch controller concept?

Thomas Rettig: For backward compatibility with existing technology, EtherCAT G devices revert to the 100 Mbit/s speed when operated in the same segment with 100 Mbit/s devices. This is beneficial in the sense that it ensures compatibility; however, it is not always ideal since it means not fully utilizing the high potential speed of 1 Gbit/s. The introduction of the branch controllers allows EtherCAT segments with different transmission speeds to be operated together. To this end, the branch controller is connected to the EtherCAT G segment and provides branch ports (junctions) to which EtherCAT or EtherCAT G segments can be connected. The EtherCAT G Coupler or EK1400 Branch Controller provides a branch port from an EtherCAT G network to a 100 Mbit/s segment so that the entire range of standard EtherCAT terminals, drives, sensors, etc. can be integrated into the EtherCAT G network. The branch concept also offers another crucial efficiency advantage in that it can minimize propagation delay times in a large network. This is because the telegram of a branch segment runs directly



Classification of the EtherCAT diagnostic functionalities

from the branch controller back to the master, bypassing all other connected segments. As a result, the branch ports can operate in parallel, simultaneously sending their own telegrams. In most applications, this parallel operation of network segments results in a significantly higher performance gain than simply increasing the transmission bandwidth. With the help of the branch concept, this results in an application-dependent performance gain in an EtherCAT G network ranging from a factor of 2 to 7 in relation to the achievable communication times – all with a 10-fold bandwidth increase. With EtherCAT G10, an even higher bandwidth of up to 100 times is available.

This interview was conducted by Stefan Ziegler, Editorial Management PR, Beckhoff Automation

Thomas Rettig:

“ Even after 20 years, Beckhoff continues to invest heavily in the development of its major core technology EtherCAT to ensure maximum supply and investment security for both our company and our customers.”

More information:

www.beckhoff.com/ethercat

AI-assisted engineering with TwinCAT Chat

Fast and efficient PLC code generation and more with artificial intelligence

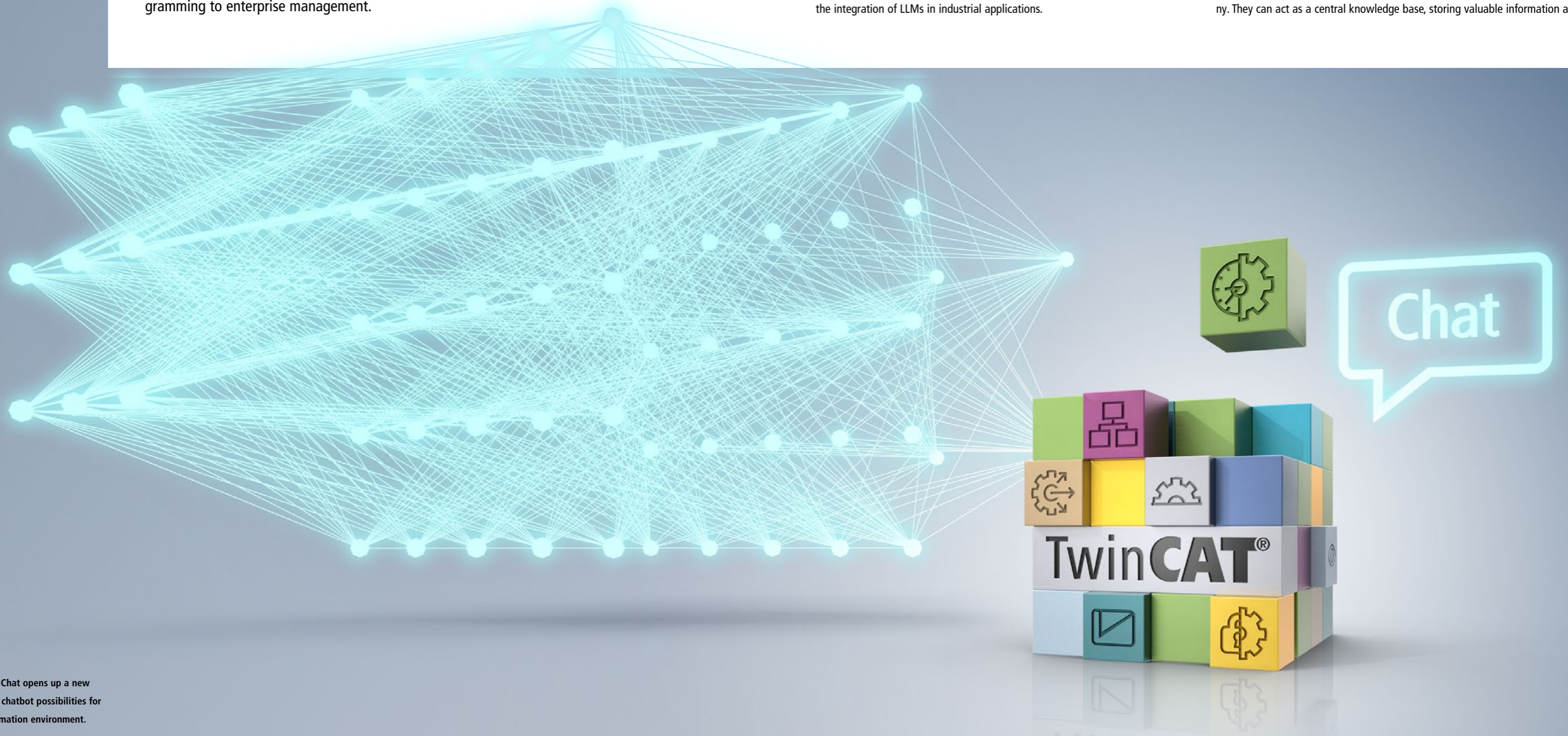
With TwinCAT Chat, Large Language Models (LLMs) such as ChatGPT from OpenAI can be conveniently used in the TwinCAT XAE engineering environment for the development of a project. In this interview, Dr. Fabian Bause and Jannis Doppmeier from TwinCAT Product Management describe the most important application considerations and possible efficiency potential from control programming to enterprise management.

Since the introduction of ChatGPT, everyone has been talking about Large Language models (LLMs). Beckhoff was one of the first suppliers to present an application in the automation sector with TwinCAT Chat at Hannover Messe 2023. What was the feedback from customers at and after the trade show?

Jannis Doppmeier: The feedback from customers was consistently positive. Both management representatives and direct users expressed a high level of interest. A large proportion of customers saw significant potential in this technology for the automation sector. Some even expressed concrete interest in testing a beta version in the future, as soon as it is available. This indicates that there is growing demand for advanced solutions in this segment. With the introduction of TwinCAT Chat, Beckhoff has made an important contribution to the integration of LLMs in industrial applications.

What fundamental advantages can LLMs offer for the automation engineer on the one hand and for enterprise management on the other?

Jannis Doppmeier: Large Language Models (LLMs) offer a number of benefits for both automation engineers and enterprise management. For automation engineers, LLMs have the potential to revolutionize the development process by automatically generating and completing code. This speeds up the entire process. In addition, you can even have LLMs create personal tutorials and ask specifically for solutions to problems that arise, which speeds up the process of finding solutions. Another advantage is the ability to consistently implement and comply with guidelines and best practices in automation. From an enterprise management perspective, LLMs promote knowledge transfer within the company. They can act as a central knowledge base, storing valuable information and



making it available when needed. In addition, LLMs can relieve the pressure on the support team by serving as the first point of contact for customer inquiries. This not only improves response times, but also potentially increases customer satisfaction. Overall, LLMs offer an efficient and innovative solution to numerous challenges in the modern business world.

Are there still technical uncertainties when it comes to using LLMs?

Dr. Fabian Bause: Yes, definitely. There are numerous technical uncertainties, but that is not surprising considering the speed of development at the moment. A key challenge for the automation industry at the moment is the “fantasizing” of LLMs. What is meant by this is that an LLM will also repeatedly generate “made-up” answers that are not necessarily recognizable as such by the user. In the early development phase, for example, we found some motion functions in PLC code generated by TwinCAT Chat that do not exist at all – at least not in TwinCAT. But these are issues that can be addressed and will improve significantly over time.

And are there uncertainties from a legal point of view too?

Dr. Fabian Bause: Absolutely. The European Union’s AI Act is currently a source of uncertainty. It has not been finally adopted yet, and for that reason alone there is a great deal of uncertainty in the industry. A key challenge for policymakers in regulating AI applications is that political processes are much slower than the rapid pace of advancement in the field of generic AI. It will be interesting to see how a generic regulation will apply to the many AI developments that are still unknown. But there is no doubt that certain regulatory measures are needed.

Will AI applications like TwinCAT Chat be able to replace control programmers with all their creativity in the future?

Dr. Fabian Bause: No, certainly not. It is not our goal to completely replace programmers, nor do the current technical developments imply that this will be the case. Instead, the goal is to provide programmers with better and better tools so that they can work effectively. It’s all about increasing a programmer’s productivity – not least as one of the key ways to combat

the skills shortage. If vacancies cannot be filled because there are simply no qualified specialists to be found, AI must be used to ensure continued competitiveness.

What are the technical features of TwinCAT Chat?

Jannis Doppmeier: TwinCAT Chat was developed to offer users a clear advantage over the conventional use of, for example, ChatGPT in the web browser. The key added value lies in its deep integration, especially with regard to the specialized requirements of the automation industry. The core features include the direct integration of the chat function into the development environment (IDE). This greatly simplifies the development process, as communication and code exchange are seamlessly integrated. Furthermore, the basic initialization of our model has been tailored specifically to TwinCAT requests. This way you can ask your specific questions directly and don’t have to tell the model that you are using TwinCAT and expect the code examples in Structured Text. Another highlight is the ability to easily adopt generated code. This not only saves developers time, but also reduces human errors that can occur during manual transfers. Interaction with TwinCAT Chat has been designed in such a way that the need to type commands is reduced to a minimum. Instead, the user can simply click on pre-tested requests that are specifically designed to improve their workflow. These requests include actions such as:

- **Optimize:** The system can make suggestions to increase the performance or improve the efficiency of the code.
- **Document:** TwinCAT Chat helps to create comments and documentation so that the code is easier for other team members to understand.
- **Complete:** If code fragments are missing or incomplete, our system can generate suggestions to complete them to ensure functionality.
- **Refactoring:** TwinCAT Chat can refactor code according to certain guidelines and policies so that it is more in line with company guidelines.

Overall, this system provides an efficient and intuitive user interface that greatly facilitates the development process.

In addition to the current focus on supporting PLC code generation, which other areas will gain in importance in the future?

Dr. Fabian Bause: The beauty of LLMs is that, with a little imagination, they can be used universally. In addition to PLC code generation, we are also working on a chatbot that automatically creates a TwinCAT HMI project. The goal is that a user will only have to formulate how they want their HMI to be structured and TwinCAT will generate the entire HMI project in the background. The customer will therefore receive immediate feedback in the form of the visualized HMI. This is made possible by explaining the programming interface for the HMI to the LLM – because in fact it is also just another “language” that can be easily mastered by the LLM. Another project involves a chatbot interface to our documentation system, which contains many gigabytes of knowledge in the form of documentation. And that is precisely the challenge for our customers: We provide a huge amount of knowledge in text form. And why? Because it is the only way to make information available to hundreds of people at the same time – in other words, written text is simply

a tool. The natural way for humans to share information is through language. One person asks, the other person understands or rather interprets the question and generates an answer based on their experience. That’s what we can achieve with LLMs – we ask a question and an LLM is able to interpret that question. No specific keywords need to be used as the system can cope with questions that may be poorly worded. If the LLM is also granted access to the large Beckhoff library, the model can generate targeted responses. So in the future, we will be able to ask specific questions rather than having to search for answers via keywords.

TwinCAT Chat also opens up new ways of working for the user. What does this mean exactly and what are the advantages in practice?

Jannis Doppmeier: Our tool is an innovative solution which increases developer productivity significantly by acting as a digital assistant. Code no longer needs to be manually created line by line. This assistant performs routine tasks that are often time-consuming and repetitive. This gives developers more time and capacity to focus on their core tasks – the actual design and conception of the software. In a market where every advantage counts, our tool offers companies the opportunity to remain competitive despite staff shortages and to meet the increasing demands of their customers.

What is the significance of the language model used?

Dr. Fabian Bause: Currently, several language models from the well-known IT giants are competing with each other, such as ChatGPT from openAI, PaLM or Bard from Google, or ERNIE from Baidu. What the major models have in common is that they are all offered as cloud services via an API. Apart from technical differences, there are regional challenges too. For example, ChatGPT and Google’s LLMs are not accessible from China. This poses a challenge for Beckhoff because the Chinese market plays a central role for us. Furthermore, the integration of a third party’s cloud service into our products entails a strong dependency on this provider. How will the service evolve from a technical perspective, how stable and backward compatible will the developments be, how might the usage costs and privacy policies for the service change in the future? Because of that uncertainty, we are working hard on training our own models – not from scratch, of course, but based on commercially available open LLMs. In this way, we are focusing on a clearly defined, much smaller scope of application rather than competing with the general models like ChatGPT.

The interview was conducted by Stefan Ziegler, Editorial Management PR, Beckhoff Automation

More information:

www.beckhoff.com/llm



TwinCAT 3 CNC Milling Base

Make milling and drilling easier to program with parameterizable blocks

Beckhoff provides a comprehensive package of different cycles for triple-axis milling and drilling with the TwinCAT 3 CNC Milling Base. It facilitates programming for these machines by encapsulating the required processes in parameterizable and reusable modules.

The new TwinCAT CNC cycle package supports a variety of different drilling strategies, ranging from simple centering and deep hole drilling to helical milling, tapping, and thread milling. These can also be combined with the included cycles for drilling patterns to facilitate efficient programming for multiple drilling in various arrangements. The milling cycles also optimally support the production of slotted holes, grooves, and differently shaped pockets and tenons. This also includes an option for producing customer-specific pockets or tenons based on contour descriptions stored in the NC program, removing remaining residual material using a separate tool, and deburring the resulting milled edges. All cycles offer extensive parameterization options for adaptation to different technological requirements. Their many features include support for different machining modes (roughing and finishing) and feed directions (conventional or climb milling), and these can be used in all principal planes (G17, G18, G19).

More information:

www.beckhoff.com/tf5293



Dr. Fabian Bause (left) and Jannis Doppmeier, both TwinCAT Product Managers, Beckhoff Automation

MX-System: Pluggable system solution for control cabinet-free automation

Modular implementation of all control cabinet functions without protective housing

A comparison of control cabinet technology over the past few decades reveals that the basic structure remains essentially unchanged, and the complexity of the required components and wiring has been consistently high. This is what prompted Beckhoff to develop a significantly more flexible and efficient control cabinet alternative in the form of the MX-System modular and pluggable automation toolkit. In the following interview, Marvin Düsterhus and Dr. Friedrich Klasing from Product Management MX-System talk through all the details, including the recent addition of a 3-row baseplate.

The MX-System is highly modular and can be optimally adapted to the application in question with a wide range of function modules.



Marvin Düsterhus,
Product Management
MX-System, Beckhoff
Automation

The MX-System was first introduced in 2021 and certainly has the potential to not only reduce the size of the traditional machine control cabinet, but even replace it completely. How have customer reactions and acceptance changed since then?

Marvin Düsterhus: A lot has actually happened since it first launched. To date, we have assessed over 70 real-world applications and successfully transformed them into corresponding MX-Systems. The inquiries we receive come from a wide variety of fields, ranging from test benches and packaging machines through to brewery automation systems. Moreover, the control cabinet solutions employed in these applications are also equally diverse, which demonstrates that a control cabinet-free machine using our MX-System can be of interest for any application. With the MX-System, it is not only possible to directly replace the control cabinet on-site, but also to arrange the entire control technology in a modular and decentralized way by breaking it down into smaller units. This realization has now also been embraced by our customers, and there is virtually no question today that the future of automation technology will be control cabinet-free. Completely control cabinet-free automation, as showcased by the MX-System, offers solutions to the challenges our customers are facing both now and in the future. These notably include complete modularization of the entire machine, standardization in components and processes, addressing the growing shortage of skilled personnel, and ensuring straightforward machine maintenance.

Dr. Friedrich Klasing: The MX-System is no longer considered just another way to implement automation solutions, but as an opportunity to stand out from the competition. The modularization of entire machines or their components has been a fundamental principle of machine building since the

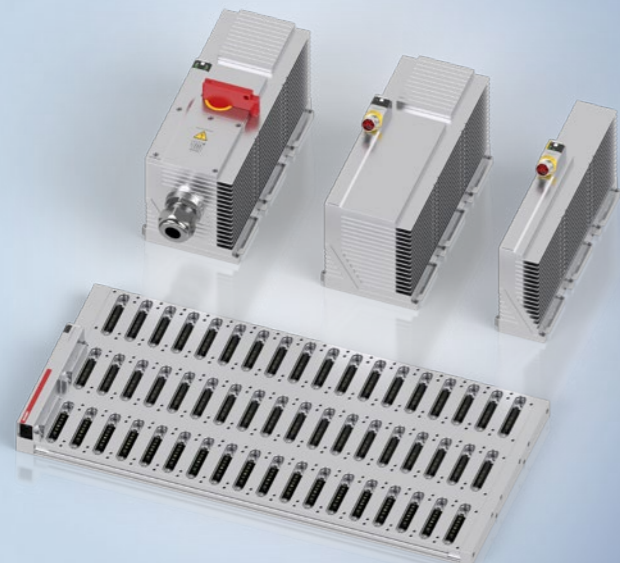
beginning of the industrial revolution, given the evident advantages it offers for repair and maintenance. Similar approaches have existed in software since the early days of computer programming and in hardware for electronic components; however, the control cabinet, acting as the link between mechanics and electronics, has successfully resisted this trend until now. The MX-System addresses this by allowing the control cabinet to be fully modularized and decentralized in line with the machine concept, with corresponding benefits for repair, maintenance, and operation. Across various industries and through comprehensive compliance (IEC, UL, CSA, etc.), there is growing interest in the MX-System worldwide. In conversations with customers, we witness the emergence of new and innovative machine concepts that would be impossible to implement using conventional methods, or only at considerable additional expense. Understanding of the MX-System has noticeably increased, as has the demand, with the latter serving as motivation to ensure we can deliver it in series next year.

Ever since it first launched, the component range of the MX-System has been continuously expanding. What have been the most important development steps or new components so far?

Marvin Düsterhus: Many machines have additional VPN routers installed in control cabinets, but this is not something we have in our own portfolio. Challenged with developing a solution, we came up with the infrastructure module, which is essentially an empty enclosure connected to our baseplate, with provisions for external connections. This allows various devices from third-party manufacturers to be seamlessly integrated into our ecosystem in a space-saving way. The family of power supplies has also expanded, notably in the case of the 48 V DC variants, for which we now offer high-performance models with



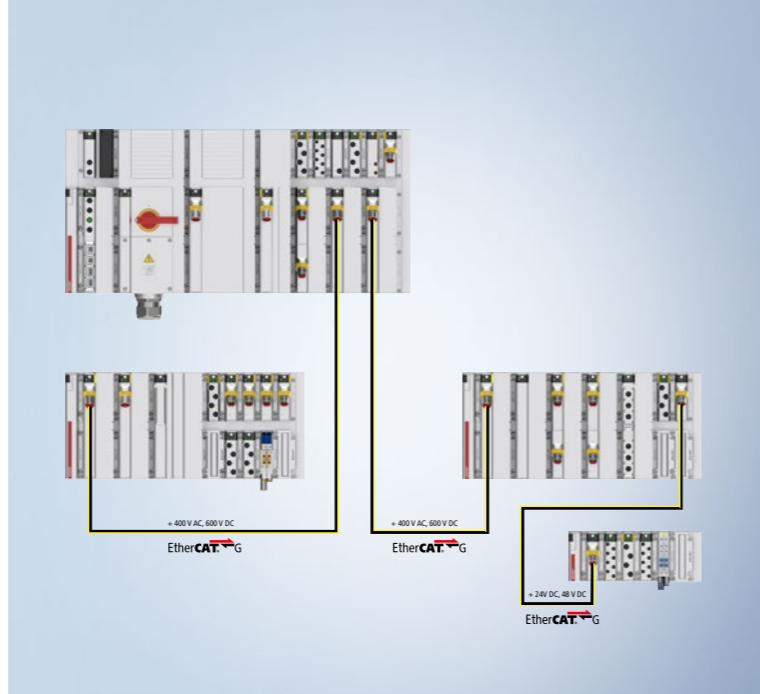
Dr. Friedrich Klasing,
Product Management
MX-System, Beckhoff
Automation



Different baseplates can be used to suit each specific application, like the new 3-row version complete with data and power connectors along with the corresponding function modules

capacities of up to 40 A. These have been specially developed with a focus on ATRO and XTS, but are also suitable for standard 48 V DC components. Another innovation is the capability to integrate pneumatics. This is where we provide electronic socket modules that can directly accommodate common pneumatic valves and can be mounted together on a baseplate. We have found this to be a highly cost-effective and space-saving solution, especially in applications with distributed or a limited number of valves, such as at the end-effector of a robot. Another major step for us is the introduction of size 3 for both baseplates and function modules, which we will unveil at SPS 2023.

Dr. Friedrich Klasing: The pneumatic modules were developed in cooperation with Festo and SMC, showcasing the successful integration of technologies from other manufacturers. The combination of the MX-System and pneumatics represents added value for all involved. It is enhancements such as these, with the corresponding added value, that will continue to enrich the spectrum of the MX-System in the future. The MX-System is set to bring about improvements in many areas of machine building, and documentation will play a crucial role in this regard. This is why we are pursuing an entirely new approach when it comes to compiling and preparing content. Who needs what information and when? This is the key question that we always keep in mind when preparing documentation. An indispensable component of the MX-System is the Beckhoff diagnostics app. While it is not the sole determining factor for the feasibility of a machine using MX-System resources, it will have a lasting influence on how machines are handled in the field. The app provides service technicians with access to previously inaccessible information, enhancing service quality while simultaneously cutting down on deployment time. What's more, when used in connection with the features of the MX-System, it can also reduce downtime and boost productivity. The potential of the app is far from exhausted, and we are currently working on expanding it as a possible access point for off-site technicians. Another advantage of the Beckhoff diagnostics app compared to apps from other manufacturers is that it can provide information for the entire machine, not just individual components such as IO-Link devices.



With the MX-System and EtherCAT, the conventional centralized approach becomes a decentralized distributed control cabinet.

What are the characteristics of the new size 3 components unveiled at SPS 2023 and to what extent do they expand the range of applications of the MX-System?

Marvin Düsterhus: At its core, the baseplate is enhanced with an additional row of data slots, while all existing function modules of various sizes remain compatible. Besides its dimensions, the baseplate itself does not feature any new technical characteristics, but it does offer new possibilities: Without changing in width, there are now significantly more slots available to accommodate even more function modules. Moreover, the extra row allows us to use our new 3-row function modules. And thanks to the larger cooling fins, it is now possible to achieve not only 32 A power feeds, but also up to 125 A, and to switch significantly larger loads. In size 3, a servo drive can deliver up to 28 A nominal current per channel, and a frequency inverter can drive a motor with up to 15 kW.

Dr. Friedrich Klasing: The focus here is less on integrating new functions and more on enhancing performance. The higher power levels in particular significantly broaden the application range of the MX-System. Up to now, machines requiring high power inputs could only be implemented to a limited extent and in a hybrid manner using the modular MX-System. The 3-row baseplates can replace the need for a control cabinet for power distribution in such cases, enabling more and larger machines to be designed on an entirely control cabinet-free basis, and thereby leverage the advantages of decentralized control technology. In the topology of a machine, a 3-row baseplate will likely always be positioned above the present 1- and 2-row baseplates, serving as a central point in a combination of star and daisy-chain topology.

A major advantage of the MX-System is the optimal support it provides for the increasingly popular machine modularization. How important is the expansion of the baseplate portfolio in this context?

Dr. Friedrich Klasing: The control cabinet will always stand in the way of a complete machine modularization in terms of both mechanics and electronics, as it always creates dependencies between different machine parts or else cannot be easily integrated into the machine room. A wide range of baseplates allows manufacturers to customize the required MX-Systems more easily to suit different machine modules. This contributes to the overall flexibility of this solution, as modules and components can be exchanged or added more easily. With the expansion of the baseplate portfolio and the associated increase in performance, even more machines can be implemented on a control cabinet-free basis. Excluding the typically larger modular machines, a 3-row baseplate can also serve as a more cost-effective alternative to two or more 1- or 2-row baseplates for a small monolithic machine with a relatively high number of 24 V DC components.

Can you illustrate the simplification of modularization and the potential savings in terms of the machine footprint with specific figures?

Marvin Düsterhus: This always depends on the application in question, as not all control cabinets are the same. There are many differences in dimensions, as well as in the installation location and position. Generally speaking, the MX-System reduces the required (screw-on) mounting space in terms of height and width compared to a typical control cabinet by about a third. The smaller modular units of the MX-System are much easier to integrate into the machine concept, allowing for a reduction in the overall footprint. To take a concrete example from the automotive industry, we looked at a machine with over 50 servo axes, whose entire mechanical section was already fully modular. The machine modules contained many decentralized I/O modules and some decentralized drives; nevertheless, there was still a 7-meter-long control cabinet on the side of the machine. This cabinet not only restricted machine accessibility, but also required all wiring from the machine modules to be routed there. By transitioning to the MX-System, the control cabinet was made completely redundant. In this case, a 3-row baseplate with a 125 A power supply was used, which feeds six additional MX-Systems as substations for the machine modules in a star configuration. Since the MX-Systems can be integrated into the machine modules without increasing the footprint, the floor space was reduced by approximately 10 percent as a result of getting rid of the control cabinet.

In addition to compactness, the cascading of the MX-System is a crucial factor for consistent machine modularization. What concrete application advantages does this offer, particularly with regard to the expanded range of baseplates?

Dr. Friedrich Klasing: Cascading or daisy-chaining several MX-Systems is just one of the many possible topologies for replacing a control cabinet with several MX-Systems. In addition to chaining several MX-Systems through a single cable, MX-System stations can also be used like a hub. This means that multiple MX-System stations are supplied with both power and EtherCAT from one (central) baseplate either in parallel or serially. Regardless of whether

multiple MX-Systems are cascaded or connected in a star topology, the limiting factor here is power. This is where the 3-row modules make a big difference, as they facilitate a power supply of up to 125 A AC from the mains. What's more, the use of central DC link modules for generating the 600 V DC intermediate circuit voltage can be implemented more effectively in size 3 compared to size 2.

This interview was conducted by Stefan Ziegler, Editorial Management PR, Beckhoff Automation

More information:

www.beckhoff.com/mx-system

Benefits of the MX-System

Modularity for future security:

- Market demand: As end customers increasingly prioritize flexibility in their production processes, the demand for modular machines and systems is on the rise.
- Decentralization: The MX-System optimally supports modularization as a machine-mountable, decentrally distributable solution.
- Flexibility: The MX-System can be cascaded in a highly flexible manner and combined with existing control cabinets and IP67 field components.

Maximum efficiency for machine building:

- Engineering: MX-System function modules simplify project planning, minimize the number of components, and reduce parts lists by up to 80%.
- Market expansion: The MX-System is IEC, UL, and CSA compliant, making it a globally compatible solution.
- Mounting: The straightforward process of attaching and screwing in the function modules replaces the need for complex mechanical effort and reduces the risk of wiring errors.
- Shortage of skilled workers: The low engineering effort and fast assembly (e.g., 1 hour of working time instead of 24) eases the burden on skilled workers and opens up potential for less qualified personnel.
- Service: Faults are easier to diagnose and components are easier to replace.

Increase in productivity for the end user:

- Optimal space utilization: The eliminated need for a control cabinet minimizes the machine footprint and optimizes the available production area.
- Flexibility: Modular machines facilitate commissioning and integration into existing production facilities.
- Service: EtherCAT and hot-swappable MX-System components result in optimal diagnostic capabilities and the fastest possible replacement.
- Inventory management: Highly functional, reusable modules minimize spare parts inventory.

Maximum vertical integration: Isar Aerospace develops and tests almost every part and component of its Spectrum rocket in-house. (Pictured here: an early prototype rocket motor, nine of which are used in the first stage.)



PC-based control and EtherCAT in aerospace technology

Rocket technology on the test bench

Isar Aerospace in Ottobrunn has made a name for itself as a real game changer in European space travel. Founded in 2018, the company is opening up low Earth orbits for commercial applications with payloads of up to 1,000 kg thanks to its Spectrum launch vehicle. There's no doubt about it that every last component is put through its paces on a space mission. This is where PC-based control and EtherCAT Terminals make an invaluable contribution, from the development and quality control of virtually all rocket components through to the launch operations at the launch pad.

It's unsurprising that Isar Aerospace would be less than impressed with the typical three or four rocket launches per year when it has its sights set on 20 to 30 economical flights into low Earth orbits. Around 350 employees develop the necessary technologies and systems almost entirely in-house, from the design and optimization of the individual rocket components through their industrial production and testing, to the final assembly of the rockets and launch pads.

Despite the relatively small size of the launch vehicle, it is easier to transport, flexible, and specifically designed to deploy small satellites into the Earth's orbit in an incredibly timely and cost-effective manner. A typical communications satellite weighs between 100 and 200 kg, although much lighter variants have been in development for quite some time. Once in orbit, several of these satellites form 'constellations' and serve to provide the communications infrastructure, among other uses. The Isar Aerospace Spectrum can transport several of these satellites, which significantly reduces costs.

Rocket production with industrial methods

Given the sheer volume of rocket launches, it is clear that production processes have to shift closer toward industrial series production. This is why Isar Aerospace takes a different approach to the design and production of launch vehicles compared to other suppliers: Many of its components, such as the combustion chambers for the rocket engines, are produced much faster using modern 3D processes than with conventional methods. This allows the company to achieve cost-effective rocket production and correspondingly economical launch costs per kilogram of payload. An equally essential part of development and production are the comprehensive quality controls and functional tests. "We test virtually every rocket component on our various test benches, almost all of which we developed ourselves," explains Philipp Lünig, Lead Engineer Control Systems at Isar Aerospace. This is because enormous forces act on the rocket and its components during launch and its flight into orbit. The aerodynamic load of the rocket reaches its peak at a point known as Max Q. Another load peak occurs when the rocket stages are cut off. "We



Based in the German town of Ottobrunn, just outside of Munich, Isar Aerospace develops and builds launch vehicles that can be used to place one or more satellites with a total weight of up to 1,000 kg into low Earth orbits.

simulate these loads in production on test benches using hydraulic units," notes Philipp Lüning. The electronics (including power supply and batteries), avionics, and the valves of the rocket engines are again tested under the most realistic space conditions possible in special thermal vacuum chambers – i.e., in a complete vacuum at extremely low temperatures. The fuel and oxygen tanks are not released unless they first pass special compressive strength and leak tests. Virtually no component or part is bolted to a rocket that has not gone through comprehensively testing first.

Large and medium-sized test benches comprising several hundred EtherCAT Terminals can be found at the company headquarters in Ottobrunn and at the rocket test bench in Esrange, northern Sweden. There are also another 20 or so test benches in Ottobrunn, some of which are mobile. "We chose Beckhoff because they support all the signal types we need, including hazardous areas and safety," enthuses the automation expert. This flexibility and modularity was important and represented a decisive factor alongside the excellent value for money of the control technology.

The test benches often have to process a large number of different signals, sometimes at high sampling rates, while the control system has to process sophisticated switching sequences. Typical automation tasks include the control of rocket engine ignition sequences or the automatic control of test facilities to maintain the required test conditions. The wide range of terminal variants and the synchronized acquisition of all control and measurement signals via EtherCAT help with setting up and operating the test benches. The automation expert adds, "This is incredibly important for us, as the fact that there is only

The control and monitoring cabinets for the Isar Aerospace launch pad in Esrange, northern Sweden, – with EtherCAT, TwinSAFE and numerous ELX Terminals – are also being designed, assembled, and extensively tested in Munich.



one system for control and measurement technology means we do not have to waste any time synchronizing the data."

Modular test benches in hardware and software

Isar Aerospace has built its own data acquisition system with TwinCAT and EtherCAT, which the automation experts can use to automate the test sequences. "With other control concepts, it would have been much more difficult, if not impossible, to reconcile all of this," notes Philipp Lüning. What's more, as all data is available in a single system, it can be easily displayed and archived in the visualization. Philipp Lüning estimates that he and his team now use around 150 different EtherCAT Terminals: In addition to EtherCAT Terminals from the EL series, which offer a perfectly adequate level of accuracy for most measurements, they are increasingly also using measurement terminals from the ELM series for high-resolution strain gauge measurement strips and vibration measurements, as well as many other products from the Beckhoff range.

Nevertheless, Isar Aerospace has some very special requirements that even the extensive Beckhoff range cannot meet. Philipp Lüning solved this problem by finding a supplier whose measurement technology equipment is available with an EtherCAT interface: "Using distributed clocks, we were able

to synchronize these few channels without any problems and map the data synchronously into our TwinCAT-based measurement and test system."

The core of each test bench is a TwinCAT framework that runs on every part of the plant. This generic PLC code is sufficient to control the test bench and record all data. The template is controlled and configured via the company's own user interfaces (GUIs), which not only offer all control functions, but also enable real-time charting, data recording, and the programming of

The metrological effort at Isar Aerospace is enormous. Accordingly, the concentration of analog EtherCAT Terminals and precision measurement terminals of the ELM series at the test benches is high.



Philipp Lüning, Lead Engineer Control Systems at Isar Aerospace, in front of the prototype of the second rocket stage: "We owe a lot to Beckhoff, because Beckhoff technology has allowed us to create robust, state-of-the-art test benches that can be adapted to our needs in no time."

additional process sequences, such as special controllers, step chains, and state machines.

Access to all the parameters and signals of a rocket helps with seamless quality assurance from production, through functional testing of individual components and assemblies, to the finished rocket on the launch pad. "Without PC-based control, it definitely would not have been so easy for us to achieve communication and synchronization between avionics and controls," Philipp Lüning is convinced.

More information:

www.isaraerospace.com

www.beckhoff.com/io

PC-based control for the implementation of NAMUR Open Architecture (NOA) at Bayer

Compact NOA edge device comprising embedded PC, HART I/O terminals, and OPC UA server

Process analytical technology (PAT) plays a crucial role in the chemical industry. Bayer AG, for example, is enhancing efficiency and transitioning from time-based to condition-based maintenance by embracing the cutting-edge NOA concept. This is implemented through the seamless integration of a compact edge device featuring a CX8110 Embedded PC, EL3182 EtherCAT HART Terminals, and Beckhoff's TwinCAT OPC UA Server, without any alterations to the existing control technology.



Beckhoff CX8110 Embedded PC with EL3182 analog EtherCAT input terminals for HART-capable field devices

Bayer is a globally recognized company that specializes in life sciences, particularly in the fields of healthcare and nutrition. Its products and services are designed to benefit humanity and protect the environment, addressing fundamental challenges presented by an ever-growing and aging global population. Bayer currently operates one formulation plant and six active ingredient facilities at the Chempark Dormagen site, employing approximately 1,230 people. Its product range includes 35 active ingredients and ten intermediates in the realm of fungicides, herbicides, and insecticides, with notable product brands from this site including Luna, Laudis, and Movento respectively.

Field device monitoring for quality assurance

When it comes to ensuring production processes run with the required level of quality, it is crucial to take measurements at various points in the process workflows. This is where Process Analytical Technology (PAT) enables real-time assessment of product quality online during the process, providing direct feedback to production operators on further process control. A classic analytical quality measurement in this context is the determination of the pH value of the medium.

Given that PAT plays a significant role in quality monitoring during production, ensuring its proper functioning is of the utmost importance. This is why

preventive maintenance for PAT has been established in the chemical industry in the past, typically following time-based maintenance schedules. Many PAT devices simultaneously provide a wealth of condition information, which currently remains largely untapped. This is due to the non-standardization of the condition information, necessitating a great deal of preliminary work to interpret the data. With the help of standardized condition information, on the other hand, opportunities arise to transform time-based maintenance into condition-based maintenance and thus further increase the efficiency of PAT operations.

NOA benefits for brownfield plants

Extracting additional vitality data or condition information from the field level poses a particular challenge, especially in brownfield plants. Currently, the existing automation architecture almost exclusively captures the measurement data relevant for process control and is not intended to be altered by the integration of new technologies. This is precisely what prompted the User Association of Automation Technology in Process Industries (NAMUR) to develop NAMUR Open Architecture (NOA). The concept described in NAMUR Recommendation NE175 extends the automation architecture without altering the existing control system. The core task of NOA is therefore to provide information from the field level to higher-level applications in order to monitor the

Process technology plants, such as those at Bayer in Dormagen, are generally highly sophisticated and designed for a very long service life. This is why integrative concepts such as NOA are crucial for subsequent process or maintenance optimization.



Agitator tank for desalination at Bayer's Dormagen site; here as well as in the other plants, the NOA concept can be implemented with very limited available space thanks to the highly compact solution consisting of an embedded PC and EtherCAT Terminals arranged as needed.



The project team: Bayer planning engineer Dr. Roger Rossmann (center) alongside Beckhoff process industry managers Lennart Winkler (left) and Sebastian Böse (right)

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 cyclic parameters, which contain information on the device condition or process quality.

The world of process automation involves a wide range of protocols and communication technologies. For the initial implementation of the NOA concept at Bayer, the Beckhoff project team – comprising Bayer planning engineer Dr. Roger Rossmann along with Beckhoff process industry managers Lennart Winkler and Sebastian Böse – opted to utilize the HART protocol. This choice offers three significant advantages for the project:

- The protocol is widely used and thus 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.
- 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 the 4–20 mA signal, the HART communication, and the supply

voltage, which means that the existing connection to the process control system is not interrupted. Corresponding data can therefore be received via the second channel and used for the 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 the need for specially developed hardware. Its functionality can be divided into three operations:

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

Commands have to be sent from the edge device in order to read out the vitality data via the HART protocol. The data to be read out and the commands under which it is stored 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. If a field device is connected to the edge device, it is automatically detected, the corresponding HART commands are sent, and the received data can then be converted using stored translation tables and TwinCAT functions.

The vitality data stored in the PLC at this time must be made available for further analysis applications in the next step. This is where NAMUR recommends the use of OPC UA. 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. The information model is based on the PA-DIM (process automation – device information model), which is extended by the vitality data for PAT field devices. Users also have the option of customizing it to include further parameters. Depending on the detected field device type, individual OPC UA nodes can be removed or added automatically.

Successful implementation at Bayer

According to Dr. Roger Rossmann, the solution from Beckhoff is characterized by its ease of implementation. He goes on to add that, "When it comes to

obtaining standardized vitality data, the approach to managing the library is not only open, but also subject to continuous further development by Beckhoff. Another positive aspect in the long term is that a change of field device is automatically detected by the Beckhoff solution, which means that no new parameterization is required. Finally, it is definitely worth noting that the edge device is easily scalable and thus allows for ongoing expansion in the brownfield. The product portfolio with Ex-capable I/O terminals also accommodates the use of a second output of the field devices for the acquisition of HART information in compliance with Ex requirements."

More information:

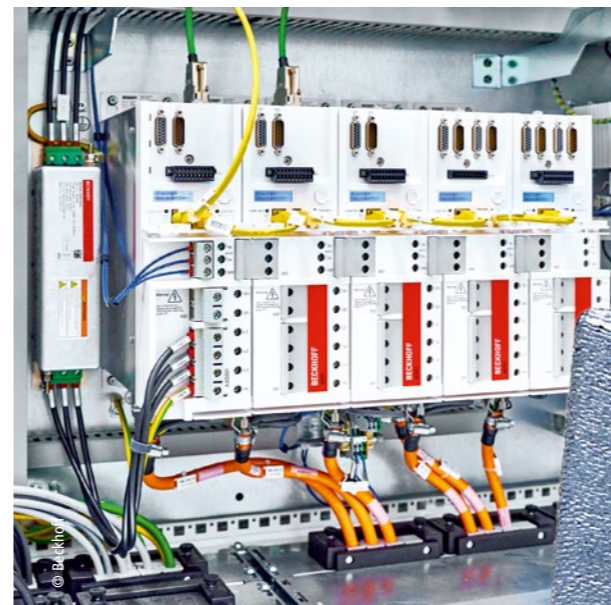
www.bayer.com

www.beckhoff.com/process

Open PC-based control and drive technology in the field of additive manufacturing

Precision and high speed for 3D printing with aluminum alloys

As a globally operating family business, GROB-Werke has been developing systems and machine tools for the most renowned automotive manufacturers, among others, for over 95 years. This period has been characterized not only by technical innovations, but also by the opening up of new markets. A prime example is the field of additive manufacturing, for which the first prototype machines were developed in 2019. With the new GMP300 Liquid Metal Printing machine, which is automated with PC-based control, wires made of aluminum alloys can now be used cost-effectively and efficiently in the printing process to achieve precise and fast 3D printing.

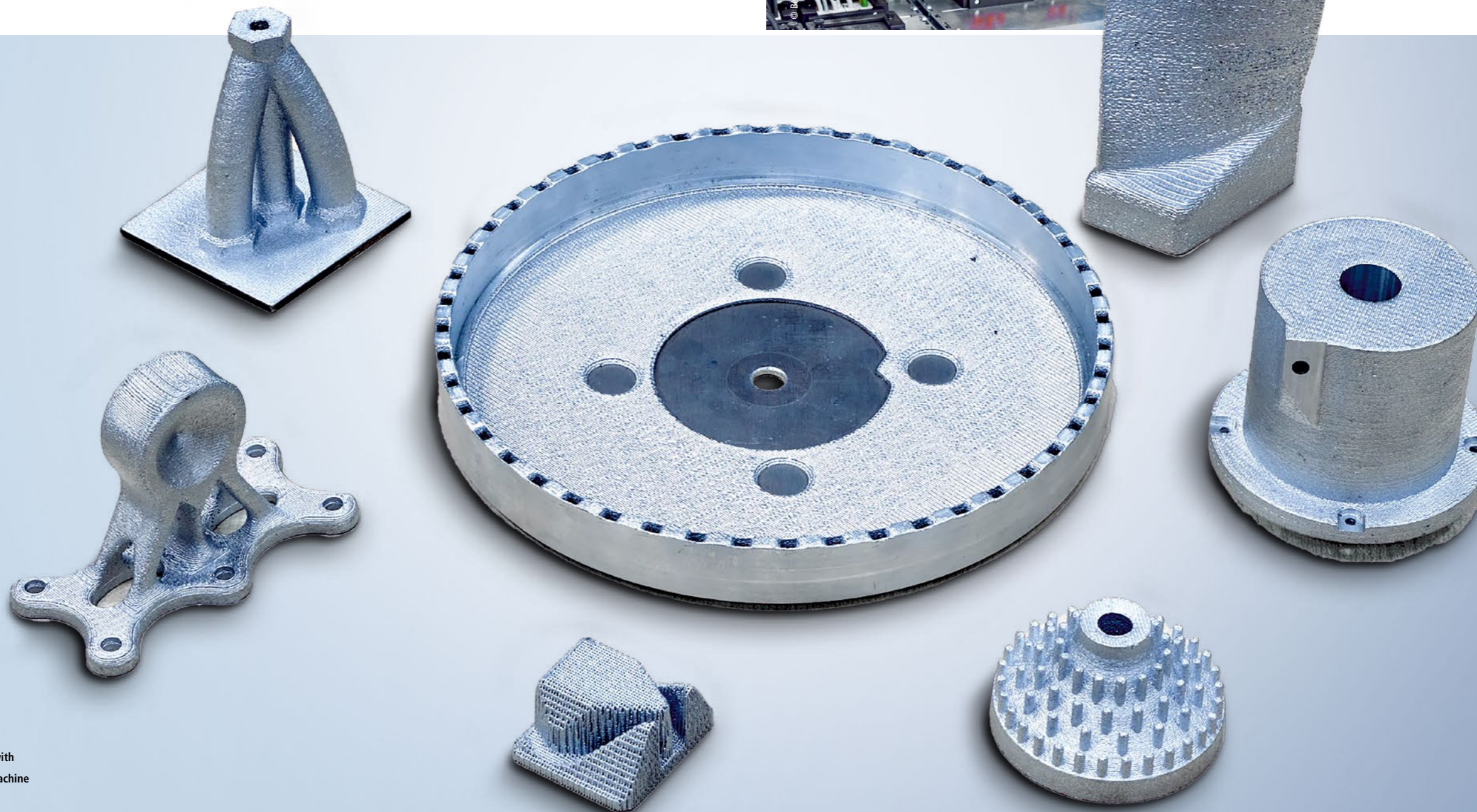


The AX5000 Servo Drives, in conjunction with servomotors from the AM8000 series, ensure dynamic and precise movements.

The portfolio of GROB-Werke GmbH & Co. KG, based in the German town of Mindelheim, ranges from universal machining centers to highly complex production systems and manual assembly stations to fully automated assembly lines mainly for the automotive sector. The focus on additive manufacturing equipment first came to the fore in 2018 as part of an innovation management process to assess future technology and which also included electromobility and fuel cell technology.

Economical and flexible additive manufacturing

The GMP300 Liquid Metal Printing machine uses a powder-free manufacturing process to produce near-net-shape components safely and quickly. This provides customers with a reliable, efficient, and cost-effective system technology – with 3-axis kinematics and a max. axis speed of 30 m/min – while also offering maximum production flexibility. Further advantages are provided by an assembly space



Examples of components produced with the GMP300 Liquid Metal Printing machine

with an oxygen-reduced atmosphere, numerous sensors for droplet, nozzle, and component height monitoring, among others, as well as the processing of aluminum alloys supplied in wire form, and reduced hazard potential as no powder has to be handled. Dr. Johannes Glasschröder, team leader for Additive Manufacturing at GROB, explains: "We have developed a completely new technology for this which makes additive manufacturing a much more interesting prospect compared to traditional processes. For instance, the raw material in wire form is far less expensive than the usual powder material. This provides the optimum conditions for producing required components from aluminum quickly and economically in small batches."

Commenting on the technical challenges accomplished, Emanuel Engelsberger from GROB's Additive Manufacturing team adds: "The precise synchronization of the CNC with the individual aluminum droplets is crucial. For their highly accurate positioning, for example, the drop time from the print head to the component must be precisely compensated. A lot of time and expertise has gone into this development in particular to enable corners and sharp edges to be produced precisely and at maximum speed, for example. The coupling of droplet frequency and axis speed also plays an extremely important role. The same applies to the large amount of sensor data, which, as well as being recorded for analyses, also forms the basis for active parameter adjustment and process control. This is the only way to compensate for any minimal errors directly during component production." While the conceivable range of applications is exceptionally broad – Dr. Johannes Glasschröder sees almost no limitations here – the requirements with regard to printing speed are just as varied. He explains that the print speed is usually 250 aluminum droplets per second, but that printing at up to 1,000 droplets per second has already been achieved.

With the slower first value, however, the results are usually more precise and can also be achieved quickly using a larger droplet volume.

PC-based control for speed and precision

Following GROB's previous success with PC-based control from Beckhoff in the area of electromobility, the additive manufacturing team also decided to put its trust in this technology. Emanuel Engelsberger explains: "Firstly, we benefited from existing experience and internal standards. And, secondly, the PC-based control technology was able to meet our requirements in terms of speed and precision perfectly." This is also confirmed by Dr. Johannes Glasschröder: "On top of this, the control platform from Beckhoff is easy to use and open to the integration of our own expansions, meaning that it is also future-proof."

The hardware core of the control solution is formed by a C6030 ultra-compact Industrial PC, which is ideally suited to this application on account of its exceptionally high single-core computing power. Dr. Johannes Glasschröder also thinks it crucial that the broad and regularly updated range of processors for Beckhoff Industrial PCs covers both future requirements and sustainability aspects. Convenient machine operation is ensured by a CP3918 multi-touch Control Panel with 18.5-inch display and customer-specific push button extension.

The required precise and dynamic movements of the total of seven servo axes are implemented via three 1-channel and two 2-channel AX5000 Servo Drives as well as AM8000 servomotors. The system-integrated safety technology of PC-based control is also used here: in the servo drives via the AX5805 TwinSAFE



The customer-specific CP3918 multi-touch Control Panel supports optimum usability of the GMP300.

drive option cards and in the I/O area with the EL6910 TwinSAFE Logic and several TwinSAFE Terminals. Overall, the I/O level is composed of numerous digital and analog EtherCAT Terminals and EtherCAT Box modules. Emanuel Engelsberger describes their key advantages as follows: "The decisive factors for us are speed and precision in data acquisition and processing. eXtreme Fast Control Technology (XFC) from Beckhoff, i.e., with the EL2262 oversampling terminal, is the only way we can set the corresponding trigger signal exactly according to our path planning and achieve the required synchronization with

the vision system, for example. And that is precisely the core application of the GMP300." In addition, there is the advantage of the wide range of interfaces that are available in the Beckhoff I/O portfolio, which make it very easy to integrate features such as IO-Link sensor technology (via EL6224).

Convenient and powerful software suite

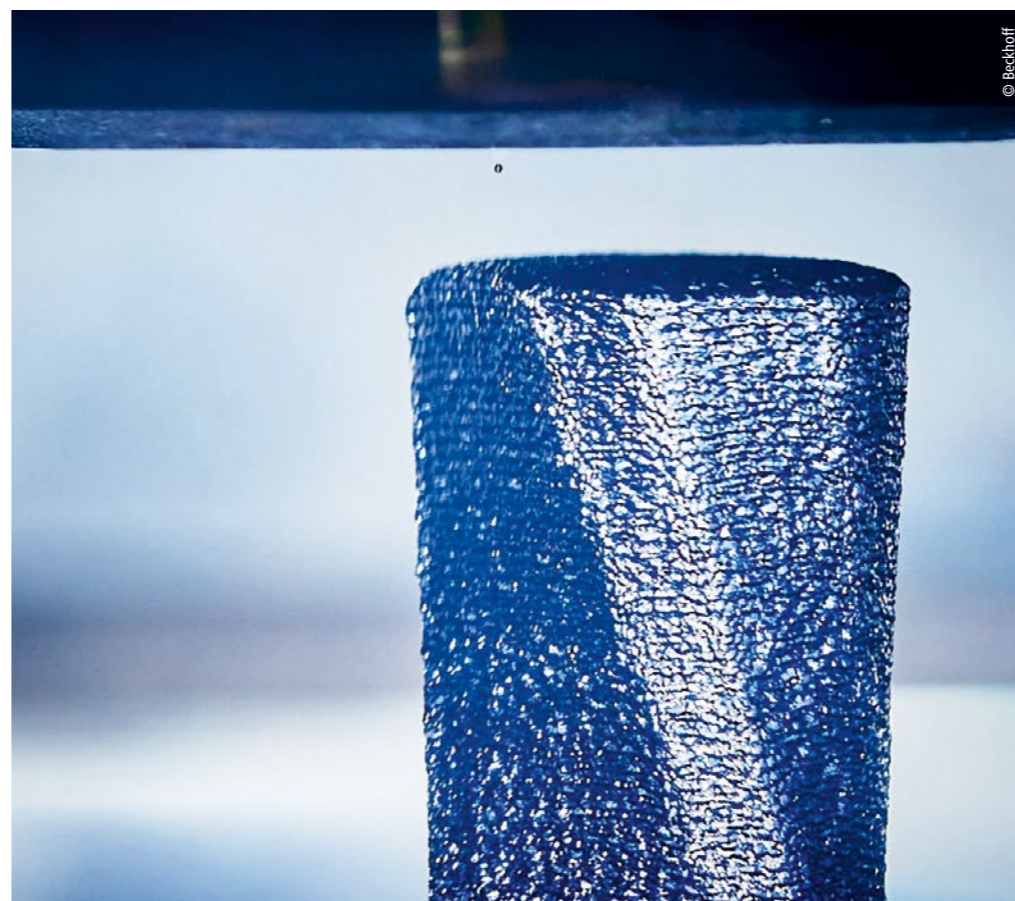
According to Emanuel Engelsberger, Beckhoff TwinCAT automation software has proven its worth not least in conjunction with the numerous EtherCAT analog terminals, due in part to the wide range of control algorithms offered by the TwinCAT 3 Controller Toolbox (TF4100). For example, he says that correct temperature control is crucial when producing a homogeneous aluminum melt from the wire-shaped raw material supplied in the print head. In the engineering environment, advantages arise from the pre-simulation of machine sequences without having to spend time on changing the development environment, as well as from the extensive virtualization options.

For the application core – the path calculation – TwinCAT 3 CNC (TF5200) forms the basis, as Emanuel Engelsberger explains: "The engineering interface, software architecture, and usability of TwinCAT have already supported me during the familiarization period. Working in TcXaeShell is very straightforward and does not require a lot of effort, which ultimately makes it easier for us to implement our core expertise. So, as mentioned, in order to position the aluminum droplet in the CNC exactly, something akin to a precalculation has to take place in order to take the droplet fall time correctly into account. Therefore, we have to know exactly where the next droplet is going to be during the trajectory curve and then set the trigger accordingly."



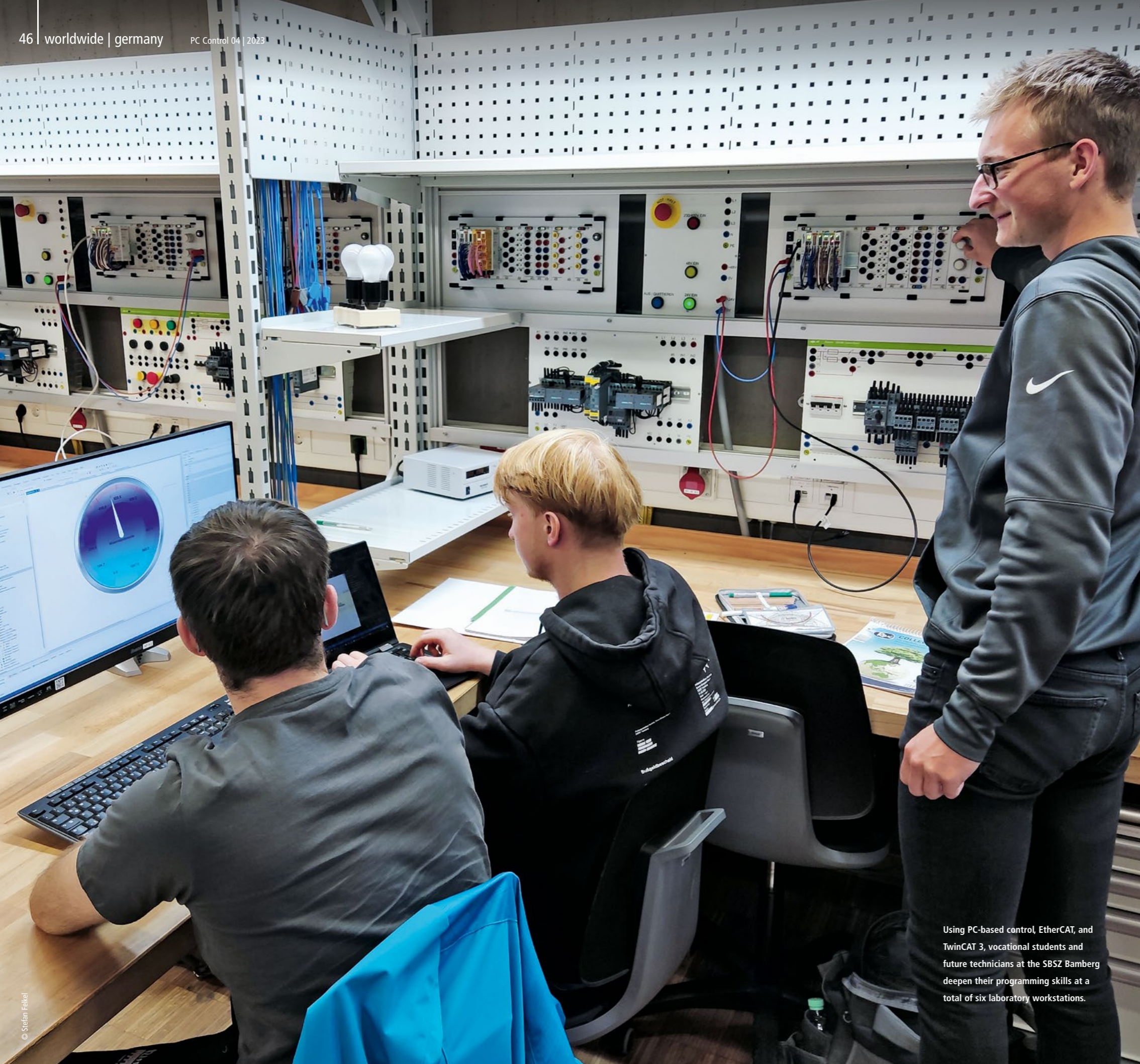
Emanuel Engelsberger and team leader Dr. Johannes Glasschröder, both from the additive manufacturing team at GROB-Werke, and Darius Wala, manager of the Beckhoff Munich branch, in front of the state-of-the-art and attractively designed GMP300 (from left to right).

The 3D structure is typically built up with 250 individual droplets (above) per second.



The powerful C6030 ultra-compact Industrial PC controls all machine and operating processes.

- More information:
- www.grobgroup.com
 - www.beckhoff.com/cnc
 - www.beckhoff.com/xfc
 - www.beckhoff.com/machine-tools



TwinCAT 3, PC-based control and demo racks
in vocational training

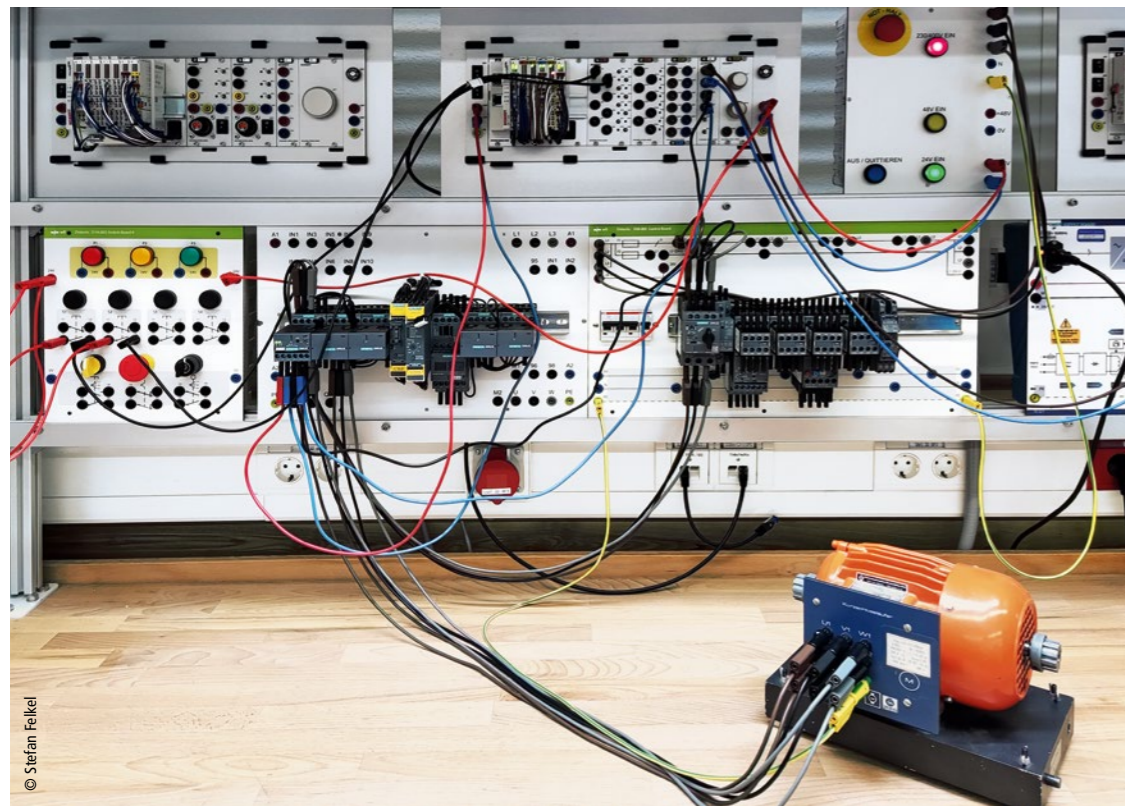
Modern laboratory workstations for PLC, motion, safety, and IoT

Industrial Ethernet and PC-based control technology have long been part of everyday life in many plants. The State Vocational School Center Bamberg (SBSZ) focuses its attention on this. At the school, expertise in advanced programming methods, motion control, and safety is imparted using the latest technologies, allowing budding trade specialists and technicians to learn about the advantages of an open automation platform using industrial PCs, TwinCAT 3, and drives from Beckhoff.

The SBSZ Bamberg conveys the necessary theoretical and practical knowledge for a wide range of occupational fields, including electrical engineering, computer science, and mechatronics. To keep pace with technical progress, both the learning content and the teaching materials constantly have to be adapted. In 2020, the Electrical Engineering 3 (Mechatronics) department had its facilities redesigned to include a new laboratory for control and drive technology.

"We want to ensure that the skilled workers of the future – electricians and technicians for automation technology and mechatronics – are provided with the best possible preparation for the tasks they will carry out in practice," says senior teacher Stefan Felkel, who designed the laboratory workstations together with colleague Markus Grill (M.Sc.). The learning units and exercises in the laboratory are therefore an important part of the training. Through various practical exercises, the aim is to prepare the vocational students to carry out tasks and programming independently. Stefan Felkel has the following to say on the subject: "Each vocational student and the aspiring technicians plan and create their own programs that they can simulate and then test on the hardware." A total of six lab stations, each of which can be used by up to three students, are available for such work. There is also a lab station for the teacher, which they can use to remotely control the power supply to the lab stations as well as the IPCs.

Using PC-based control, EtherCAT, and TwinCAT 3, vocational students and future technicians at the SBSZ Bamberg deepen their programming skills at a total of six laboratory workstations.



Each of the total of six lab stations is equipped with two C6525 Industrial PCs for programming, setting up, and testing in various exercises.

Safety, motion plus vertical integration

For each workstation, there are three training modules focusing on PLC, safety, and motion, which can be flexibly patched with the C6525 Industrial PCs.

The PLC training board contains digital and analog I/O terminals (EL1895, EL3174, EL4132) plus an AS-i master terminal (EL6201) and EL3214-0090 analog input terminals for two potentiometers. In addition to two EL7221-0090 EtherCAT Terminals (48 V DC, 8 A, OCT) for controlling servomotors, the Motion learning module also includes a brake chopper terminal (EL9576) and a fan module (ZB8610). An EL5151 encoder interface for setting setpoints completes this module.

The Safety training board comprises a TwinSAFE input terminal (EL1918), a 4-channel TwinSAFE output terminal (EL2904), an IO-Link master terminal with TwinSAFE SC communication interface for IO-Link (EL6224-0090), and a digital EtherCAT Terminal (EL1859). "Together with TwinCAT 3 as the programming platform and various TwinCAT 3 functions, we cover a huge range of learning scenarios which always have a practical focus," emphasizes Stefan Felkel.

"Our three training boards – Motion Servo, TwinSAFE, and TwinCAT I/O – form the basis for this. To ensure that these are compatible with the existing training set-ups, the modules were adapted to the requirements of Stefan Felkel and Markus Grill by Franco Angelico, Beckhoff Application, and Jens Thorun, Beckhoff Demo Systems," adds Wolfgang Negele from the Beckhoff sales team in Nuremberg.

For Stefan Felkel, it is important that everyone has their own industrial PC and can easily connect it to any hardware. PC-based control and EtherCAT create

maximum flexibility here: via corresponding network connections, the industrial PCs can be flexibly connected to the respective hardware of the laboratory workstation or to other mobile training trolleys.

Training with practical relevance and TwinCAT 3

In addition to using hard-wired programmed logic controllers, the laboratory is primarily used to teach the basics of programming sequence controls. The key element here is TwinCAT 3 as the engineering platform. TwinCAT 3 NC PTP and the Safety Editor are also available for the Motion and Safety learning modules. The advantage of TwinCAT is that students can use the IPC to program the application and as a soft PLC. In addition, the students can use their own laptops without having to deal with any major licensing costs. "This usually leads to even more intensive focus on the topic of PC-based control," says Stefan Felkel. According to him, the main advantage of industrial PCs over traditional, hardware-heavy control platforms is how flexible they are to use. "We also use various extensions, such as for OPC UA from the connectivity area," he says. In addition to TwinCAT 3 Motion Designer (TE5910) and TwinCAT 3 Drive Manager 2 (TE5950), TwinCAT 3 Bode Plot Base (TE1320) is also used to design and optimize the drive axes.

With regard to programming languages, the vocational and technical students start with function block diagram (FBD). This is followed by an introduction to PLC programming with simple tasks. After completing this basic phase, electricians and technicians for automation technology then program exclusively in Structured Text (ST). In order to reinforce the theoretical principles of a fieldbus in practice alongside Ethernet and EtherCAT, components that are controlled via AS-Interface are integrated in a task.

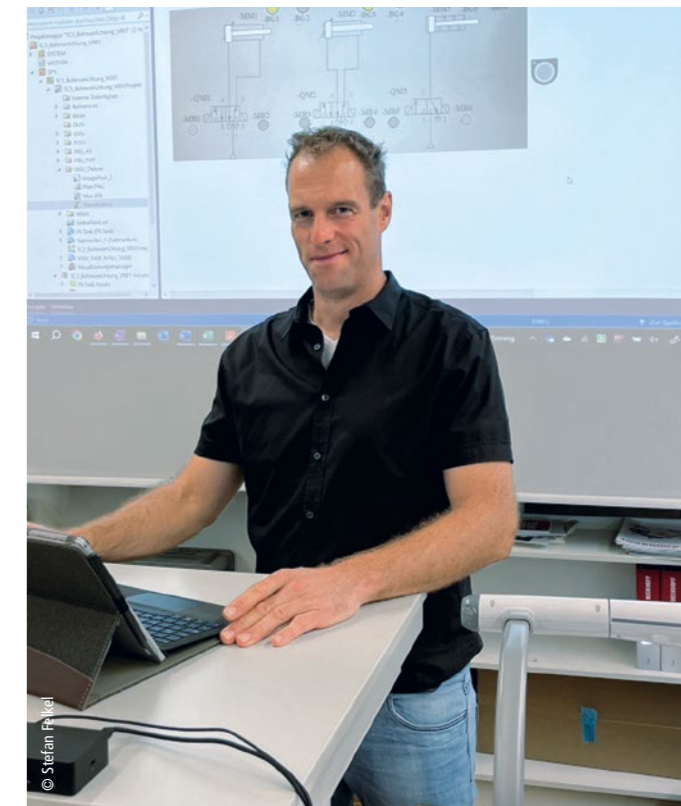
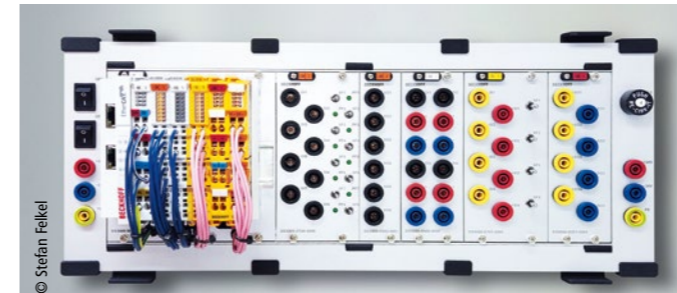
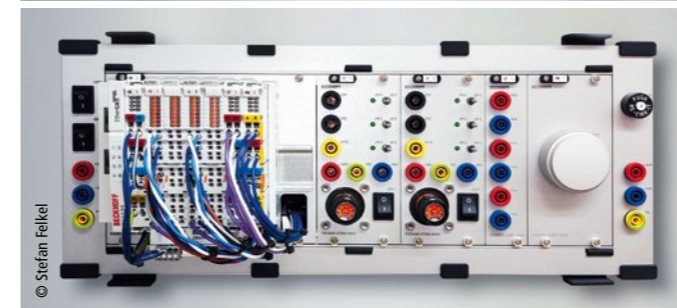
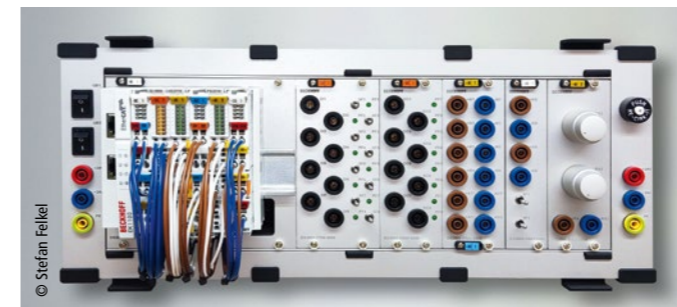
From contactor circuits to robot applications

In the area of drive technology, the basic contactor circuits are taught both via hard-wired programmed logic controllers and corresponding programs using the C6525 Industrial PCs. "With the control of motors via a safety relay, we provide an introduction to the topic of safety, which is then deepened with TwinSAFE," says Stefan Felkel. The controlled operation of servomotors (AM8132) via the EL7221 EtherCAT Terminals (compact drive technology) and the loading of an asynchronous motor in order to determine its characteristic curve complete the drive technology tasks.

At the end of their training, the students are given the task of programming a robot system: Two robots and five other stations containing basic automation elements (sensor technology, electropneumatics, bus systems) are to be controlled. To do this, the students have to analyze the function of each sub-station, identify its interfaces with neighboring stations, and initiate communication. Program design, programming as well as testing and documentation complete the project. "We want to create as exciting a practical application as possible and at the same time address many fundamental subject areas," says Stefan Felkel, explaining the level of commitment involved in the training program.

The range of training courses is set to be expanded further in the future to include the topic of servomotor control. The corresponding AX5000 Servo Drives are already available and are currently used to build up new teaching modules.

For each of the six lab stations, modules for the topics of PLC (top), motion (center), and safety (bottom) were set up with EK1100 EtherCAT Couplers and various EtherCAT Terminals from Beckhoff.



Graduate engineer Stefan Felkel:

“The flexibility of PC-based control and the straightforward licensing model of TwinCAT 3 were a huge advantage when setting up and using the lab stations.”

Plans are also in place to integrate translatory motors as well as special motors. As a final comment, Stefan Felkel adds the following: "All in all, I would like to thank Franco Angelico, application engineer at Beckhoff in Nuremberg, in particular, for the excellent partnership we have enjoyed and his huge contribution to getting the modules up and running."

More information:

www.sbsz-bamberg.de

www.beckhoff.com/io

www.beckhoff.com/twincat3

PC- and EtherCAT-based condition monitoring in a forging press retrofit

System-integrated measurement technology simplifies individual condition monitoring

Significantly increased vibration on machines can result in many forms of negative impacts such as reduced system performance or damage to the machine and foundation. Condition monitoring systems (CMS) are able to detect harmful vibrations at an early stage and optimize maintenance intervals. Using the example of retrofitting a forging press with a maximum press force of 2000 metric tons, Wölfel Engineering explains how efficiently the process was tailored and implemented with PC-based control and measurement technology from Beckhoff.

Based in Höchberg, Bavaria, Wölfel Engineering GmbH + Co. KG has been an expert in all fields related to vibration, structural mechanics, and acoustics for more than 50 years. "Our services range from individual consultations with engineers to delivering turnkey solutions for vibration problems," explains Dr. Marcus Ries, Head of Vibration Measurement and Reduction. As a prime example of PC-based condition monitoring, he cites the customized condition monitoring of a large forging press weighing approx. 150 metric tons, which was put into operation back in 1989 and modernized several times in the following years.

Reliable plant operation through condition monitoring

The first 15 years of operating the press were marked with clearly increased vibration levels which damaged both the machine and the foundation. While renovating the foundation in 2004, engineers completely overhauled the way in which the press was installed and coupled to its foundation. Although this initially reduced the increased vibration tendency, the dynamic application forces continued to cause issues in the mechanical connections (e.g., expansion screws being torn off). This resulted once again in increased vibrations in 2018, prompting fears of a production shutdown. To ensure that the press continued to operate reliably until the planned overhaul in the same year, the company provisionally revised the installation, while monitoring the effects with a temporary CMS based on a standard measuring system.

Dr. Ries explains why this intermediate step was successful: "Based on a renewed increase in the vibration level combined with a further drop in the natural frequency, the CMS detected that the makeshift measures were failing and enabled operators to directly implement countermeasures such as retightening or replacing broken connections. This prevented further damage to the concrete base as a result of insufficient pretensioning. More importantly, the machine continued to operate around the clock for several months until the scheduled repair. As the parts were being pre-produced during this time, our customer was able to build up a buffer for the imminent downtime, thereby ensuring their ability to supply."

After repairing the press and foundation, technicians installed a permanent CMS tailored to the vibration problem in question – based on findings of the dynamic vibration behavior as well as on results of the temporary CMS. In addition: "Our customer received training on site on how to use the system and was assisted in defining the alarm thresholds. Thanks to a specific sensor selection and the CMS based on PC-based control from Beckhoff, our customer can now detect a change in the force pretensioning and vibration behavior even earlier than before. They can then forward this information to the plant monitoring system in an automated and integrated manner."

Decentralized system simplifies CMS retrofit

According to Dr. Ries, there was a prerequisite for implementing predictive maintenance: The permanent CMS had to be implemented as a retrofit solution without modifying the press design and the monitored variables had to be fed into the existing press monitoring system via a data bus (Modbus). This was supported by the open nature of the PC-based control system with regard to interfaces and communication systems. Wölfel Engineering considers this to be a great advantage because it enables the end user to easily obtain initial condition assessments.

In addition, the decentralized sensor connection which forwards data via EtherCAT minimizes the cable routing paths and greatly increases the system



The eccentric press, which was installed in 1989 and weighs approx. 150 metric tons, has been modernized several times. In this context, the press was retrofitted with a customized condition monitoring system.

reliability. In fact, Wölfel Engineering can rely on proven industrial standard components with PC-based control, which is reflected, among other things, in its exceptional reliability: failure-free operation since 2019. This also includes the EtherCAT Box modules for data acquisition, which enable on-site digitization when installed directly on the plant and prevent long analog signal paths.

By selecting the right sensors and placing them directly on the critical, force-transmitting components, the new CMS provides direct insight into the state of the press installation and foundation. EL3114 analog input terminals, for example, collect data from position sensors. This allows the pretension (tie rod) to be measured to detect a bolt crack as primary damage. It also concludes that a displacement at the disk spring unit represents crack formation, i.e., secondary damage to the foundation. The EP3752-0000 EtherCAT Box modules are each equipped with two integrated 3-axis accelerometers. They provide the raw data for calculating the natural frequency of the entire plant as an early indicator for renewing the foundation. They also detect any possible tilting of the head plate. The following infrastructure components are used: an EK1122 2-port EtherCAT junction for connection to the ACC press head and an EK1100-0008 (M8) EtherCAT Coupler for connection to a further control cabinet.

Dr. Ries describes the advantages of the PC- and EtherCAT-based CMS as follows: "An approach involving PC-based control and distributed sensor technology simplifies monitoring and data processing in order to define alarm limits. Although other (disturbance) variables are present, their influence is minimized. The system would also have enabled complex data processing using models, advanced feature extraction, and machine learning if necessary. However, these options were not required in this case. Since commissioning, the customer has successfully used the system for predictive maintenance tasks, such as planning maintenance and procuring spare parts based on demand."

Powerful embedded PC and the future potential of EtherCAT P

The data is collected and processed centrally – and the specified alarm thresholds are monitored – using a CX5140 Embedded PC with TwinCAT software

(TwinCAT 3 PLC and TwinCAT 3 Modbus TCP). The CX5140 can automatically transmit warnings, alarms, and information regarding the detection of faulty sensors by email. To track trends, Modbus can be used to permanently store and transmit statistical values of the measurement data (interval data) to the customer's in-house monitoring system. When alarm limits are exceeded, the raw signals are temporarily stored for later error analysis. "The process of defining limit values for vibrations and temperatures is quite complicated. These parameters differ from one workpiece to another, even in the case of good parts," adds Dr. Ries. "However, when using a PC-based control platform – i.e., machine control and measurement technology are integrated into one system – the CMS always detects which workpiece is currently being processed. This means that the limit values can be precisely defined for the workpiece in question. What's more, the CX5140 Embedded PC provides sufficient computing power even for extensive condition monitoring applications. EtherCAT Terminals can be attached directly to the DIN rail-mountable IPC, which enables extremely compact CMS solutions."

For future projects, Wölfel Engineering is currently examining the efficiency potential of the EtherCAT P single-cable solution, which combines EtherCAT communication and power on a 4-core standard Ethernet cable. In this case, the corresponding CMS could be implemented with the EPP3174-0002 or EPP3752-0000 EtherCAT P Box modules, the EK1322 EtherCAT P junction, or the EK1310 EtherCAT P supply.

Dr. Marcus Ries, Head of Vibration Measurement and Reduction at Wölfel Engineering: "PC-based control from Beckhoff considerably simplifies the product-related definition of limit values in the CMS by integrating machine control and measurement technology."



More information:

www.woelfel.de/en

www.beckhoff.com/measurement

www.beckhoff.com/ep3752-0000

The CX5140 Embedded PC – with directly attached EtherCAT Terminals and EP3752-0000 I/O box modules connected via EtherCAT – reliably collects all the data required for condition monitoring.





AJYa Vacuum Technology from China specializes in vacuum-assisted die casting technologies for light-weight and structural parts in the automotive industry.

A CP2924 multi-touch Control Panel offers a clear overview of the current system status as well as zoom and swipe functions for convenient operation on 24 inches in portrait orientation.



PC-based control for vacuum die casting of automotive parts

High die casting quality through optimum control of vacuum generation

In die casting, vacuum generation in the shot chamber and mold cavity helps to avoid air and gas inclusions in the castings, as these would impair the stability of the finished parts. For this purpose, AJYa Vacuum Technology from China developed a complex but particularly effective multi-stage solution. A suitable control platform was implemented in cooperation with the automation partner Beckhoff.

Suzhou AJYa Vacuum Technology Co., Ltd., based in the Suzhou metropolis in the Jiangsu province, has been focusing on applications for die casting and injection molding systems since the foundation in 2010. Striving to meet the needs of customers and the market for the latest technologies, AJYa has consistently invested in research and development. That enabled the company to develop in-house a new generation of hydraulic vacuum valves, mechanical

hydraulic valves, mechanical valves as well as the HG series of high vacuum systems, the SP series of ultra-high vacuum systems and integrated multi-functional systems. This enabled breakthroughs for lightweight construction, which is becoming increasingly important in the automotive industry, in the areas of die casting, development and design of structural components and corresponding production technologies.

In 2021, the development team at AJYa focused on the field of integrative casting and broke through the bottleneck of multi-stage vacuum control for the die casting process. In cooperation with Beckhoff, AJYa developed a reliable and effective automation platform using PC-based control technology. The result is a control system that synchronizes all phases in the sequence flow of the multi-stage evacuation process. For that purpose, it accurately monitors and analyzes all key data such as the vacuum pressure in the mold cavity and shot chamber, the speed of the plunger rod and the contamination of each die during ongoing production. The resulting high vacuum of less than 50 mbar increases the yield strength of the castings by 10 to 15% and the corresponding elongation by 30 to 40%. The combination of multiple linked vacuum valves reduces the leakage risks and optimizes the vacuum generation. The machines offer a variety of production modes to help implement the suitable settings for maximizing the output of high-quality products.

AJYa has relied on hardware and software products from Beckhoff in various projects for motion control and high-precision measurement applications starting from 2010. The openness and expandability of the modular PC-based control technology from Beckhoff then enabled AJYa to realize the innovations and functional optimizations of the die casting vacuum control and leak detection system for the molds.

Innovation through flexible control technology

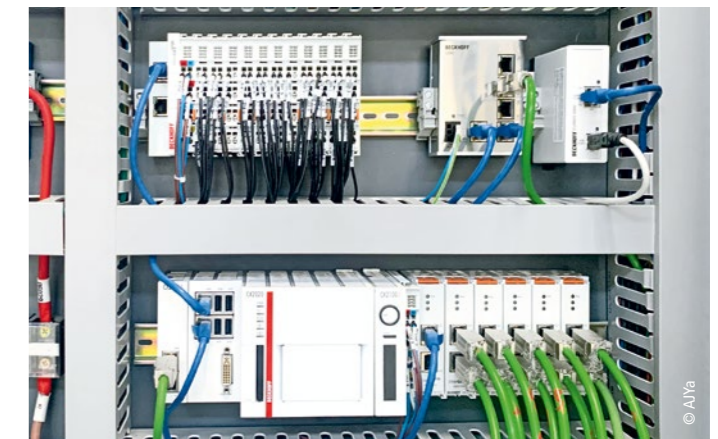
A powerful CX2020 Embedded PC with Intel® Core™ processor is used to control all system components. The control system also uses a large number of EtherCAT Terminals for digital and analog I/O signals as well as EK1122 junctions. Here, AJYa benefits from the Hot Connect function of EtherCAT through the flexible and reliable connection of multiple substations. The EL6631-0010 (PROFINET RT controller terminal) as well as the EL6692 EtherCAT I/O modules (EtherCAT bridge terminal) provide flexibility for high-speed communication with other devices.

The parameters required for system operation are mapped on the VacuMaster management software developed by AJYa in-house, which is integrated with TwinCAT automation software from Beckhoff via an ADS driver. On that basis, device information and process data from all units within the system are monitored, stored and analyzed.

A multi-touch CP2924 Control Panel is used for operation and monitoring of the system on site. According to Jinping Sun, an engineer at AJYa, the operator benefits from the advanced multi-touch functionality with convenient zoom and swipe functions. The visualization on the 24-inch display offers the operator a clear overview of the current system configuration.

Wengang Dai, Technical Director of the Technical Center at AJYa, explains the advantages of PC-based control technology from Beckhoff: "We have relied on PC-based control technology from Beckhoff since 2010. One of the main reasons for this is that the engineering environment enables the efficient development, debugging and reproduction of basic automation projects. The second reason is that the wide range of I/O modules from Beckhoff facilitates efficient design of the hardware configuration. What's more, it can be integrated with our customers' IT systems quickly and reliably. In addition, the modular structure and optimal openness of the control system offer great efficiency and flexibility. This means that Beckhoff components can be used in virtually all applications – as well as in our customer projects."

The AJYa experts Jinping Sun and Wengang Dai next to an SP series ultra-high vacuum system, where a PC-based control platform ensures optimum control of the multi-stage vacuum generation in automotive die casting machines.



A CX2020 Embedded PC and a variety of EtherCAT Terminals enable the acquisition of digital and analog signals for the precise monitoring and analysis of process parameters in vacuum die casting machines.

More information:

www.ajy-china.com

www.beckhoff.com/automotive



© Nordfels, Edmund Jenner

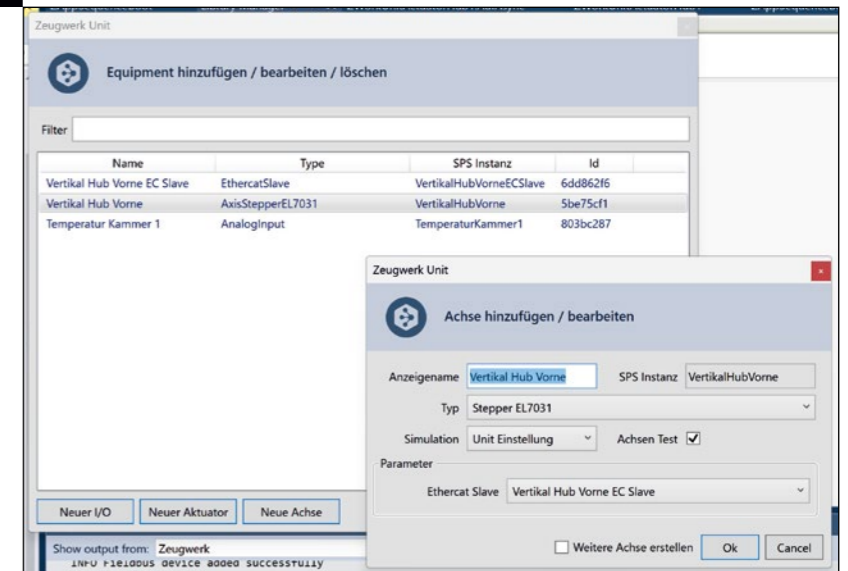
“With Zeugwerk Framework and Zeugwerk Creator, we are bringing many elements of state-of-the-art software development into the world of control software to facilitate a standardized, holistic, and sustainable development approach,” explains CEO Matthias Pfurtscheller. A broad spectrum of Zeugwerk customers are set to benefit from this approach, ranging from custom and series machine builders to automation specialists and machine operators. Furthermore, the Services division provides customers with access to expertise in implementing specific solutions and using modern software paradigms such as CI/CD tools and unit testing.

According to Matthias Pfurtscheller, the extent to which users can benefit from state-of-the-art software engineering can be illustrated by the following prime example: “The mechanical engineering company Nordfels recognized several years ago that standardization in the development process provides a clear advantage in terms of speed and quality when implementing machine projects. This makes it an ideal customer for Zeugwerk, on the one hand because Nordfels is already familiar with the potential benefits of a standardized development process, and on the other hand because we can provide immediate assistance in implementing new possibilities offered by TwinCAT and state-of-the-art software development.” This project was backed by the comprehensive support of the Austrian Beckhoff sales offices in Hagenberg and Innsbruck, with the experienced experts Klaus Wurm and George Hampel, along with the associated Beckhoff support specialists.

TwinCAT as an open and state-of-the-art software platform

Zeugwerk can already draw on 20 years of TwinCAT experience and has been an active Beckhoff Solution Provider since 2022. According to Matthias Pfurtscheller, the open Beckhoff control platform makes it possible to efficiently implement modern software paradigms such as object-oriented programming,

Example Nordfels production line



Standardized application development seamlessly integrated into TcXaeShell

TwinCAT as the basis for state-of-the-art software engineering in automation

Handling increasing software requirements while enhancing engineering efficiency and quality

Software company Zeugwerk GmbH, headquartered in the Austrian town of Wattens, is convinced that state-of-the-art software engineering is becoming an increasingly important factor in automation. They believe this is the only way for machine builders to cope with the increasing demands on automation software despite the looming shortage of skilled workers, while at the same time increasing the speed and quality of project implementation. This mindset is what prompted Zeugwerk to launch its Framework and Creator products, which are based on TwinCAT from Beckhoff and used by machine builder Nordfels GmbH in Bad Leonfelden, Austria, among others.

© Zeugwerk



Zeugwerk managing directors Matthias Seehauser (left) and Matthias Pfurtscheller are also positioning themselves as Beckhoff Solution Providers in Austria.

code generation, and test automation. By offering all the necessary interfaces and including an API with its products, Beckhoff opens the door to contemporary methods in the development of control software. He continues, "TwinCAT provides the foundation for implementing state-of-the-art development approaches with the possibility to address both engineering and runtime automatically via corresponding interfaces. The TwinCAT Automation Interface and the PC-based control platform represent important components in this regard."

Zeugwerk defines software engineering as a holistic and sustainable approach to the entire life cycle of a software product. The aim is to achieve a comprehensive level of standardization, from the requirements analysis and project planning through to the implementation, commissioning, and use of the software along with the accompanying support. The company believes this is the only way to maintain – or even increase – the quality and speed of development in spite of increasing requirements and a shortage of skilled workers. Matthias Pfurtscheller explains, "We operate on the principle of 'Do what works to develop better software faster.' Rather than trying to reinvent the wheel, we incorporate elements from IT into the world of automation technology." It is also very important for the software developers to see an immediate benefit in their own daily work and not feel overwhelmed by new or changed ways of working.

Simplifying software development processes

In the world of software development, the use of frameworks has proven to be key to simple and efficient workflows. Frameworks define large parts of

the structure and architecture of a software product with templates, libraries, and standard modules. This allows software developers to concentrate on the functional and project-specific requirements in programming while working with a standardized software architecture. Framework-based development is already standard in the IT world; however, Zeugwerk's experience shows that this approach to control development is still relatively new. Nevertheless, the advantages are clear, since the predefined, often modular structure provides additional support for standardized practices in project planning and commissioning. Furthermore, standardization through framework-based software development offers significant potential and numerous opportunities to automate various steps in the development process, including documentation, testing, delivery, and code generation.

Zeugwerk Framework is a standardized application template along with various libraries that offer extensive functions for application development. It covers standardized aspects such as communication, data, functional units, and various modules for implementing machine processes. Zeugwerk Creator is an extension of the TwinCAT development environment TcXaeShell, which significantly simplifies and accelerates application development through context-specific menus, dialogs, and functions, as well as through standardization with Zeugwerk Framework. Regarding the integration as a plug-in, Matthias Pfurtscheller adds, "Expanding TcXaeShell with Creator allows for seamless integration with Zeugwerk Framework to establish consistent, fast, and error-free workflows. The primary advantage here is that the existing, familiar

development environment is enhanced with new features for standardized application development, thereby minimizing the familiarization time. As a result, application engineers never have to leave the TwinCAT environment." The TwinCAT Automation Interface has simplified the integration process, serving as the necessary interface to the Visual Studio or TcXaeShell engineering environment and enabling programmatic access to a TwinCAT project. In conclusion, integration would never have been possible without the TwinCAT Automation Interface.

Clear advantages for machine building

Another advantage of the TwinCAT Automation Interface, as highlighted by Matthias Pfurtscheller, is the automatic code generation, which speeds up development significantly. Configuring plant software with the corresponding modules and typically very similar structure can be achieved much faster in this way. Users can then continue programming and refining in the familiar TwinCAT environment. Matthias Pfurtscheller goes on to explain that, "Users can configure their applications using the Zeugwerk Creator functions without having to write a single line of code. The structure of the application is always the same and can be created on a project-specific basis in no time. Automatically generated test environments for commissioning and backup/restore options for data are further advantages afforded by the integration and use of Creator. Nordfels was able to cut the time needed to create a major machine project from several days to just a few hours, for example."

Tasked with tackling this project for machine builder Nordfels, Zeugwerk developed a custom extension for TcXaeShell that enables the automatic, menu-driven generation of the PLC for a machine project. This offers dialogs for creating stations and substations, which subsequently perform the generation of all necessary code segments. This additional functionality can be used in the TcXaeShell development environment as if it were part of TwinCAT. Further functions, such as the creation of a new station, are offered as menu items in the TcXaeShell in the appropriate places to naturally add application parts to a Nordfels PLC. According to Matthias Pfurtscheller, this approach ensures that the additional functionality is actually used, as the benefits are significant and the barrier to entry is minimal.

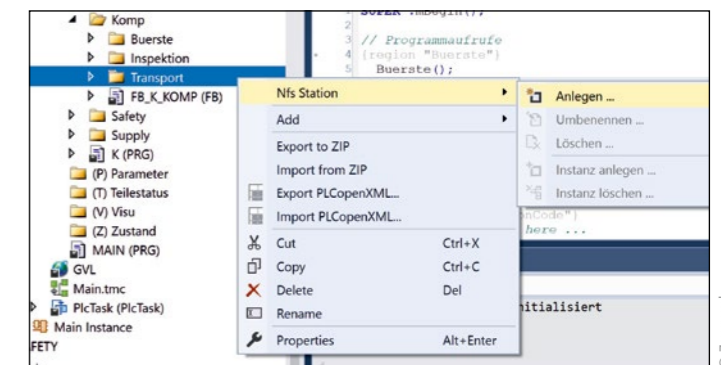
Edmund Jenner, CEO of Nordfels, confirms the benefits as follows, "The introduction of modern software paradigms has made cross-team and cross-project software creation possible in a meaningful way, which opens up completely new perspectives for us in terms of further development and reuse of each individual software project." Nordfels has gained a quality, speed, and reusability advantage for every future automation project thanks to this unique development, while also consolidating consistent, standardized workflows across the entire team.

```

1 // This function block is a container for all I/O that are used by this unit.
2 // The parent of all objects can be directly transferred in their constructor (f
3 // that have to be managed (e.g. [DebounceInput] (xref:ZEquipment.DebounceInpu
4 FUNCTION_BLOCK TransportIo EXTENDS TransportContainer
5 VAR
6   (attribute 'hide')
7   _ioBridge : ZApplication.IoBridge(_parent);
8 END_VAR
9 VAR_INPUT
10
11 (region "TemperaturKammer1 : AnalogInput")
12   TemperaturKammer1 : ZEquipment.AnalogInputInt;
13   (attribute 'Zid' := '517897b2-f947-44eb-9645-23dd029915e1')
14 (endregion)
15
16 IF isInitialized
17 THEN
18   RETURN;
19 END_IF
20
21 _ioBridge.SetLogger(_parent._logger);
22
23 (region "TemperaturKammer1 : AnalogInput")
24   TemperaturKammer1.SetLogger(_parent._logger);
25   TemperaturKammer1.SetName('Temperatur Kammer 1');
26   TemperaturKammer1.SetSimulation(on:=_parent._data.Config.Simulated);
27   TemperaturKammer1.SetConversionParameters(terminalMin:= 4, terminalMax:= 20,
28     elecMin:= 10, elecMax:= 20,
29     physMin:= 2, physMax:= 6,
30     physicalUnit:= 'bar');
31
32   TemperaturKammer1.SetTerminalResolution(resolution:=16);
33   _ioBridge.AddAnalogInput(TemperaturKammer1, publish := _parent._com.Publish.Eq
34 (endregion)
35
36 (region "UserInitCode")
37 // put your individual init code for this I/O here
38 (endregion)
39
40 (attribute 'Zid' := '517897b2-f947-44eb-9645-23dd029915e1')
41 (endregion)
42
43 (attribute '_ZwPlcUnitEquipmentImplementation_') // Do not remove this attribut
44
45 _isInitialized := TRUE;

```

Code generation combined with object orientation and libraries forms a stable foundation.



Context-specific menus facilitate consistent, fast, and error-free working methods.

More information:

- www.nordfels.com
- www.zeugwerk.at
- www.beckhoff.com/twincat



ETG celebrates 20 years of organization and technology

The members of the ETG Board and Technical Committee at the EtherCAT Anniversary Meeting

20 years of EtherCAT and 20 years of EtherCAT Technology Group (ETG): This is something to celebrate. To mark these milestones, Beckhoff invited guests to a gala dinner in the "Kaisersaal" of the Grand Hotel Kaiserhof Victoria in Bad Kissingen. The ETG Board of Directors, the Beckhoff team working at the ETG headquarters in Nuremberg, EtherCAT developers from the very beginning, and members of the ETG Technical Committee and the Marketing Committee were among those who have made a decisive contribution to the success of EtherCAT.

The committee meetings took place around the festive evening: Both the Technical Committee and the Marketing Committee meet twice a year to discuss the results of the various technical working groups and to coordinate the worldwide marketing activities of the organization. Participants came from as far away as Japan and Korea.

Martin Rostan, Executive Director of the ETG, looked back on 20 years of EtherCAT and EtherCAT Technology Group in his tongue-in-cheek keynote speech: from "Fast Lightbus" to EtherCAT, from the ETG start with 33 found-

ing members to the world's largest fieldbus organization with almost 7,400 member companies from 73 countries, and from zero to 60 million EtherCAT devices. 213 ETG trade fair booths, 175 roadshows in 51 countries, 59 Plug-fests, countless working group and standardization meetings and, of course, the diverse work of the ETG teams contributed numerous entertaining photos, anecdotes and remarkable experiences. Martin Rostan thanked the Beckhoff developers for preparing what is recognized as the best fieldbus technology for the ETG for dissemination and further development, the ETG team for 20 years of dedicated collaboration, as well as the ETG board and committee members for helping to shape the organization and the technology – and ETG honorary member Hans Beckhoff for consistently opening up EtherCAT and his diverse support of the ETG.

In his welcoming speech, Hans Beckhoff first highlighted the role of the original development team, which has achieved extraordinary things. He then congratulated the ETG team on their success and thanked them for their energetic work over the past 20 years.



Keynote speech by Martin Rostan (left), Executive Director of the ETG, during the gala dinner celebrating 20 years of EtherCAT

More information:
www.ethercat.org



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