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# PCcontrol

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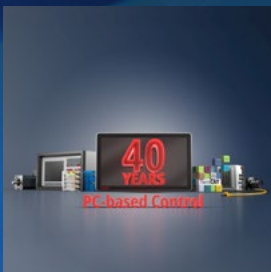


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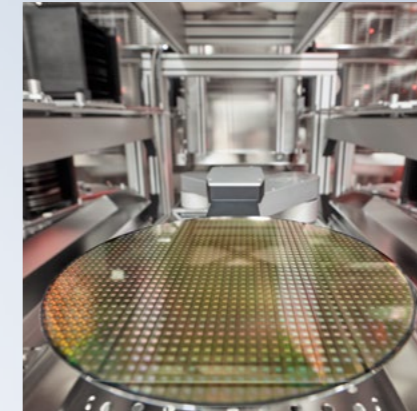


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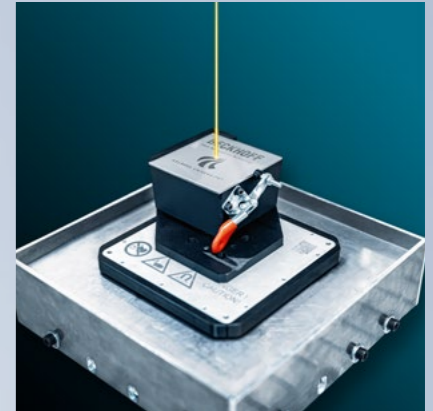
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33415 Verl/Germany  
Phone: +49 (0) 5246 963-0  
info@beckhoff.com  
www.beckhoff.com

Project management/editor: Stefan Ziegler

Editors: Mathis Bayerdörfer  
Stefan Kuppinger  
Vera Nosrati

Phone: +49 (0) 5246 963-140  
editorial@pc-control.net  
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Automation technology builds a bright future for machine and system engineering

# Beckhoff Automation increases global sales to 1.24 billion euros

Beckhoff Automation has closed the 2025 financial year successfully and has increased its global sales to €1.24 billion, with 6% growth compared to the 2024 financial year.

"2025 was a solid financial year for Beckhoff," summarizes Hans Beckhoff, Managing Director and Founder of the family-run high-tech company. He continues: "We have left the impact of 2023 and the resulting downturn in 2024 behind us." Global order intake increased over the course of 2025. Beckhoff currently assumes that the economy will experience a new growth phase two years after the start of the current cyclical crisis in many areas of the world.

### PC-based control as a cross-industry automation concept

For 46 years, the family-owned company has won customers over with the continuous development of its hardware and software portfolio for PC-based automation technology. The holistic product range forms the basis for universal, industry-independent automation solutions that can be flexibly adapted to the requirements of individual industries. "We are delighted that our software-based automation philosophy continues to gain significance on the market and is being used in more and more applications around the world," says Hans Beckhoff. He continues: "It is clear that our newer product lines, such as the MX-System for control cabinet-free automation, are also meeting with high demand from customers and interested parties, thereby contributing to our company's growth."

### 80 million euros for research and development

As in previous years, Beckhoff invested around 80 million euros in research and development in 2025 and plans to continue investing at the same rate in 2026. As a financially independent company, Beckhoff thus lays the foundations for driving technological innovations forward in the long term. "By merging information technology and automation and implementing the latest hardware and software technology in our products, we continue to provide the industry with pioneering and powerful automation solutions," states Hans Beckhoff. He explains that current developments, particularly in AI, are leading to new features, tool chains, and business models, which Beckhoff will present at this year's Hannover Messe.

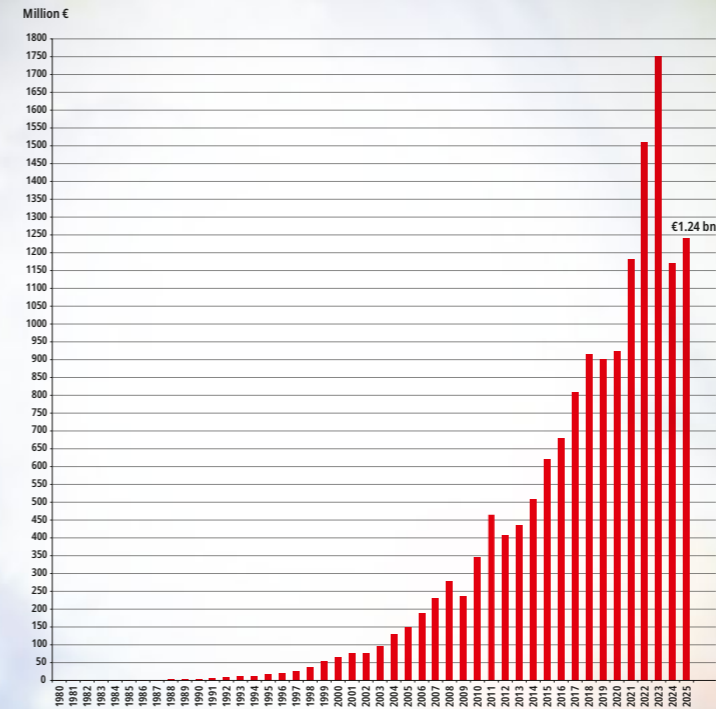
### In-house expertise and cultivation of young talent

Beckhoff's stable and highly qualified work force is key to assuring that their products are a success in terms of their development, manufacturing, and sales. Currently, the family company employs 5,450 workers worldwide, of which 2,000 are engineers. Beckhoff is active in over 75 countries, with 23 branches in Germany and 41 international subsidiaries and representative offices.

Beckhoff places great importance on training and educating their talented employees in order to consistently meet the continuous need for qualified specialists. In the summer of 2025, 61 young people started their careers at Beckhoff. 32 of them started an apprenticeship. 29 students started a work-integrated study program in cooperation with the Bielefeld University of Applied Sciences and Arts (HSBI), Gütersloh campus. The company currently employs a total of 116 apprentices and 110 students. With its diverse range of nine apprenticeships and four bachelor's degree courses, Beckhoff is focused on developing young people with a passion for technology and thus investing in the future of the region.

### Outlook for the 2026 financial year

Beckhoff expects to see stable development over the 2026 financial year. "Since October 2025, we have noted that the trend has been positive again, with strong progression in the first quarter of 2026," reports Hans Beckhoff, continuing, "we seem to have gotten past the international economic crisis. However, the current global political situation still harbors uncertainties for the 2026 forecast." Overall, Beckhoff is nevertheless optimistic about the future and continues to focus on sustainable business development through its powerful PC-based automation technology for international machine and system engineering.



Since 2000, Beckhoff Automation has recorded average annual growth of around 13%.

Hans Beckhoff, Founder and Managing Director of Beckhoff Automation:

“ We develop high-tech products because we have a calling to do so; with our automation technology, we enable the global machine and system engineering industry to solve today's complex control problems and shape the industry of tomorrow.”



German Chancellor Friedrich Merz visits Beckhoff Automation at Hannover Messe

# Physical AI captivates the political and industrial world

During the traditional opening tour of Hannover Messe on April 20, 2026, German Chancellor Friedrich Merz visited Beckhoff Automation, a high-tech company. At the Verl-based family company's booth, its founder and Managing Director Hans Beckhoff, together with his children Frederike Beckhoff and Johannes Beckhoff, provided exciting insights into how artificial intelligence is being implemented in industrial production.

This year, the world's leading exhibition for industry opened its doors in the capital of Lower Saxony under the motto "Think tech forward". The Federal Chancellor was accompanied by a delegation of around 50 other guests, including his wife Charlotte Merz, Katherina Reiche, Federal Minister for Economic Affairs and Energy (CDU), Olaf Lies, the Minister-President of Lower Saxony (SPD), and Valdis Dombrovskis, Commissioner for Economy and Productivity at the European Commission, along with around 100 journalists. Frederike Beckhoff, Corporate Development at Beckhoff Automation, welcomed the guests and introduced them to the family-run technology company, the principle of PC-based control, and the products required for this, as well as the fields of application for automation technology.

Physical AI up close and personal: ATRO, the modular industrial robot, greets Brazil, this year's partner country for Hannover Messe.



## Federal Chancellor welcomes Brazil, partner country to Hannover Messe, with physical AI

Johannes Beckhoff, Product Management at Beckhoff Automation, then presented Beckhoff's key topic for Hannover Messe 2026 to the visitors: the fusion of artificial intelligence and classic machine control as the basis for physical AI. He showed how machine programming and control itself can be executed by AI using a technology demo in which pieces with numbers and letters could be moved by ATRO, the modular industrial robot. The AI runs completely locally in the machine, independent of cloud services. "This means that the machine operators have sovereignty over the AI and also over their data," says Johannes Beckhoff. The Federal Chancellor entered a text command into the AI, which is integrated into the TwinCAT automation software, telling it to create a greeting for Brazil, the partner country for Hannover Messe, from the letters in the demonstrator. The AI then executed the task by giving a real-time command to the robot via the control system: form the words "Bom dia Brasil" (Hello Brazil). Johannes Beckhoff explains: "We've given the machine a real brain. This machine brain illustrates how AI not only generates text or images, but can also interact with the physical world." This application showed the guests that LLMs (large language models) moved out of the chat window a long time ago and can now intervene in real movement sequences. Beckhoff has truly proved that physical AI will fundamentally change the industry and holds immense potential for machine and system development.



A visit to the Beckhoff booth within the scope of the Chancellor's opening tour of Hannover Messe: Johannes Beckhoff (Product Management, Beckhoff Automation), Charlotte Merz, Katherina Reiche (CDU, Federal Minister for Economic Affairs and Energy), Olaf Lies (SPD, Minister-President of Lower Saxony), Federal Chancellor Friedrich Merz (CDU), Valdis Dombrovskis (Commissioner for Economy and Productivity at the European Commission), Hans Beckhoff (founder and Managing Director of Beckhoff Automation), and Frederike Beckhoff (Corporate Development, Beckhoff Automation) (from left to right).



For 40 years, PC-based control technology has laid the technological foundation for all Beckhoff automation components and solutions.

A success story celebrates two anniversaries

# 40 years of PC-based control and 30 years of TwinCAT

When Beckhoff elevated the industrial computer to the status of a central control system four decades ago, a paradigm shift occurred. For 40 years, PC-based control has been putting the power of IT standards and Moore's Law directly into the hands of machine and system engineers. The introduction of TwinCAT in 1996 marked another decisive evolutionary step for the model for success that is PC-based control. With the switch from DOS to Windows, programming in accordance with IEC 61131-3, and integrated engineering, Beckhoff created a future-proof solution based on the principle of separating hardware and software and today serves as a platform that integrates all automation functions.

In the 1980s, industrial production was characterized by the classic, hardware-based PLC. The PLC was considered reliable, but on the downside, it was inflexible and expensive, with limited computing power. In 1986, Beckhoff responded to these limitations by delivering the first PC-based machine control system, which gave the target application – a double miter saw – a significant boost in productivity.

## Separation of PLC and hardware

The decisive technological step was the abstraction of the PLC function from proprietary hardware to a highly flexible solution based on industrial IT components. Beckhoff ensured deterministic behavior by developing its own real-time extensions for standard operating systems – mainly Windows initially, but also others since then, including TwinCAT/BSD and Linux®. Machine builders were thus able to benefit directly from the rapid innovation cycles in IT and increasing processor performance. In the 1980s, for example, PC-based control brought floppy disk drives directly to the machine. Later, Ethernet

communication opened up new possibilities in production and for integrating production into databases, ERP systems, and IoT solutions. Today, PC-based control forms the basis for physical AI in the factory.

## High-speed communication

Appropriate I/O systems were required in order to use the ever-increasing computing power of industrial PCs up to field level. Beckhoff therefore flanked PC-based control with its own communication systems. Initially, data transmission took place via Lightbus. Introduced in 2003, EtherCAT has since become a global standard that is deployed by users across all industries and markets today.

From today's perspective, the concept for success that is PC-based control impresses with its exceptional scalability and significant reduction in interfaces. "A high-performance industrial PC, an equally powerful fieldbus interface with peripheral devices such as sensors and actuators connected to it, and control

software with real-time capabilities for motion and logic control – that's all it takes," sums up company founder and Managing Director Hans Beckhoff. This approach provides the capability to consolidate all machine functions – from a simple PLC to highly complex robotics – into a single controller. As well as saving space, time, and money, this also eliminates latency between distributed controllers.

In line with the Beckhoff philosophy, Beckhoff has been developing and manufacturing all electronic assemblies and motherboards itself in Westphalia since the 1980s, to the highest quality made in Germany standards. This not only offers users security and long-term availability, but also enables them to continue implementing the latest IT standards and processor generations in machine building.

## Basis for physical AI

Four decades after the launch of PC-based control, the industry is increasingly turning away from proprietary black box solutions and focusing on the future viability of open, standardized systems. After all, PC-based control technology provides an ideal basis for the required IT/OT convergence as well as for leading technologies such as machine learning and physical AI. As it celebrates its 40th anniversary, PC-based control is credibly able to assert itself as providing a future-proof and high-performance foundation for the manufacturing industry.

## TwinCAT as the functional core

By abstracting the control function from proprietary device hardware, Beckhoff achieved a paradigm shift in automation as early as 1986. Building on this, the market launch of The Windows Control and Automation Technology (TwinCAT for short) 30 years ago completed the basis for the success PC-based control enjoys today. TwinCAT provided a means for transferring IT standards to automation and building them into an integrated, high-performance, and deterministic control platform with real-time extensions – initially with a focus on Windows, but since then also on operating systems such as TwinCAT/BSD and Linux®. In addition, Beckhoff combined all the engineering in a single software concept and supported globally established PLC programming conforming to IEC 61131-3, as well as IT standards including C, C++, MATLAB®, and Simulink®.

For 30 years, TwinCAT by Beckhoff has provided an integrated software foundation for future-proof PC-based control technology across all industries and automation functions.



Right from the start, TwinCAT has been characterized by outstanding performance data: PLC cycles were radically shortened to as little as 100 µs and main memory was suddenly available in almost unlimited quantities. TwinCAT also offered extremely powerful motion functions right from the outset, from simple standard axes to electronic gearing and cam plates to 5-axis CNCs. The number of axes that could be controlled grew every year, from 10 to 50 to 100 to over 1,000 axes today, with the cost per axis sinking simultaneously. With the concept of the all-electric machine, more powerful, more precise, and more efficient solutions could be implemented early on. Even back then, this visionary software-centric approach liberated machine builders from the narrow performance limits of conventional control hardware in a way that would stand the test of time.

## Openness and functionality

A key way in which the TwinCAT architecture adds value results from its openness, which consolidates the full spectrum of automation in a single software concept. While the focus was initially on PLCs, motion control, and I/Os, the platform now comprises well over 100 highly specialized functions, including functions for high-performance measurement technology, control technology, and communication. All machine functions are thus calculated deterministically on a central industrial PC and transferred to the I/O level with exact clocking via the high-speed EtherCAT fieldbus. This allows processes to be controlled and regulated with top temporal resolution and accuracy. In terms of practicality, the installation work, space required in the control cabinet, and overall costs are all reduced.

The performance capability of advanced industrial PCs also facilitates seamless integration of many other high-end technologies. Machine vision with TwinCAT Vision and system-integrated robot control are anchored in the software as native runtime modules. Implementing artificial intelligence is rapidly increasing in importance. The TwinCAT Machine Learning Creator can be used to generate AI models for analyzing image data, time series, and process data without any previous experience or prior knowledge, making local monitoring solutions and anomaly detection possible directly in the control environment. The TwinCAT CoAgent assistance tool supports users throughout the entire life cycle – from engineering to live machine operation.

## Fit for the future with PC-based control

As the software-centric design of the architecture continues to work on the inherent principle of scalability and convergence with IT, even three decades after its market launch, users are well equipped for future challenges with TwinCAT. PC-based control in total provides an ideal foundation for deep IT/OT integration and integration into cloud or edge infrastructures. Whether physical AI, new communication standards, or stringent cybersecurity concepts – TwinCAT adapts all new market requirements as a modular framework. At the same time, machine builders are safeguarding their ability to innovate in the long term thanks to the combination of computing power, availability, and openness.

More information:

[www.beckhoff.com/technological-milestones](http://www.beckhoff.com/technological-milestones)

40 years of PC-based control: A paradigm shift makes history

# Faces of innovation

PC-based control celebrates its anniversary. What began as a technological paradigm shift has developed into a genuine success story over the past 40 years. Yet behind this story are not only innovative technology and the courage to do things differently, but also special people who have been passionate about automation for years and even decades. We are speaking to these pioneers of PC-based control in this and the next issue of PC Control to hear how the success story of PC-based control is reflected in the work they do every day.

## Roland van Mark, Senior Product Manager Industrial PCs

### Relentless increases in performance

I have been familiar with Beckhoff products for more than 30 years and actively involved in the success of our industrial PCs, panels, and Panel PCs for more than 20 years. PC-based control is both a blessing and a curse for us in IPC product management.

Why? One component of the success of PC-based control is the continuously increasing performance of CPUs. Driven by global use, tech giants such as Intel and AMD are developing more powerful processors at reasonable price points year on year. What a blessing it is when the key component of your own solution is being improved, optimized, and made more powerful at a seemingly unstoppable rate. At the same time, however, it is also a curse, because turning globally available CPUs into reliable PC-based control hardware requires a great deal of know-how and extensive integration work. External environmental conditions, external electromagnetic interference, the support of special

interfaces that were often developed many years ago, 24/7 continuous operation, the highest demands on the real-time behavior of the CPUs, and the availability of a CPU over many years are just some of the tasks that need to be solved.

However, if you systematically overcome these and other challenges time and time again, you can enjoy uninterrupted technological progress and increased performance. This is how the outstanding capabilities of PC-based control have become the catalyst for a successful global hardware business.

What a blessing that we invented PC-based control 40 years ago and have been offering unique, high-performance automation software in the form of TwinCAT for 30 years. A real win-win situation not only for us, but also for our customers!



“PC-based control and TwinCAT are a real win-win situation not only for us, but also for our customers!”



## Andreas Thome, Senior Product Manager Embedded PC

### Long-term availability as a key strength

Embedded PCs are an important pillar of the PC-based control philosophy by Beckhoff. The basic idea of moving the industrial PC to the DIN rail was born in the early 2000s and was first implemented as a series product in 2003. The aim was to create a PC-based controller with the smallest possible dimensions, direct connection of bus terminals, and a flexible embedded Windows operating system. This concept has given rise to a broad portfolio of embedded PCs that still stand out today due to their special properties: compact design, flash memory, embedded operating systems, scalable CPU portfolio, direct I/O integration, modular expandability, fanless design whenever possible, and a wide range of optional interfaces.

Long-term availability of at least ten years – followed by a 10-year service period – is one of the key strengths of the CX series from Beckhoff. The very first device, the CX1000, serves as the best example of this: It was not discontinued until 2024 and was therefore available on the market unchanged for as long as 21 years. This exceptionally long availability is only possible because Beckhoff develops and manufactures all the electronics for the embedded PCs, including motherboards, in-house.

The CX series Embedded PCs have continuously and significantly promoted the spread of PC-based control: Their compact, PLC-based form factor appeals to traditional control engineers, while their fully-fledged PC capabilities combined with TwinCAT automation software tick all the right boxes.

“The basic idea of moving the industrial PC to the DIN rail was born in the early 2000s and first implemented as a series product in 2003.”

## Josef Papenfort, Product Manager TwinCAT

### Mapping machines completely in software

TwinCAT is the central element of PC-based control. Alongside IPC, I/O, and drives, it is the software that connects all components and allows them to work in perfect synchronization. TwinCAT transforms a PC – regardless of the underlying operating system – into a powerful control system that combines PLC, motion control, safety, measurement technology, vision, and AI functions. All of this is built on the real-time capability that TwinCAT has been providing for different operating systems for the last 40 years.

field of PC-based control technology in the world. With PC-based control and TwinCAT, the machine or system can be completely mapped in software – the entire expertise of the machine builder is contained in the application software. This means that the machine builder remains independent of hardware device and operating system. TwinCAT users have been enjoying this benefit for three decades already.

While PC-based control technology was ridiculed in its early days many years ago, it is now an established standard. With TwinCAT, we have significantly shaped and continuously developed this standard. Today, TwinCAT is the most widely used tool in the

“While PC-based control technology was ridiculed in its early days many years ago, it is now an established standard.”



“PC-based control and EtherCAT: a perfect symbiosis of maximum computing power and highest communication speed.”



Kai Ristau, Head of International Sales

#### Innovative capability without proprietary boundaries

Whenever I talk to customers and partners in international markets today, the extent to which PC-based control has influenced Beckhoff's worldwide success is made clear time and time again. From the very beginning, the principle of PC-based control was more than just a change in technology – it was a real paradigm shift in automation.

Today, around two thirds of the Beckhoff sales are generated outside Germany. The underlying reason is the openness and flexibility of PC-based control. Beckhoff connects “Made & Manufacturing in Germany” with powerful standard hardware and intelligent software, enabling the company to take a flexible approach to delivering solutions to a wide range of requirements in various locations all over the world – from semiconductor production in Asia to packaging machines in North America and highly automated production systems in Europe.

Martin Rostan, Senior VP Technology Marketing

#### New dimensions for high-end automation

The change from conventional PLC to PC-based control technology marked a quantum leap in automation. PC-based control is scalable, flexible, and offers virtually unlimited computing capacity. Its power supports sophisticated control algorithms, multi-axis control, image processing, and sophisticated application programs in a single control system. And all this while achieving cycle times of less than a millisecond.

In comparison, traditional PLC architectures – as well as conventional fieldbuses and almost all industrial Ethernet systems – require several milliseconds. This may be sufficient for very simple control tasks, but for highly dynamic machines, precise motion control applications, or synchronized multi-axis systems, every additional millisecond means a measurable loss of quality and performance. Shorter cycle times

ensure faster reactions, higher throughput, greater accuracy, more stable control, and ultimately increased productivity – an advantage that PC-based control makes significant use of. This is where EtherCAT comes into play: As the only fieldbus system that fully supports the performance of PC-based control, it does not create a bottleneck. On the contrary, EtherCAT delivers the ultra-fast communication that this technology demands. The special functional principle of EtherCAT means that it places hardly any load on the PC and requires no additional hardware: It is implemented entirely in software via the existing Ethernet interface.

The result is a perfect symbiosis of maximum computing power and highest communication speed – PC-based control and EtherCAT drive each other to peak performance and open up new dimensions for high-end automation.

“From the very beginning, PC-based control was more than just a change in technology – it was a real paradigm shift.”



The strength of open standards such as Windows, Linux®, and EtherCAT is particularly evident in exports. They facilitate integration into existing IT and production landscapes and create trust among globally operating customers. For many partners, the ability to innovate without proprietary boundaries represents decisive added value.

The customers who have benefited the most are those who recognized the potential of PC-based control early on and consciously took this step – their willingness to break new ground has often paid off quickly. It is precisely this combination of openness, scalability, and innovative strength that has formed the basis for Beckhoff's international success for 40 years.



Marcel Ellwart, Semiconductor Industry Management

#### A single architecture for all applications

The semiconductor industry places the highest demands on precision, real-time capability, reliability, and flexibility. Processes in the nanometer range require precisely synchronized movements, fast processing of large volumes of sensor data, and seamless integration of motion control, image processing, temperature control, and vacuum control.

PC-based control combines open-loop and closed-loop control along with visualization and communication on an open industrial PC platform, with EtherCAT providing support for deterministic and extremely fast data transmission.

The modularity and scalability of PC-based control technology means that all applications – from

laboratory systems to large plants – can be mapped using an identical architecture. The flexible adaptability of the control system means that it can also respond quickly and efficiently to future requirements. This was something that the semiconductor industry recognized many years ago.

In combination with our TwinCAT software, special functions such as vision, safety controller, and AI-based process analysis are already integrated today. The long-term availability of our components and their compact design make Beckhoff PC-based control ideal for use in the semiconductor industry.

“The flexible adaptability of the control system means that it can also respond quickly and efficiently to future requirements.”

Doug Schuchart, Intralogistics Industry Management

#### More flexibility and more protection

In intralogistics, many of the world's largest end customers, including Walmart, Amazon, UPS, and FedEx, are headquartered in the USA. While Europe adopted PC-based control at an early stage, the US intralogistics industry preferred proprietary PLC solutions in the past. This trend is now changing rapidly.

The resilience of the supply chain is a key driver. The global supply chain crisis has exposed the weaknesses of closed PLC platforms. If components were not available, projects came to a standstill, and critical warehouse processes were disrupted. Open PC-based control platforms offer more flexibility and more protection for the supply chain.

The second major change is AI. Unlike previous technology trends that lacked immediate practical applicability, AI is already delivering measurable benefits in warehouse optimization and order

processing. Companies are now realizing that AI-driven forecasting, predictive maintenance, and operational intelligence are becoming key competitive advantages.

The markets for e-commerce and parcel services are highly competitive. The pressure for faster deliveries, reliability, lower costs, simpler returns, and reduced product damage is constantly increasing – while profit margins are shrinking all the time. In response, companies are investing heavily in automation and AI. They are increasingly realizing that traditional proprietary PLC systems neither protect against future supply chain disruptions nor support full AI integration. Open PC-based control platforms have established themselves as the basis for intelligent, adaptable, and highly optimized warehouse processes.



“PC-based control has established itself as the basis for intelligent, adaptable, and highly optimized warehouse processes.”

Open, scalable, and fast: PC-based control technology opens up new performance horizons



# THE 10 major advantages of PC-based control

PC-based control technology provides a basis to help mechanical engineering navigate the fundamental change it is experiencing with the implementation of industrial digitalization. A new level of flexibility and performance is being achieved by seamlessly integrating all automation functions as software modules and relocating them to industrial grade IT hardware. The following arguments clearly show why a universal PC-based control platform is where the future of automation lies.

**1 Software instead of hardware**  
The paradigm shift in PC-based control is based on the fact that automation functions no longer run on dedicated hardware. Instead, PC-based hardware combined with TwinCAT software can take over all tasks. Logic control, motion control, and all other functions are implemented as pure software modules. This saves hardware costs, drastically reduces the space required in the control cabinet, and increases flexibility enormously for future system adaptations.

**2 Hard real time with standard OS**  
A centerpiece of PC-based control is the ability to make standard operating systems such as Windows real-time capable. The TwinCAT real-time system is integrated at kernel level and guarantees deterministic cycle times down to the low microsecond range. As a result, PC hardware can be used for time-critical tasks, minimizing jitter and ensuring that even incredibly demanding control loops run precisely and reliably.

**3 Everything on a single platform**  
Instead of using a separate controller for each discipline, PC-based control combines all automation functions on a single computer: PLC, motion control, communication, measurement technology, vision, and robotics share the same hardware and database. This eliminates communication bottlenecks and dead times between systems, simplifies troubleshooting, and significantly reduces hardware, engineering, and maintenance costs. Even the previously separate worlds of control and safety technology can be seamlessly integrated with PC-based control.

**4 Integration in Visual Studio**  
With the introduction of TwinCAT 3, the automation software was seamlessly integrated into Microsoft Visual Studio, creating a standardized development environment for automation engineers and IT developers alike. Users benefit from professional software engineering tools, modern source code management, automated testing, and end-to-end debugging functions. The strict division between the traditional IT world and the automation level is eliminated in this way.

**5 Multilingual programming**  
The limitations of traditional PLC programming are removed with TwinCAT. Traditional IEC 61131-3 languages (e.g., Structured Text) are still fully supported but can be seamlessly combined with high-level languages such as C and C++. In addition, sophisticated models developed in MATLAB® or Simulink® can be compiled directly and executed in hard real time. This allows the appropriate programming language to be used for each specific automation task.

**6 Multi- and many-core use**  
Modern industrial PCs feature powerful multi-core processors. TwinCAT fully supports this and can, for example, distribute a single application across several cores via multi-thread capability. With TwinCAT Core Boost, the computing performance of individual real-time or user mode cores can also be increased by up to 50% to maximize performance and optimize the system to meet specific requirements.

**7 EtherCAT as a system bus**  
An extremely fast data bus is required to bring the enormous computing power of modern industrial PCs to the machine. For this very purpose, Beckhoff has developed EtherCAT – an open, standardized industrial Ethernet fieldbus that is now widely used all over the world. EtherCAT processes data “on the fly”, enabling cycle times of less than 100 microseconds as well as highly precise synchronization using distributed clocks. The protocol also supports a highly flexible network topology.

**8 Convergence of IT and OT**  
The common PC architecture means that integration with higher-level IT systems is included as standard. With no need for a detour via complex gateways, a PC-based control system can communicate directly with databases or send data to cloud platforms. Standardized protocols such as OPC UA, MQTT, AMQP, or REST APIs are available natively. Last but not least, this also makes PC-based control a suitable and secure basis for industrial AI solutions, edge computing, and predictive maintenance concepts.

**9 High scalability**  
PC-based control offers simple and high scalability. The portfolio includes many different form factors, ranging from embedded PCs through numerous control cabinet industrial PCs and panel PCs, and even the IPC modules of the MX-System for control cabinet-free automation or the control cabinet industrial server with up to 32 CPU cores – all of which are of course suitable for industrial use and have long-term availability. The numerous processors that are available to choose from enable the PC hardware spectrum to be adapted to the specific application in even greater detail and with even more accuracy.

**10 Openness and modularity**  
Beckhoff relies on open IT standards for PC-based control. As a result, automation specialists benefit directly from the rapid increases in performance that the global PC technology market has been making possible for four decades. The system also supports modular concepts in which parts of a machine act as flexible modules. As a result of its openness to numerous fieldbuses, third-party devices can also be integrated with ease.

The new MX-System Designer: An engineering tool for control cabinet-free automation

## “We are drastically simplifying implementation”

With the MX-System, Beckhoff has redefined the hardware architecture of automation and paved the way for control cabinet-free machines and systems. The company is now taking the next logical step: the MX-System Designer web-based engineering tool delivers a structured and technically validated electrical design right from the concept phase. Daniel Siegenbrink, MX-System product manager, reveals exactly how the Designer works and what added value smart project planning, plausibility checks, and the planned integration of AI also offer.

### The MX-System has been around for approximately four years. What was the motivation to launch the MX-System Designer on the market now?

Daniel Siegenbrink: In practice, we are increasingly seeing that the MX-System is fundamentally changing the process of electrifying machines and systems. It was, therefore, a logical step for us to provide our customers with a tool that makes upstream planning much easier and brings it into the digital age. Another driver was our own experience in project planning for modular systems. We have processed almost 1,000 customer inquiries in recent years. Internal software was developed at an early stage to cope with this volume. Without it, we would not have been able to plan the individual solutions efficiently and prepare them in a comprehensible way for our customers. Another key factor is that we hope the Designer will act as a huge disseminator of MX-System syntax on the market. We are drastically simplifying the implementation of the solution. From now on, every user will be able to create their own individual solutions quickly and easily.

### What were the specific challenges for Beckhoff in creating the tool?

Daniel Siegenbrink: For the first time, we are offering an in-depth engineering tool that can be accessed and used directly in a web browser. To achieve this, we had to develop and implement an intuitive operating concept. The conceptual approach is also completely new: The MX-System Designer is deliberately not a conventional product configurator. Rather than being a question of choosing single components, it is about planning the entire electrical architecture of a

machine in a structured way – from power, control, and I/O level right through to the connected peripherals. The technical challenges of implementation were kept within reasonable limits, as the physical logic of the MX-System – with standardized interfaces, modules plugged and bolted onto baseplates – provides an excellent basis for a digital planning model. But we are only at the start here. The biggest architectural task was to cast a stable and scalable digital foundation on the basis of which we could

Daniel Siegenbrink, MX-System product manager, Beckhoff

” Rather than being a question of choosing single components, it is about planning the entire electrical architecture of a machine in a structured way.”

easily implement additional features in the future. After all, it is usually more challenging to add a third story to an existing house than to plan a three-story building from the outset.

### Do users need to have special engineering knowledge to use the tool? Is support available from Beckhoff if required?

Daniel Siegenbrink: Special software or IT knowledge is definitely not required to use the tool. The tutorial video on the Beckhoff website is absolutely

sufficient. Users must know their machine and its required functionality – in other words, they must know which actuators, motors, and sensors are required. The rest, i.e., the translation into the system architecture, is largely done intuitively and carried out by the Designer. We know that customers who are already using the tool were able to get to grips with it right from the start. If there are any questions about topology, our specialists will of course be happy to help at any time.

### Is there a charge for the tool? And what do users need to consider when using it?

Daniel Siegenbrink: The MX-System Designer is a purely online tool that runs on our servers. A local installation on the user's computer is, therefore, not necessary. This is a huge advantage, as the software is available worldwide in an identical, up-to-date format, providing a standardized planning basis for machine builders, project managers, and electrical planners. It is completely free of charge to use. All you need is a standard MyBeckhoff account on our homepage, which is of course also free of charge.

### With the software, is the design of the entire system in the hands of the machine builder, or does Beckhoff also play its part here?

Daniel Siegenbrink: Sovereignty over the system architecture should and always will be in the hands of the machine builder. With the MX-System Designer, Beckhoff is now essentially providing the digital framework and the intelligence in the background. The tool enables customers to act autonomously, quickly, and without errors; it re-

duces downstream adjustments in the engineering process and it visualizes the system structure.

### What exactly can be planned with the MX-System Designer?

Daniel Siegenbrink: First, of course, the MX-System itself, i.e., the baseplates and all the function modules located on them. The entire bandwidth of IPC, drive, system, and I/O modules is fully integrated as standard. In addition, we are also integrating our decentralized peripherals – including the EtherCAT P Box modules in IP67. One particularly important aspect is the structured cable specification. The MX-System Designer enables suitable, pre-assembled cables to be selected. We are talking about almost 2,000 different connector combinations that can be proposed and selected in various lengths for connections between MX-System modules and motors or sensors. This makes the wiring process as transparent as possible right from the concept phase.

### Does the software tool include a plausibility check with regard to the creation of the overall system?

Daniel Siegenbrink: Yes, in-depth plausibility checks are a central part of the functional scope and a truly unique selling point. The system automatically checks the key aspects of the electrical system design. This starts with obvious dependencies: If, for example, a 48 V servo drive is pulled onto the baseplate, the Designer immediately points out that a 48 V power supply must also be installed. Details like these are often overlooked in project planning in the heat of the moment. However, the tool goes far beyond this into deeper physics: It calculates the total power requirement of the system, checks the load distribution within the baseplate, monitors the power limits of the individual modules, and even calculates voltage drops over the defined cable lengths. In this way, we ensure that users only generate combinations that are technically permissible and functional.

### Is the software modular, and do you plan to add more functions over time? If so, what could they be?

Daniel Siegenbrink: As with all new technologies from Beckhoff, we start with a solid, functional basis, continuously expand it, and add new features. The use of artificial intelligence is an obvious topic for us – we want to take the step from simple drag-and-drop functions to prompt-based system generation, where the user describes in words what the machine should do and the AI generates the initial system design. Topics such as the automated export of 3D CAD models of the fully configured MX-System station are also on the roadmap. However, the ultimate goal is maximum vertical integration: In the future, it should be possible to seamlessly transfer the structured visualization from the web tool to our TwinCAT Engineering environment in order to build a direct bridge from electrical hardware planning to software parameterization.

More information:

[www.beckhoff.com/mx-system-designer](http://www.beckhoff.com/mx-system-designer)



With the MX-System Designer, system architectures can be modeled graphically and checked for technical consistency early on in projects.



## Industrial PCs with Intel® Core™ Series 2: CPU update with significant performance boost

Beckhoff is integrating Intel® Core™ Series 2 processors into C6040 ultra-compact Industrial PCs, C6640, C6650, and C6675 control cabinet Industrial PCs with ATX motherboard, and C5240 19-inch slide-in Industrial PCs. The significant boost in performance this introduces means that users may benefit from the latest CPU innovations and the convergence of automation and the IT world that is typical of PC-based control.

The Intel Core Series 2 family of processors offers up to twelve performance cores and up to 4 GHz base clock and 5.9 GHz turbo frequency, making it ideal for all applications with the highest demands on single-core computing power and/or highly parallelized applications that benefit from many powerful cores. Felix Wildemann, Product Management Industrial PC at Beckhoff Automation, says: "For some applications, especially non-control tasks that rely on the operating system's own scheduling, there are many advantages to a hybrid CPU architecture. In the control/automation field, however, many performance-hungry applications require high single-thread performance and CPU cores that are uniformly organized. That not only delivers more performance per core but also significantly simplifies engineering. We have seen the trend toward hybrid processor architectures for several years at all levels, including Arm® processors, and are therefore all the more pleased that Intel has listened to industry feedback and added the Bartlett Lake 12P series of CPUs to their embedded roadmap, which offers a real advantage in industrial applications."

Measuring just 132 x 202 x 76 mm, the C6040 ultra-compact Industrial PC is one of the most powerful computers in this series. It is versatile in use and particularly suited to complex axis controls, complex HMI applications, and

applications with extremely short cycle times, as well as machine learning and machine vision applications. "Beckhoff's C6040 ultra-compact Industrial PC is powered by Intel Core Series 2 processors with P-cores, delivering deterministic compute performance optimized for industrial workloads at the edge," says Todd Matsler, Sr. Director & GM, Manufacturing Segment at Intel Corporation. "This long-life platform enables predictable real-time control alongside advanced vision and AI applications within a compact industrial PC design. This collaboration underscores Intel's commitment to scalable, high-reliability edge computing solutions for next-generation industrial systems."

The C6640, C6650, and C6675 control cabinet Industrial PCs use an ATX motherboard and offer a wide range of equipment options including the use of large, high-performance graphics cards for particularly advanced machine learning and machine vision applications. The C5240 19-inch slide-in Industrial PC is also equipped with components of the very highest performance class, making it ideal for machine and system engineering applications.

More information:  
[www.beckhoff.com/intel-core-series-2](http://www.beckhoff.com/intel-core-series-2)

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## EP741x MDR controller: Smart intralogistics with integrated safety technology



The EP741x MDR controllers from Beckhoff set new standards for safety, efficiency, and modularity in an automated material flow. The IP54-protected modules are available with or without integrated safety, depending on requirements. In combination with the control of 24 V and 48 V motors from a wide range of manufacturers, system builders and operators benefit from maximum flexibility, reduced wiring work, and significantly lower system costs.

The ongoing capacity expansion in e-commerce and intralogistics calls for modular, flexible, and reliable conveyor systems. Motor-driven roller conveyors (MDR) offer enormous efficiency advantages through zone-based operation, but often reach their performance limits when using traditional bus systems. With the new EP741x MDR controllers, however, this is no longer the case. The integration of EtherCAT allows update rates in the sub-millisecond range. This ensures absolute synchronization of the routing logic, even with extensive conveyor lines and complex systems.

Building on the established EtherCAT Box architecture, the EP741x takes over the sensorless control of brushless DC motors (BLDC) in the 24 to 48 V voltage range. A key advantage is that the modules can be combined with motor rollers from any supplier, which simplifies engineering and greatly reduces spare parts inventory. The controllers are available as a 2-channel version (EP7412) and as a particularly compact 4-channel version (EP7414). The fully cascable design in protection rating IP54+ with integrated connection cables and standardized M8 or M12 connectors reduces costs, eliminates wiring errors, and minimizes installation time. At the same time, the reduced installation depth facilitates direct, space-saving mounting in the profiles of the conveyor rails.

An absolute first in the industry for MDR solutions is the optional Safe Torque Off (STO) safety function via Safety over EtherCAT (FSoE). While conventional controllers usually require a complete shutdown of the power supply to fulfill emergency stop requirements, the EP741x-9071 uses an intelligent design. It safely disconnects the motor power stage, but maintains the logic voltage for the control electronics. The system thus remains in a safe state. Users benefit from a decentralized safety architecture that allows them to define individually controlled safety zones. This eliminates the need for additional safety components or complex parallel wiring and elevates the modularity of material transport systems to a new level. For applications with lower safety requirements, Beckhoff also offers the new MDR controllers as cost-optimized 2-channel and 4-channel variants without safety functionality (EP741x-0071).

More information:  
[www.beckhoff.com/ep7412](http://www.beckhoff.com/ep7412)  
[www.beckhoff.com/ep7414](http://www.beckhoff.com/ep7414)

Cyber Resilience Act and the Machinery Regulation:

# PC-based control and EtherCAT – secure by design, ready for the future

The risks that the manufacturing industry faces due to cyberattacks and malware are constantly growing. Regulations such as the Cyber Resilience Act (CRA) and the new Machinery Regulation aim to counter these by imposing stringent requirements on manufacturers and machine builders. With PC-based control and EtherCAT, Beckhoff offers an optimal technological foundation for meeting these requirements and gaining a lead on the market in the future.

The regulatory requirements in industrial manufacturing are undergoing a fundamental shift as the Cyber Resilience Act (EU) 2024/2847 and the revised Machinery Regulation (EU) 2023/1230 have come into force. In the future, cybersecurity will require a continuous interplay between technology and processes. Beckhoff anticipated this need early on; for more than ten years, the company has been operating its own Product Security Incident Response Team (PSIRT) for professional vulnerability management and has made detailed security guidelines available. As a co-founder of the industry-specific CERT@VDE, Beckhoff is also actively involved in sharing vulnerability information across manufacturers.

## Security with PC-based control and EtherCAT

Beckhoff is actively driving standard development to bring automation technology into line with the new EU regulations. Since the international IEC 62443 series of standards alone does not currently provide a sufficient basis for the CRA, Beckhoff is helping drive the development of the European version, EN IEC 62443, within CEN-CENELEC. The aim is to achieve practical standardization that guarantees effective security.

From a technological standpoint, PC-based control and EtherCAT provide an inherently secure foundation. By centralizing system communication through the industrial PC, the native security capabilities of the operating systems in use – such as Windows or Linux® – can be fully applied to the PLC runtime, including

integrated firewalls. Furthermore, the system architecture benefits significantly from communication via EtherCAT. Even 20 years after its introduction, the protocol remains consistently geared toward hardware-based real-time control and clearly separated from higher-level IP networks, which leaves very little room for attack. EtherCAT can therefore be used in a cybersecure and standard-compliant manner without any protocol changes. This enables system certifications in accordance with IEC 62443-3-3 for EtherCAT systems, even if the individual devices are not explicitly certified. Beckhoff has already received UL certifications for three different blueprint scenarios (DK-177530-UL, DK-178394-UL, and DK-178399-UL), each tailored to a typical family of industrial applications – a crucial factor in maintaining existing system designs.

## Evaluation and certification

At product level, Beckhoff relies on a dedicated security evaluation process. All products are continuously evaluated and further developed with regard to their compliance with the CRA and, where necessary, also with IEC 62443. In many cases, they already meet the requirements through their existing design and only require extended documentation. For safety components, full compliance with the new Machinery Regulation will be ensured in time for its entry into force in January 2027. Beckhoff is expected to complete IEC 62443-4-1 certification this year to safeguard the product development lifecycle. At the same time, the security of the company's own IT and production infrastructure will soon be validated through ISO 27001 certification.

“Cybersecurity is not static, but an ongoing process that requires tailored technologies and clear guidance,” summarizes Torsten Förder, responsible for Product Security Compliance at Beckhoff. “Where others in the market recommend excessive protective measures, we focus specifically on what is needed to deliver effective security. With this streamlined approach and the Beckhoff portfolio as a technical foundation, users remain secure, protect their investments, and maintain their edge.”

More information:  
[www.beckhoff.com/cybersecurity](https://www.beckhoff.com/cybersecurity)



## Vision Unit Illuminated: Complete vision solution with 16 new devices and crossed polarizing filters



Beckhoff's Vision Unit Illuminated (VUI) is a compact unit comprising a camera, illumination, and focusable optics complete with liquid lens technology. The series has now been expanded to include 16 devices with new image sensors as well as crossed polarizing filters.

The VUI is industry-ready and designed for the harsh day-to-day conditions of machine building – compact, robust, and engineered for easy integration into the control system. The extensive portfolio of units now includes 16 additional devices with new image sensors. With resolutions of 5.1, 8.1, and 12.4 MP, they are suitable for a wide range of de-

manding applications – from fast cycle detection to detailed quality inspection with elevated measurement and detection accuracy.

The devices are also available with crossed polarizing filters. This expands the range of applications, as the easy-to-use unit enables additional vision tasks to be solved by suppressing surface reflections. In this way, features can be captured with high contrast and without reflections, even through shiny transparent surfaces such as glass, plastic, and water.

More information:

[www.beckhoff.com/units](http://www.beckhoff.com/units)

## Economy drive system: Economy drive solution – Complete with an extended power range

Beckhoff's economy drive system is a coordinated platform of servomotors, servo drives, and variable frequency drives for compact, cost-efficient machine concepts offering full integration into the world of PC-based control. An extended power range and new external braking resistors and mains filters are opening up even greater application potential.

The AX1000 economy servo drive has been extended to include an additional three-phase variant rated at 12 A. It now covers the rated current range from 3.4 to 12 A, while in the single-phase range it is available with currents from 1.65 to 6.9 A. One notable aspect is the high packing density: The power supply, DC link capacitors, and braking circuit are fully integrated, despite the extremely compact dimensions. The housing is made of robust plastic, which reduces weight and material costs. The devices can be installed next to each other in the control cabinet without minimum distances having to be maintained between the drives.

The AF1000 economy variable frequency drive is also available in a new three-phase variant rated at 5.5 kW, providing a cost-optimized solution for basic drive applications such as conveyor systems, pumps, or fans. The series covers the power range with single-phase supply from 0.37 to 1.5 kW, as well as with three-phase supply from 0.75 to 5.5 kW. It offers a scalable solution for a wide range of applications, not only with the single-axis devices typical of this segment, but also with the very cost-efficient double-axis devices.

As a full-range supplier of system components, Beckhoff is also able to supply suitable accessories including external braking resistors and mains filters for the economy drive system. The AX2090-BW10-xxxx braking resistors are available in different variants for devices with single-phase and three-phase supply, as well as different power ratings. This ensures that the braking resistors are



optimally adapted to the application. In addition, the high-quality AX2090-NF1x-xxxx mains filters ensure excellent interference suppression for the economy devices. When the components are combined, they meet industry standards up to category C2 in accordance with EN 61800-3.

More information:

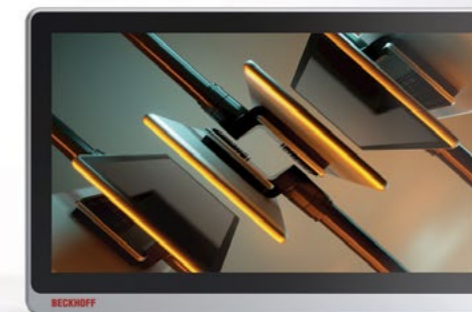
[www.beckhoff.com/economy-drive-system](http://www.beckhoff.com/economy-drive-system)

Red Dot Award for Next multi-touch panel generation:

## Scalable performance, attractive design



reddot winner 2026  
industrial design



Beckhoff has received the prestigious Red Dot Award 2026 for the Next multi-touch panel generation, in recognition of its consistent focus on intuitive human-machine interaction combined with a high level of technological integration and an attractive design. The scalable control panels and panel PCs provide machine and system engineering companies with a future-proof automation solution that combines minimalist design language with industrial suitability in a cost-effective manner.

The Red Dot Award is among the world's most renowned product design competitions and evaluates submissions not only for their aesthetics, but also for their functionality and degree of innovation. The fact that the Next multi-touch panel generation has been recognized underlines its application-oriented design concept. The front and rear follow a clear design language, which minimizes operating errors and enables harmonious integration into modern system concepts. Design has always been of great importance to Beckhoff. Ultimately, a control panel or a panel PC is much more than just an operating device today: it is the visual and emotional figurehead of the machine and its appearance has an impact on the entire production environment. In addition to visual aesthetics, the Next multi-touch panel generation therefore places particular emphasis on tactile sensation: High-quality materials and a pleasant haptic feel significantly enhance the user experience and ease of use.

### From HMI to smart hub

To meet industrial requirements, the HMI devices are made of die-cast aluminum and are therefore very robust. However, the design is not only built to last, but is also evidence of well thought-out engineering. To make its in house

production in Germany highly cost-effective, Beckhoff has integrated production dependent adaptations directly into the housing design. The symbiosis of sophisticated design and well thought-out production technology enables lean processes, allowing users of the Next multi-touch panel generation to benefit from high cost efficiency without having to compromise on the usual quality and functionality.

The award-winning generation of panels is driving the transformation of the classic HMI into an intelligent hub for data acquisition and visualization, as control and visualization tasks are performed on a common platform. This significantly reduces space requirements, cabling work, and latency times. The panel generation is based on a revised electronics concept with standardized interfaces, end to end EtherCAT communication, and seamless integration into TwinCAT.

### Gateway for edge computing and AI

Modern Intel Atom® and Arm® processor generations deliver the performance required for networked industrial systems. The scalable performance spectrum qualifies the Next multi-touch panel generation as a central gateway for edge computing and AI.

More information:

[www.beckhoff.com/next-panel-generation](http://www.beckhoff.com/next-panel-generation)



EtherCAT and XTS for mechanical end-of-line testing in battery cell production

## High system throughput due to fast data communication and flexible product handling



Removal of the tested battery cells via delta kinematics implemented with Beckhoff servomotors

In electromobility, maximum performance is expected not only from the vehicle batteries themselves, but also with regard to their production. V4Smart, a specialist in lithium-ion round cells resulting from a joint venture between Porsche and Varta, has successfully implemented this in a complex system for mechanical end-of-line testing of battery cells based on ultra-fast EtherCAT communication and the XTS intelligent transport system from Beckhoff.

Behind V4Smart, based in Nördlingen, is an interdisciplinary team specializing in the development and production of high-performance lithium-ion round cells. The focus is on the technological advancement of electrochemical storage systems – from materials research all the way to scalable cell production. One example is the new end-of-line test facility for battery cells, e.g., for the Porsche 911 Carrera GTS and Turbo S with hybrid drive. This was implemented in close cooperation with the mechanical engineering division of Varta Microbattery, Ellwangen, the system integrator Nema Automation, Bretzfeld, and Beckhoff in Verl and Crailsheim. Nema CTO Andreas Hütter describes the wide range of tasks as follows: “As a system integrator, we assumed responsibility for control system design, circuit diagram creation, control cabinet design, software programming, and commissioning – and carried out all of this work in full.”

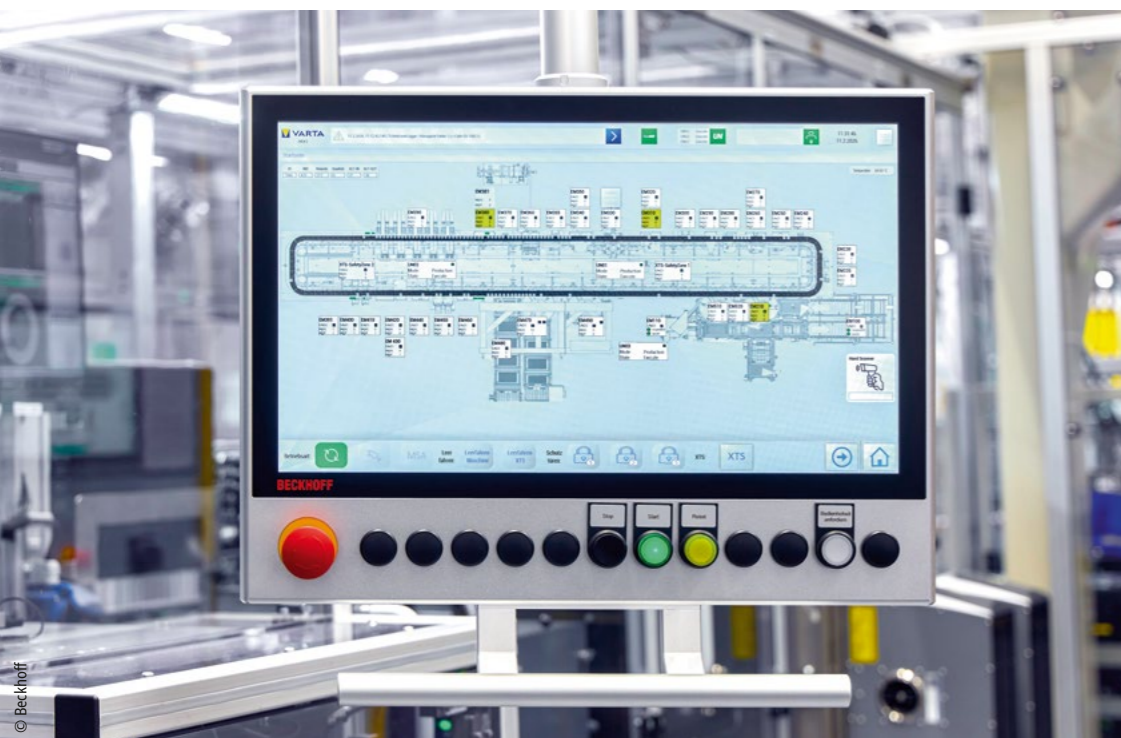
### Complexity in system design and process sequences

The overall system consists of two mirrored sections, each of which is approx. 15 m long and 3 m wide. In this way, the high required output of 80 tested parts per minute was achieved while maintaining easy operability. In each sub-system, an XTS system supplied in full by Beckhoff's systems engineering division, with a circulating track length of 28.5 m, ensures fast and flexible transport of the battery cells to the more than 30 work and testing stations. The data complexity is completed by around 1,000 I/O data points, half of which are recorded via decentralized EtherCAT Box modules and half via EtherCAT Terminals dis-

tributed across a total of 26 control cabinets. Accordingly, as Michael Luber, Head of the Formation Segment at V4Smart, explains, high-performance and reliable communication technology is essential for such a large and data-intensive system – made possible by EtherCAT, the Industrial Ethernet standard developed by Beckhoff and now established worldwide. The large amount of data to be transmitted requires an efficient EtherCAT network topology that is precisely tailored to the application – a star topology from which all other network participants are integrated in a linear fashion.



The project team in front of the battery cell test facility (from left to right): Michael Müller (Packaging Application, Beckhoff), Michael Luber (Head of Formation Segment, V4Smart), Hannes Junker (Software Engineering, Nema Automation), Andreas Hütter (CTO, Nema Automation), Felix Eitel (Team Leader Electrical Design/Control Technology, Varta Microbattery), Tilman Plaß (Industry Manager Automotive, Beckhoff), Julius Eyerann (Head of Engineering, Nema Automation), and Markus Seckler (Application, Beckhoff)



Despite its complexity, the system can be clearly displayed and conveniently operated on the Beckhoff multi-touch Control Panel with push-button extension.

The process stations to be served include around 20 optical inspection units as well as additional assembly areas, for example for applying the lower battery cell insulation and for applying a heat-shrink sleeve, including the required heating tunnel. Felix Eitel, team leader for electrical design/control technology at Varta Microbattery, explains: "The battery cell is tested for a wide range of mechanical characteristics. The casing is checked for scratches, dents, and water or electrolyte stains. The same applies to the cell cap and base, with the battery cell additionally being rotated. The bottom insulation is then applied and its correct placement verified. This is followed by the thermal application of the heat-shrink sleeve, including checks for correct length, complete coverage, and any damage. Finally, each battery cell is marked with a UV laser, the print is inspected by a camera, and the cell is removed by a delta robot."

Andreas Hütter confirms how demanding this final process step in battery cell production is: "The sheer speed and reliability required to achieve the specified 40 test parts per minute per sub-system, along with a reject rate below 1%, already calls for extremely powerful and fully integrated control technology, as well as highly flexible product handling – such as that enabled by XTS. The heat-shrink sleeve application with the heating tunnel, as well as the numerous camera systems for inspecting the upstream processes, were also major challenges."

#### XTS as a central system element

The central, unifying element of the system is the intelligent XTS product transport system from Beckhoff. This is evident not only in the large track length of 28.5 m in each of the two sub-systems, but also in the more than 100 XTS motor modules and 100 movers used in each one. In addition,



In each of the two mirrored sub-systems, measuring 15 x 3 m, an XTS system with a circulating track length of 28.5 m is used (shown here: the buffer zone after the heating tunnel).

With XTS, the battery cells can be transported through the heating tunnel for applying the heat-shrink sleeve without difficulty – protected by a dedicated safety zone that prevents excessive dwell time.



XTS was the decisive factor in choosing Beckhoff's PC-based control as the automation technology, as Felix Eitel explains: "Varta Microbattery has been using this PC-based control technology in its packaging systems for many years. For the end-of-line tester for V4Smart, however, XTS was in fact the primary factor. This transport system was the only way to achieve the required dynamics and speed in product handling."

Andreas Hütter adds: "The decoupling of the product transport from the machine cycle is crucial here. After all, the system includes a wide variety of processing stations – some parallelized, others single-station – as well as the heating tunnel as a continuous process that must be synchronized with cyclic operations. This requires the high degree of flexibility that XTS offers. In addition, the available space for the system is limited, and XTS makes it possible to achieve a very compact machine layout. A conventionally designed system would have been at least one third larger."

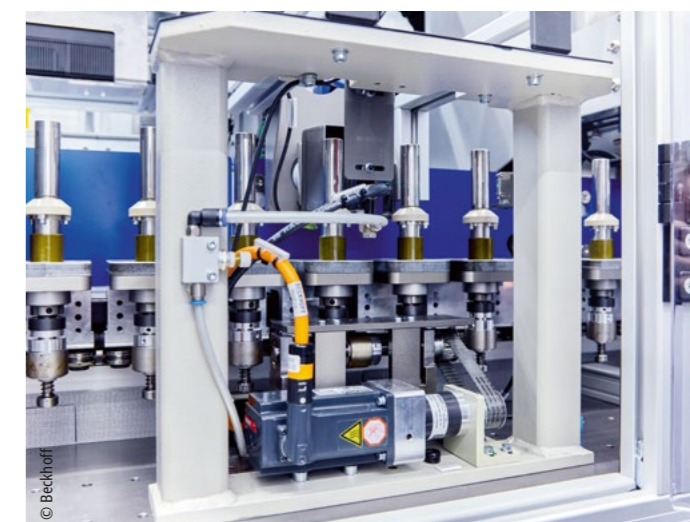
According to Andreas Hütter, integrating the 2 m long heating tunnel for applying the heat-shrink sleeve would also have been more difficult without the flexible XTS. The movers travel through this tunnel at a speed of 60 mm/s. The challenge was that all battery cells inside the heating tunnel had to be reliably moved out of the heated area even if a fault occurred in an upstream process, in order to prevent damage from excessive heating. In a conventional setup, troubleshooting would have to wait until the heating tunnel had emptied. With the flexible XTS system, this waiting time is eliminated, as it can be divided into two safety zones using an additional power supply module. This allows the front section of the system to be stopped and serviced in the event of a fault, while the movers carrying the battery cells can exit the heating tunnel without interruption.

Felix Eitel explains another special feature of the product transport: "The workpiece carrier mounted on the XTS mover further increases the system's flexibility. The battery cell is mounted so that it can rotate, allowing it – via a magnetic coupling to an AM8000 servomotor driven by the AX8000 multi-axis servo system – to be rotated once it reaches the respective work stations. This is used at 13 stations in each sub-system, i.e., for the optical inspections, at the cleaning stations, and in the heating tunnel." The One Cable Technology (OCT) of the servomotors also offers advantages, as it significantly reduces the cabling work, takes up less space, and makes maintenance easier.

AM8000 servomotors are also used in the two pick-and-place applications – implemented as delta kinematics – at the beginning and end of the process sequence. These are calculated via TwinCAT 3 Kinematic Transformation on the central Beckhoff machine controller. TwinCAT 3 Motion Pick-and-Place handles the actual motion planning. A second Beckhoff control computer provides clear visualization and convenient system operation via TwinCAT HMI and three Beckhoff multi-touch Control Panels.

#### Working together to find the optimum solution

The mutual support among the partners involved also contributed significantly to achieving the desired solution. Andreas Hütter confirms that the collaboration with Beckhoff – and in particular with the sales office in Crailsheim – was close, solution-oriented, and on equal footing, covering everything from product design to application-related questions. Michael Lubert highlights the consistently goal-oriented approach: "Despite four partners being involved and the corresponding process complexity, any challenges that arose were always addressed in a very constructive and positive manner. They also responded quickly and efficiently."



At a total of 13 work stations, a magnetic coupling to an AM8000 servomotor enables battery cells to be rotated and thus, for example, inspected from all sides.

More information:

[www.v4smart.com](http://www.v4smart.com)

[www.varta.com](http://www.varta.com)

[www.nema.de](http://www.nema.de)

[www.beckhoff.com/automotive](http://www.beckhoff.com/automotive)



The linear robot from RO-BER handles heavy containers fully automatically, ensuring the safety of Bürkert's logistics staff.

Depalletizing cell with MX-System solves age-old floor space problems in intralogistics

# Going control cabinet-free to maximize space savings

Bürkert Fluid Control Systems faced a classic production logistics challenge at its Criesbach Campus in Germany: manually feeding heavy containers into the automated small parts warehouse was slowing down processes and putting strain on personnel. However, there simply wasn't enough floor space for conventional automation solutions. That's when Bürkert commissioned gantry robot and material handling equipment manufacturer RO-BER to deliver an exceptionally compact depalletizing cell that receives pallets from AGVs (Automated Guided Vehicles). Despite this solution, the end user still needed more space savings to satisfy its high demands: the MX-System from Beckhoff, which allows the system to operate entirely without a control cabinet, provided the solution to the limited space constraints.

Floor space is one of the most valuable resources in intralogistics – usually, every single square centimeter counts, and this was certainly true for Bürkert. The supplier of measuring, control, and regulation systems for liquids and gases is on a steady growth trajectory, which means it has to achieve constant improvements in its internal material handling and logistics. Bürkert does not sell standard products but instead focuses on valve designs and materials precisely tailored to each customer. As a result, the company's product range comprises 140,000 sellable items. Frank Landgraf – who is responsible for all logistics processes at Bürkert – described the starting point: "Getting to grips with this kind of diversity in production and intralogistics is a real challenge. While automation used to focus on assembly, today the greatest potential lies in intralogistics." He also believes that it is important to consider ergonomics; "Manually handling heavy crates of 20 kg or more isn't the way we do things now – and given the labor shortage we're experiencing, it isn't a method we can support anymore." The process of feeding material into an automated small parts warehouse with around 27,000 bays was creating a bottleneck at the Criesbach site. The company was looking for an automated solution, but the on-site conditions left little room to maneuver. The system had to fit into an existing niche that would have been too small for conventional robot cells and bulky control cabinets.

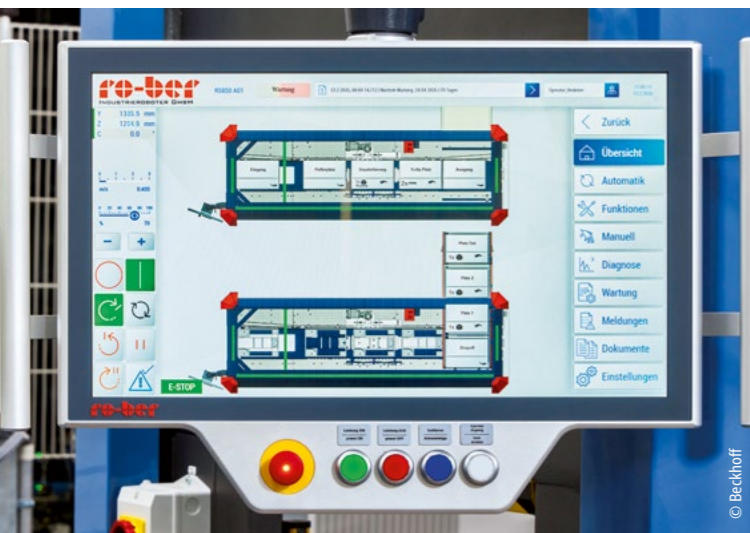
## Less work, less space

With this goal in mind, Bürkert approached RO-BER Industrieroboter, based in the German town of Kamen. As RO-BER specializes in sophisticated gantry



Mounted directly in the superstructure of the machine, the MX-System completely replaces the conventional control cabinet and controls all axes and processes.

robot systems, their team worked with the specific requirements for the Criesbach site to develop a tailor-made cell for depalletizing Euro containers from floor rollers. A linear robot with a multi-functional gripper removes the containers and places them, perfectly aligned, on the conveyor system in the automated small parts warehouse. While RO-BER was able to fall back on its proven range of solutions for the mechanics and robotics, it pursued new paths

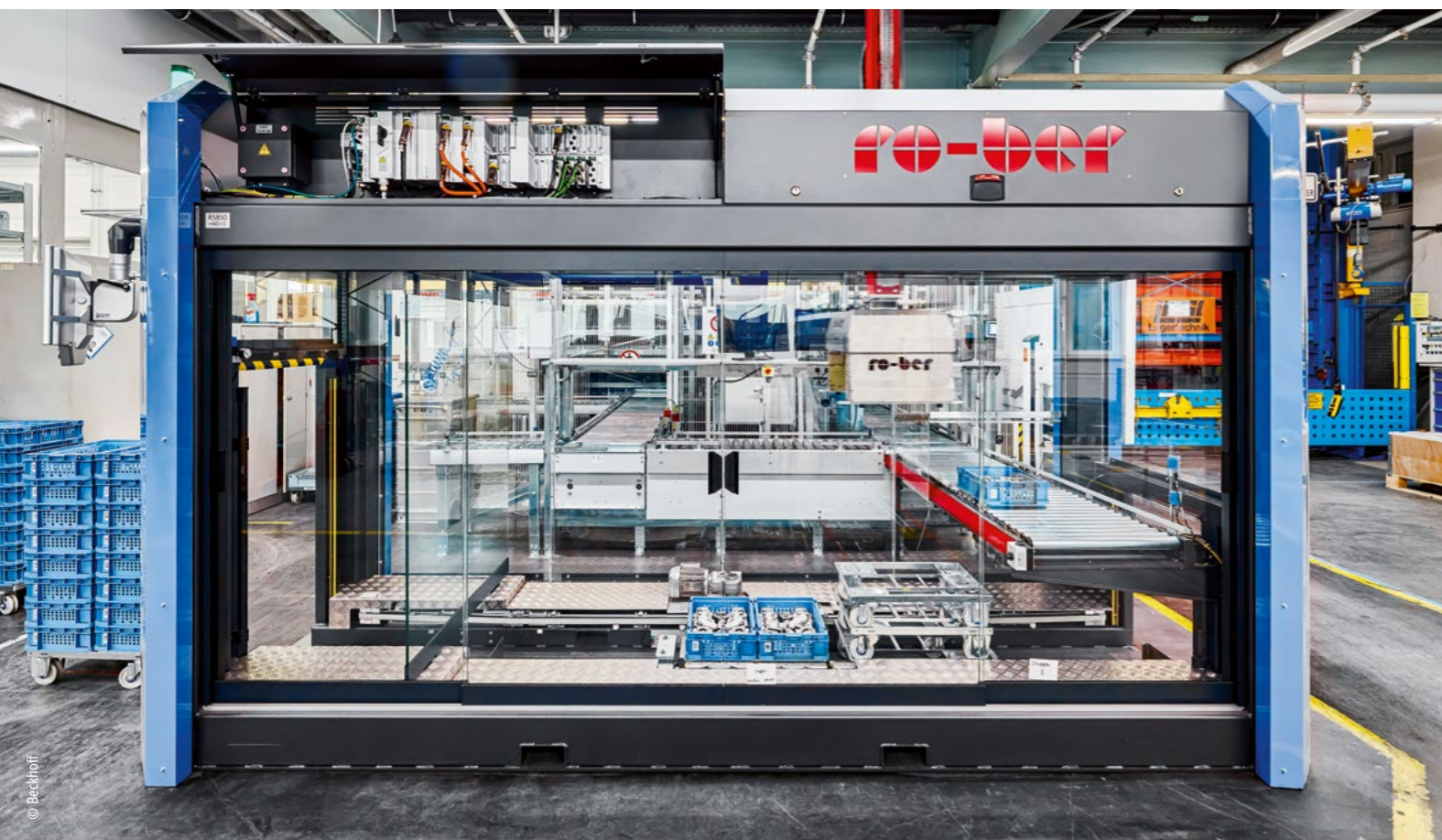


The operator has access to all functions and process data for the networked system via the custom Beckhoff control panel.

for the automation aspect. To ensure the requisite compactness, RO-BER opted for the MX-System from Beckhoff.

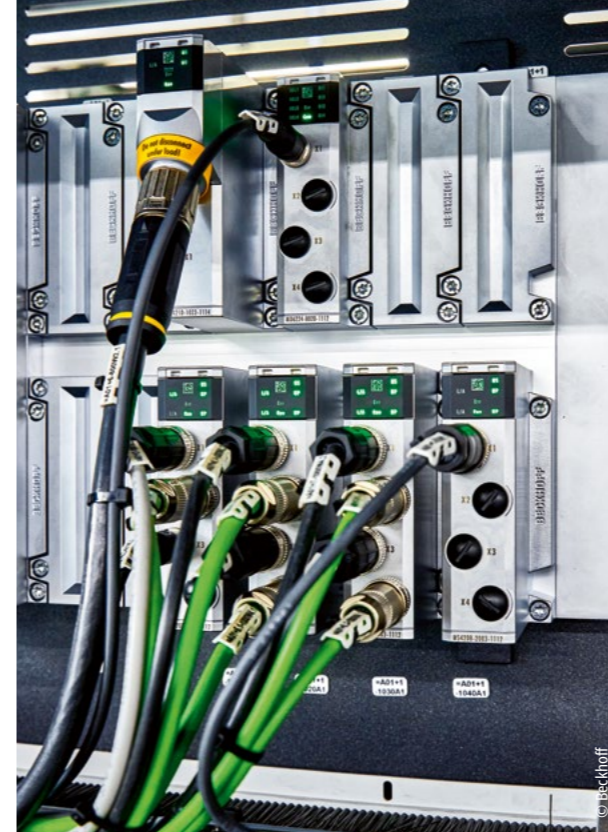
“As a pluggable, modular solution for control cabinet-free automation, it quickly caught our attention,” explains Elmar Stöve, Managing Director of RO-BER. The MX-System is a modular automation system that contains all control cabinet functions – from control and drive technology to I/Os, power

The RO-BER depalletizing cell fits seamlessly into the limited space next to the automated small parts warehouse at Bürkert’s Criesbach, Germany site.



supply, and fusing. The robust, IP67-protected function modules make it possible to completely eliminate conventional control cabinets in many applications. All the required modules are plugged onto a machine mounted baseplate. For RO-BER, this meant that there was no need to plan any separate space for installing a control cabinet. Instead, the automation was integrated directly into the machine superstructure, which significantly reduced the amount of space and cabling work required while simplifying the design of the entire cell. Faster assembly and commissioning

“The benefits of the MX-System span the entire life cycle of the equipment, from design and planning to maintenance,” explains Antonia Kuhn, who works in sales at Beckhoff. “During assembly, the baseplate’s standardized interface concept eliminates the need for manual wiring and complex cable routes. Function modules are simply plugged in and screwed in place, which automatically establishes the electrical connection. All field devices are connected to the MX-System modules with pluggable, connectorized cables, further eliminating any potential wiring errors.” This resulted in an enormous gain in efficiency for the machine builder. “A complete MX-System could be installed on the machine in just a few minutes, with an industrial PC, servo drives, main switch, infeed, 48 V power supply, and I/O modules,” confirms Elmar Stöve. “That’s a huge difference compared to the time required for installing traditional control cabinets – which can be hours or even days.” One Cable Automation (OCA) reduces the amount of wiring work required for the motors, as power, data, and feedback are routed in a single cable. This also reduces the potential for errors. In addition, every component from the MX-System portfolio can be diagnosed – a major advantage from a maintenance perspective.



The MX-System function modules can simply be plugged onto the baseplate, reducing assembly time from hours to minutes.

#### Seamless integration and networking

“For us, automatic depalletizing wasn’t just about the functions that a new machine would bring – it also had to allow seamless integration into higher-level structures and connection to our automated guided vehicles,” states Marius Mazugo, who works in process optimization at Bürkert. This is where open, PC-based control technology and EtherCAT from Beckhoff shows its strengths, as it accommodates all common IT and communication standards, allowing the user to achieve seamless traceability in logistics control, production control systems, and company databases. When an AGV enters the plant, the system automatically recognizes the order, depalletizes the Euro containers, takes them to the automated small parts warehouse, and stacks the empty floor rollers, which the AGV then picks up. This fully automatic cycle eliminates the need for manual intervention and avoids downtime.

#### Project planning and scalability made easy

In addition to the MX-System, the depalletizing system also features a custom control panel from Beckhoff’s CP39xx series, on a mounting arm with a compact push-button extension. The HTML5-capable display with TwinCAT 3 HMI is designed for intuitive operation and provides a detailed diagram of the machine and its processes, as well as dynamic real-time graphical monitoring of the EtherCAT network for rapid diagnostics of the system. In addition to servomotors from the AM8000 series, the system uses a number of IP67 EtherCAT Box modules. The entire application was configured in TwinCAT 3 automation software. “For RO-BER, an experienced user of Beckhoff technology, no programming changes were needed in order to use the MX-System,” states Elmar Stöve. The flexibility of the software and the high computing power of the industrial PCs can handle and manage extremely complex automation tasks. In principle, RO-BER systems are even able to process mixed pallets or different packages.



Think outside the cabinet: Frank Landgraf from Bürkert, Elmar Stöve from RO-BER, Antonia Kuhn from Beckhoff, plus Stefan Keilbach and Marius Mazugo, both from Bürkert (left to right).

#### Excellent ergonomics and process stability

For Bürkert, investing in the new depalletizing system has paid off. “RO-BER really brought our ideas to life in terms of the functions that it provided and the way the system operates: smooth and error-free,” summarizes Stefan Keilbach, team coach in the Warehouse and Logistics department at the Bürkert Campus. “The system also has an advanced look and integrates very well visually.” The project underlines the trend toward modular, compact logistics units that can be flexibly integrated into established material flows. The MX-System is a technological catalyst here: machine builders no longer need to design systems around control cabinets and can instead integrate automation into the mechanical system directly. This results in machines that are compact, sleek, and easier to maintain.

#### Real competitive advantages

The collaboration between Bürkert, RO-BER, and Beckhoff shows that thinking outside the box – or, in this case, outside the cabinet – leads to innovative solutions that can significantly increase efficiency and add value. “We see huge potential in the MX-System and have many ideas for more automation projects,” says Elmar Stöve, looking to the future. “For example, at this year’s LogiMAT, we were exhibiting a new compact palletizer cell that reflects this approach to equipment.” It is yet another sign that control cabinet-free machine building is no longer a far-off vision; it’s a reality in today’s industrial production, where it is already delivering real competitive advantages.

See a demonstration of RO-BER’s cabinet-free piece-picking cell with the MX-System.



More information:

[www.buerkert.de/en](http://www.buerkert.de/en)

[www.ro-ber.de/en](http://www.ro-ber.de/en)

[www.beckhoff.com/mx-system](http://www.beckhoff.com/mx-system)

Within the framework of a modular production structure, the new Aumann A-NWS/V machine offers the option of positioning several compact winding cells next to each other as required.

Aumann's team of experts, led by Christian Gerkenmeier (second from left), is already planning to implement the next machines and systems cabinet-free with the MX-System.

MX-System with modular machine concept for electric motor production

# Better winding without a control cabinet

Winding coils is a task that has to be carried out billions of times in industry. Fast, precise, and reliable processes are therefore very important. However, increasing requirements in terms of cost efficiency and new manufacturing structures are placing significant demands on machine builders. In this regard, the MX-System from Beckhoff opens up completely new possibilities for Aumann, as demonstrated by the implementation of the first control cabinet-free machine for electric motor production.

Whether it is for transformers, electric motors, or solenoid valves: when it comes to winding coils, nobody can beat Aumann. The machine builder has been making production machines for this purpose in Germany for around 90 years – for industries such as the automotive, electrical, mobile communications, IT, and medical technology sectors. The company's range of products covers almost all common winding techniques – and more besides. "Over time, we have added peripheral processes such as pre-assembly, contacting, testing, bonding, and joining," explains Jürgen Hagedorn, Technical Manager Winding Technology at Aumann Espelkamp. "In some of our systems, the winding process only accounts for 20 to 30% now." According to the company, it is the only supplier in the world that covers the entire value chain from wire enameling and winding to the final assembly of the products – and supplies the appropriate automation technology at the same time.

As the demands on the wound coils increase, the requirements for the production technology naturally grow as well: winding must be precise, repeatable, and reliable – but also extremely fast and perfectly tailored to the product being manufactured. This is where the Espelkamp site comes in. It is precisely this kind of sophisticated winding solutions, primarily for electric motors, that Aumann Espelkamp GmbH specializes in within the Aumann AG group of companies.



By placing the MX-System in the substructure of the winding machine, the classic control cabinet can be dispensed with completely.

### More flexibility for the user

What is becoming evident is that, in addition to productivity, end users are increasingly focusing on flexibility. This in turn has a major impact on the basic set-up of the machines – for example, in the orthocyclic needle winding of rotors for electric vehicles. "This type of winding is very demanding," explains Christian Gerkenmeier, Head of Mechanical Design and Winding Technology at Aumann Espelkamp: "The wire has to be laid down perfectly in layers." For this reason, the manufacturer relies on a special combination of servomotors and a mechanical crank drive that produces sinusoidal needle strokes – up to now, primarily in large machines capable of winding up to eight components horizontally at the same time.

"The moving masses are quite high, however, which limits the speed," Christian Gerkenmeier points out. "By moving the winding process to a vertical position on the new A-NWS/V machine, we have significantly reduced the moving masses." The dimensions are also significantly smaller, as only two to three coils are wound at the same time. "The new procedure enables a much higher winding speed combined with greater precision," emphasizes Jürgen Hagedorn. Instead of the

previous 60 windings per minute, the A-NWS/V achieves more than 250 cycles. Aumann is following a modern approach in this regard: instead of using one large system permanently designed for a fixed number of components, the idea is that the user positions several compact winding cells next to each other. Connected by gantry, they take up no more space in total than a horizontal multiple winding system. However, the number of cells and thus the dimensions of the overall system can be flexibly adjusted as required. This also requires an exceptional solution in terms of electronics and electrical engineering, because a classic control cabinet – either directly on the machine or in its vicinity – would again significantly restrict the modular freedom. It was therefore clear to Aumann that a truly new approach was needed.

### Paradigm shift for the industry

"Beckhoff has been our preferred partner for automation for many years," says Christian Gerkenmeier. When designing the new machine in close collaboration with Beckhoff, attention quickly turned to the MX-System and the underlying potential of control cabinet-free automation – heralding nothing less than a paradigm shift in automation technology. The user chooses the right function modules for their application from an extensive modular system, attaches them to the standardized baseplate, and screws them into place. Nothing more is needed to implement all the automation and switching technology of a machine in a decentralized and IP67-protected manner. All modules are integrated into the EtherCAT network and supplied with power via standardized interfaces.

"Aumann was one of the first Beckhoff customers to explore the MX-System in detail, as the potential it holds for future machines became clear early on," notes Marvin Düsterhus, Product Management MX-System. At the heart of the Aumann solution is the MC6030 IPC module with an 11th generation Intel® Core™ i5 processor and 16 GB RAM. The MS1132 system module with main switch, fuse protection, and power supply provides 3-phase 400/480 V AC and up to 32 A system-wide. There are also various other modules, e.g., for drive control or the EtherCAT communication connection. As the MX-System is very compact, it was easy to integrate into the substructure of the new machine. Networking within the machine is implemented – in addition to the MO6224 MX-System communication interface – consistently via decentralized EtherCAT Box modules of the EP series. Not only does this eliminate the need for a classic control cabinet, it also makes the otherwise usual terminal boxes superfluous. In addition, the cabling effort is reduced significantly.

### Advantages on both sides

"Focusing solely on efficiency and performance is not enough in today's world," says Christian Gerkenmeier. "We have to take costs into account increasingly too." As Aumann Espelkamp has outsourced the control cabinet design, a lot can be achieved with the MX-System. The entire cost block is eliminated – a saving that the machine builder can pass on directly. At the same time, it brings an important part of the value creation back in-house. Furthermore, the time-to-market is shortened. The modular, pluggable concept of the MX-System speeds up not just assembly, but also engineering.

"Space requirements, effort, costs, and delivery times: all of these are reduced. We also need fewer specialists and are no longer dependent on external service providers. All in all, a huge amount of benefits." At the same time, Christian

Gerkenmeier is keen to stress: "The customer still has a choice of course. They can order their machine with or without a control cabinet." But the Aumann expert believes he knows which option will prove more popular: "I am convinced that our customers will largely opt for the MX-System in the future." Ultimately, control cabinet-free automation offers major advantages on both sides – for the machine builder and the end user.

### Automation in familiar surroundings

Another important argument for both sides is that the automation remains the same except for the form factor. "We have a lot of experience with Beckhoff technology," explains Jürgen Hagedorn. "The fact that engineering, PLC programming, and drive control continue to take place as usual in TwinCAT, with virtually no differences to other Beckhoff products in terms of parameterization and programming, is therefore a valuable advantage for us. It means that, from a purely technical point of view, the switch to the MX-System is not a big leap." As a result, the solution fits seamlessly into the rest of the machine's automation and drive technology.

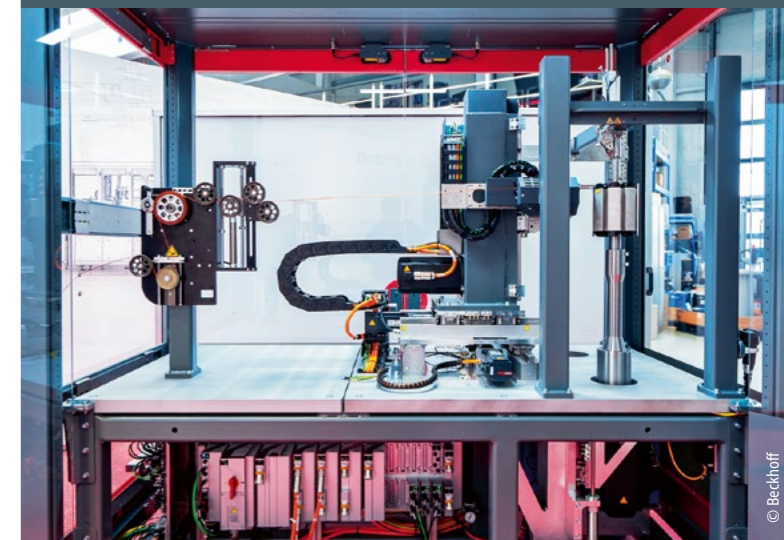
The servomotors of the AM8000 series, which move all axes of the wire laying system and the rotor holder, are directly connected to the MD8xxx servo drives of the MX-System. The aforementioned EtherCAT Box modules from Beckhoff's EP family form the connecting link for communication and the connection of sensors and actuators within the machine. Of course, the operator interface also plays an important role. "Aumann has been using Beckhoff Control Panels for a long time," says Robin Bertling, who works in sales at Beckhoff. "For the A-NWS/V winding machine, however, the HMI – a CP3916 multi-touch Control Panel – was re-designed: ergonomic and user-friendly as before, but with a customer-specific design that corresponds to the Aumann look and feel." The machine builder has also put the automation technology to the test in a number of other areas and has revised and modernized it – for example, with the integrated TwinSAFE safety solution or with pre-assembled, standardized cables.

### Further references in sight

Aumann is now planning to implement further solutions with the MX-System. "We want to move towards series production," states Jürgen Hagedorn, "because the vertical needle winding machine has shown that we are on the right track. We will therefore not only be applying the modular design systematically to future machine generations, but will also be taking the MX-System into account from the outset." Aumann also sees promising opportunities for control cabinet-free automation when it comes to special machine construction. "Some customer projects lend themselves well to being our next reference, because they are planned with Beckhoff technology throughout anyway," says Christian Gerkenmeier, looking ahead. For example, there are plans for a fully automated production line featuring the MX-System. "If we implement complete systems in this way instead of individual processes, it will be easier for us to prove to end users that control cabinets are a thing of the past!"



As the HMI for the new needle winding machine, the CP3916 multi-touch Control Panel was customized specifically for Aumann and tailored precisely to the application.



By moving the winding process to a vertical position, Aumann reduces the moving masses – which significantly improves the cycle time.

More information:

[www.aumann.com](http://www.aumann.com)

[www.beckhoff.com/automotive](http://www.beckhoff.com/automotive)

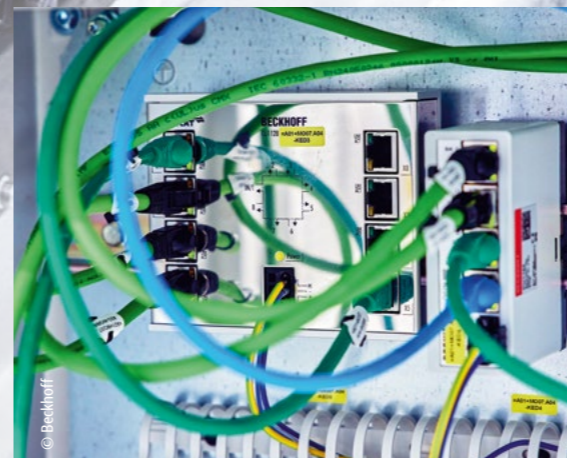
[www.beckhoff.com/mx-system](http://www.beckhoff.com/mx-system)

XTS in a variable system for producing multi-component plastic dowels

# 30%

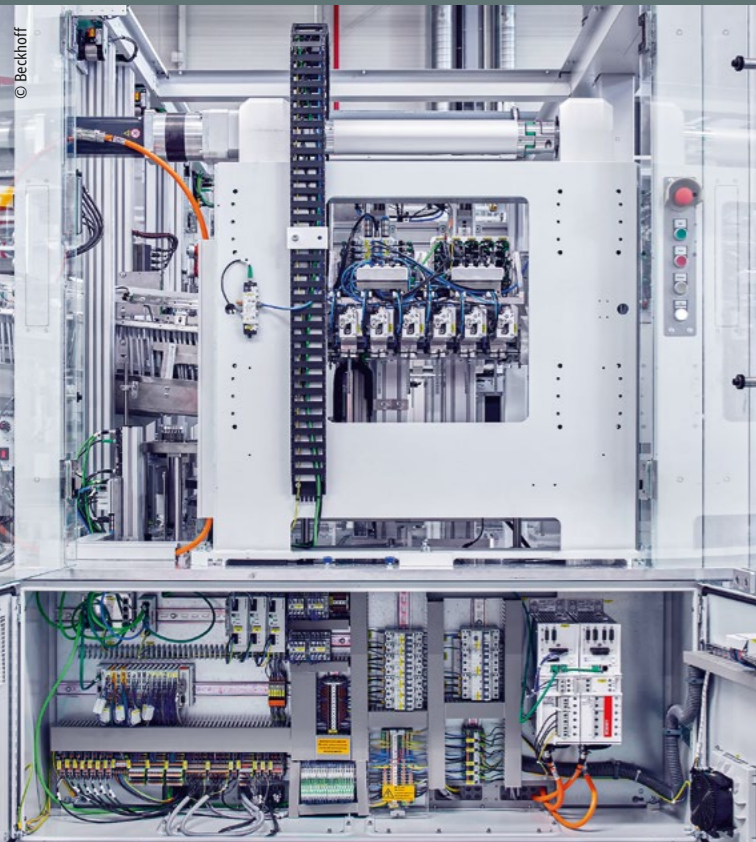
## more throughput with greater flexibility

48 movers connect the individual stations and form groups of 2, 4, or 6 as required on a track approximately 10 m in length.



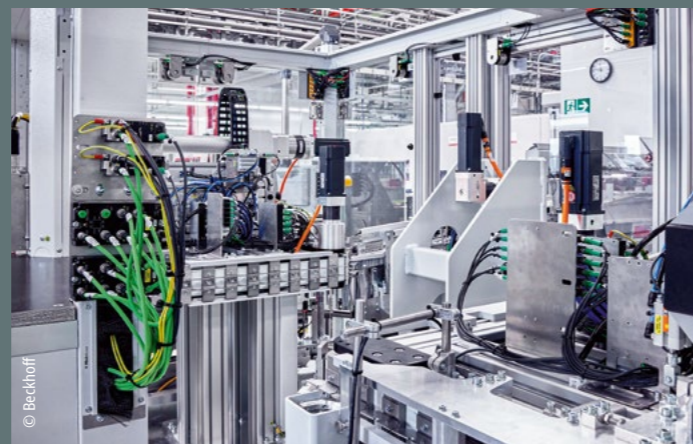
Achieving an increase in output rate of more than 30% on almost the same footprint requires sophisticated assembly processes and high-end automation. This is why fischer Innovation has opted for the performance and precision of Beckhoff XTS and motion control, supplemented by a wide variety of I/O components, for a new system for the fully automatic assembly, labeling, and packaging of multi-component plastic dowels.

fischer Innovation is mapping the modular machine concept at control level with infrastructure components including the CU1128 8-port junction (pictured) and CU2508 real-time Ethernet port multipliers.



Thanks to decentralization, the smaller control cabinets fit under the machine frame.

One Cable Technology (OCT) connection technology for the AM80xx servomotors and the EP and EPP Box modules saves space not only in the system but also in the control cabinet.



With Beckhoff XTS and PC-based control, fischer Innovation was able to increase the output rate of the assembly system for multi-component plastic dowels by 30% with improved variability.

A spin-off of the fischer Group's custom machine building division, fischer Innovation in Horb am Neckar has decades of expertise in the construction of assembly and production systems.

True to its history, the machine builder's focus is on fully automated assembly systems for a wide range of plastic dowels and the production of steel dowels, which are then assembled and packaged. Assembly and filling systems for cartridges that are filled with two-component adhesives or other chemical products, for example, represent its third area of expertise. Generally, the machine concepts support material infeed through printing and packaging and finally palletizing.

"As a matter of principle, we design all systems on a modular basis so that we can provide a flexible response to customer requirements. Although changes to requirements as early as the design and assembly stages are relatively rare, they are inevitable after the first few years, so that the systems can support the production of new products," explains Alexander Schäfer, head of control technology, software, and electrical design at fischer Innovation. "And the greater the bandwidth of technologies and functions, the more important a scalable and flexible automation platform like PC-based control becomes," adds Dieter Völkle from the Beckhoff sales team in Balingen. This is particularly evident in the latest project, a fully automated production system for multi-component plastic dowels. "The system represents a milestone in terms of managing complexity and optimizing the process of previous production lines," points out Eckhard Bubenberger, division manager at fischer Innovation.

#### XTS is opening up optimization potential

The specifications for the new system were ambitious: Flexibility and output were to be significantly higher on a similar footprint: "Around a third more

output compared to the existing systems," explains Alexander Schäfer. Not an easy task with around 250 dowel variants, most of which are produced, packaged, and prepared for dispatch on a make-to-order basis. "When changing products, we must be able to make all settings without manual adjustments," says Eckhard Bubenberger, describing another key requirement. Market requirements are constantly evolving, and with them the demand for multi-component plastic dowels. This inevitably leads to adjustments to the assembly process. With XTS and the various software tools, fischer Innovation can now reconfigure the system as required. "Achieving significantly reduced set-up times compared to the previous automatic assembly machines," emphasizes Alexander Schäfer.

The assembly concept was implemented with PC-based control on an XTS track approximately 10 m in length with 48 movers, which link the individual process stations for the assembly of the multi-component plastic dowels. On the first station, the basic component of the multi-component dowel is inserted into the brackets of a mover. A product-specific label is then applied by two CO<sub>2</sub> lasers. Due to the high power, both lasers are controlled via Safety over EtherCAT (FSoE).

#### Optimized processes through variable mover grouping

Compliance with the short cycle time requires using two of the slow laser stations (double the previous number) in the system, with one product now being moved towards each station at the same time. Reducing cycle times by implementing slow processes several times and supplying components simultaneously is a key feature of the XTS. This duplication of the process stations is possible because each mover can be controlled individually and does not have to follow a fixed sequence. Each mover represents an axis in TwinCAT and can be controlled individually using various functions. "This means that the components placed in the movers can be grouped and

positioned as required – without the movers being mechanically locked in place," says Dieter Völkle, highlighting an important feature of XTS. TwinCAT NC actively controls the mover positions even at standstill and keeps the dowels in position.

Both features come into play in subsequent process steps, where the movers are positioned in groups of 6 under six parallel stations and precisely fixed by energizing the motor modules. "Precisely means with 0.1 mm accuracy," Eckhard Bubenberger points out. On the way to the removal and packing station, the dowels on the movers are swiveled 90° at full speed via a guide rail. This means that they arrive at the grippers with the correct orientation. This detail saves fischer Innovation an additional swivel axis on the grippers of the SCARA robots. Groups of 4 are again ideal for removing and setting down the dowels.

#### From simulation to finished program

XTS simulation mode was incredibly helpful when planning and validating the system concept. For example, the simulation showed that the most effective way to achieve the increase in throughput was with 48 movers and six parallel press-in stations. "Being able to set up and interlink all process steps with such flexibility with XTS was what convinced us," says Eckhard Bubenberger. The XTS was delivered as a pre-assembled and tested functional assembly, including a control cabinet, and integrated into the machine in Horb. "All we had to do was install the software created with the simulation tool and we were able to get started almost immediately," recalls Alexander Schäfer.

The position data calculated and coordinated by TwinCAT based on the setting patterns is sent to the robots in the removal and packaging unit via EtherCAT. "Rather than just dropping the dowels into the box, we specify the insertion

depth and the horizontal offset for each layer," explains Alexander Schäfer. The setting patterns are part of the parts list for an order. The data is stored in a central database on the production controller and can be retrieved by the machine operator via OPC UA and the TwinCAT Database Server.

#### Consistently decentralized and modular

The control architecture is also designed according to the principle of maximum flexibility. "Thanks to the wide range of infrastructure components for EtherCAT, fischer Innovation can set up the network in the same way as the process stations and expand it as required," Dieter Völkle points out. Each feed unit has its own control cabinet, which is connected to the control computer (a C6032 ultra-compact Industrial PC) via star distributors. The palletizer is integrated via an EL6695 EtherCAT bridge terminal, for example. fischer Innovation connects the sensors and actuators for the process stations via EP and EPP Box modules.

"On the basis of our positive experiences, EtherCAT P is our preferred standardized cabling concept for our special machines," says Alexander Schäfer. On the control side, there are plans to replace the existing visualization with TwinCAT HMI, as well as to integrate more robot variants. Additional space will be saved in the control cabinet by converting the drive technology from AX5000 compact servo drives to the AX8000 multi-axis servo system. "We can use the know-how gained from this project for external projects in the future and recommend the use of XTS without reservation," concludes Eckhard Bubenberger.

More information:

[www.fischer-innovation.de](http://www.fischer-innovation.de)

[www.beckhoff.com/xts](http://www.beckhoff.com/xts)

PC-based control automates test wafer handling in semiconductor production

# Contamination and errors don't stand a chance

Click here to watch the video on automated test wafer handling with PC-based control.



Test and calibration processes tie up a lot of resources in semiconductor production. Fabmatics has developed the Test Wafer Center (TWC) to reduce the associated complexity and increase efficiency. The TWC is a cleanroom system which automates the identification, sorting, and storage of test wafers. All tasks from robotics to IT integration are combined on a single end-to-end platform under the control of a Beckhoff CX series Embedded PC. Plant operators benefit from reduced set-up times, seamless traceability, and significantly greater overall plant efficiency.

The global semiconductor industry is experiencing unabated demand for microchips. Production facilities are subject to strict calibration and monitoring processes to ensure high quality and high yield in semiconductor manufacturing. "Test wafers", which run through process stations to verify specified parameters, are used in this context. Regular wafers can only be processed once testing and calibration have been completed. Test wafers account for up to fifty percent of the wafers in circulation in modern semiconductor fabs. Logistics and administration are correspondingly complex. This is precisely where automation specialist Fabmatics comes in. The company has decades of automation experience in cleanrooms and supplies systems worldwide that automatically identify, transport, handle, and store wafer cassettes. The new TWC acts as a central hub for test wafers within intralogistics. It automates the kitting, intermediate storage, and re-sorting of test wafers in the cassettes to ensure just-in-time delivery to the process stations.

The fully automated Test Wafer Center (TWC) optimizes the material flow of test wafers to increase system availability in chip production.

Test wafers are used for the challenging calibration and monitoring processes required in semiconductor production.

### Minimizing risk through automation

The values handled in semiconductor production are considerable. "The value of a fully assembled wafer cassette quickly exceeds the acquisition costs of the mobile robot that transports it," says Carsten Grunert, group leader product development at Fabmatics, getting straight to the point. "That's why process reliability in the plant has top priority." In many fabs, test wafers were previously provided manually or via fragmented subsystems that were difficult to integrate. "But the less manual intervention in the cleanroom, the fewer sources of error and contamination risks there are," continues Michael Neumann, whose remit at Fabmatics includes specializing in PLC development. "Ultimately, integrated automation delivers an increased yield of functioning chips." Damage caused by improper handling, contamination, or simple allocation errors can, therefore, quickly result in high financial losses and significant delays in the production process. In general, time is an extremely critical factor in semiconductor production. Especially after scheduled maintenance intervals, the process systems must be requalified by the test wafers as quickly as possible.

### Central control for complex handling

To fully automate the process, Fabmatics has designed the TWC for 200 mm semiconductor fabs as an integrated system with compact dimensions of around 2.8 x 2 m. The system features up to 93 storage bins (equivalent

to 2,325 wafers) and 14 material handling locations for wafer cassettes. The mechatronic core is formed by a six-axis robot for handling the cassettes and a SCARA robot that handles the delicate transfer of the individual wafers. On the automation side, Fabmatics relies entirely on PC-based control from Beckhoff. A fanless CX2043 Embedded PC acts as the central controller, bundling the entire control logic and communication as well as the integration of drive technology, image processing, and robotics on a compact hardware platform. The physical integration of the peripherals is decentralized via EK1100 EtherCAT Couplers and various EtherCAT Terminals from the EL series. EtherCAT junctions ensure a structured, fail-safe network topology. The hard real-time capability of the communication protocol enables highly dynamic synchronization of the robots with downstream processes. The TWC also integrates RFID readers for unique identification of the cassettes and camera-based systems for robot positioning.

### IT convergence and software engineering

A major advantage of the Beckhoff architecture for Fabmatics is the integration of the TwinCAT 3 automation software. It transforms the embedded PC into a multitasking real-time controller with the complete configuration, PLC programming, and diagnostics located under one roof. Instead of linking isolated systems, Fabmatics programs the entire automation in a standardized development environment. This eliminates interface losses and simplifies plant

design. Fabmatics also considers the integration of modern IT toolboxes to be essential. "To facilitate modern programming, code must be versionable today," stresses Michael Neumann. "By integrating tools such as Git, TwinCAT provides a platform for working on control projects in parallel and across teams." In addition, this solution makes the source code traceable, increases the reusability of function blocks, and increases general engineering efficiency. Functional safety is also seamlessly integrated with Fabmatics. The TWC uses TwinSAFE Terminals in combination with Safety over EtherCAT (FSoE) to transmit safety-related signals directly via the standard network. "The previously separate worlds of automation and safety technology are merging, eliminating the need for error-prone single-core wiring, reducing the space required in the control cabinet, and cutting costs," says Carsten Grunert.

### Facing new challenges together

The implementation of the automated Test Wafer Center is generating direct economic added value for semiconductor manufacturers. Just-in-time delivery of suitably configured test wafer batches eliminates manual search and sorting times. After maintenance work, the required calibration wafers are available at the process stations without delay, reducing downtime and stabilizing fab output. At the same time, fully automated handling reduces the error rate to a minimum. The seamless traceability of each wafer prevents mix-ups.

In this sense, the TWC demonstrates clearly how PC-based control technology is able to meet the high demands of the semiconductor industry and at the same time open up potential for process optimization. The collaboration between Fabmatics and Beckhoff is constantly evolving. "In addition to conventional control technology, we are also integrating more and more drive technology from Beckhoff in new applications," reveals Michael Neumann, "from the highly dynamic servo drives in the AX8000 series to the compact servomotor EtherCAT Terminals in the ELM72xx series and the associated motors." Fabmatics is looking to the future with technologies such as AI-supported code generation, the use of digital twins, and advanced security concepts. "As Beckhoff is our preferred automation supplier, we will certainly be using the ever-evolving PC-based control modular system again for the challenges that lie ahead," concludes Carsten Grunert.

Long-standing cooperation in automation: Carsten Grunert (left), Michael Neumann (right), and Kathrin Kammer (second from left) from Fabmatics, and Martin Rau (second from right) from Beckhoff



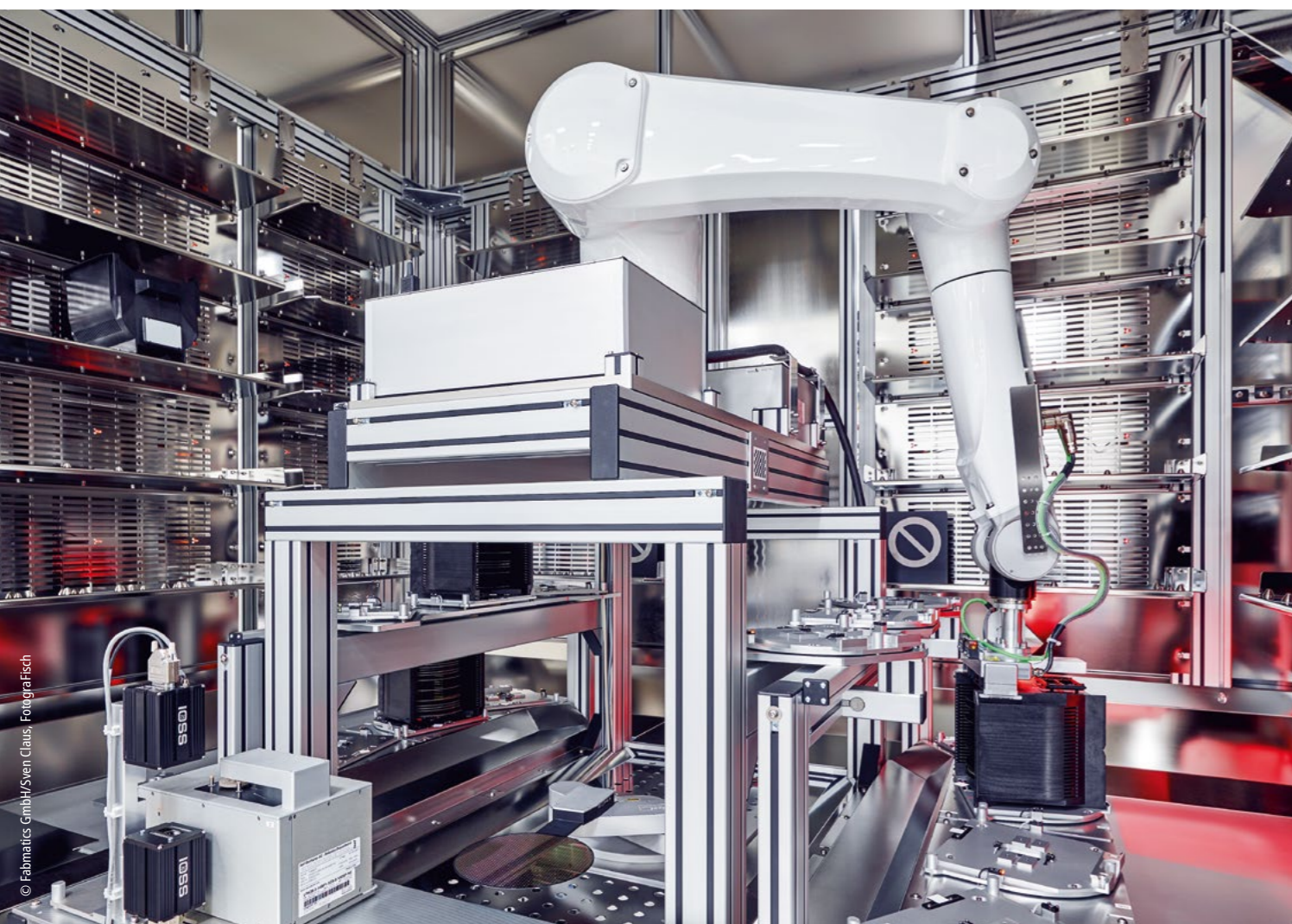
The CX2043 Embedded PC from Beckhoff consolidates PLC, motion control, safety, vision, and robotics on a compact hardware platform.

More information:

[www.fabmatics.com](http://www.fabmatics.com)

[www.beckhoff.com/semiconductor](http://www.beckhoff.com/semiconductor)

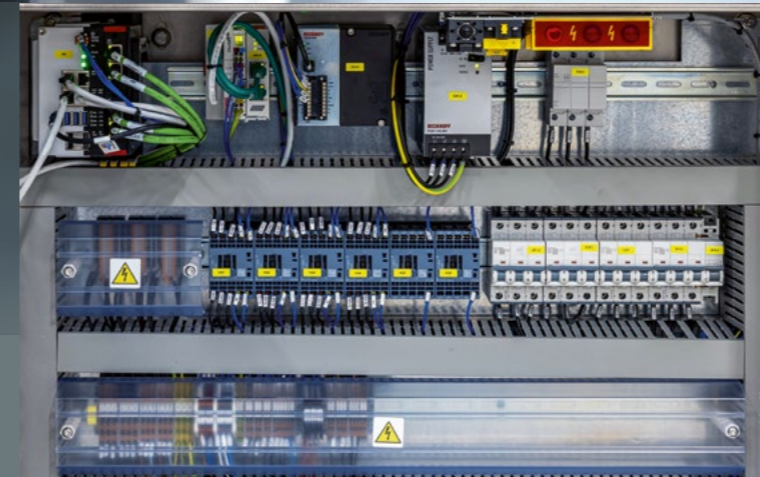
The mechatronic core of the TWC is formed by a six-axis robot for cassette handling and a SCARA robot for the careful transfer of delicate individual wafers.



With the IVB Flex packaging machine, the intelligent XPlanar product transport system combines operational flexibility, process reliability, and traceability.

Using XPlanar in leak detection for pharmaceutical packaging

# Floating, fast, and safe handling of medical bags



Left: View of the control cabinet with the C6030 ultra-compact Industrial PC, EK1100 EtherCAT Coupler, EL6631 2-port communication interface, CU8130 UPS, and PS3031 power supply (above, from left to right).

To make its medical bag handling processes faster and safer, Bonfiglioli Engineering has deployed the magnetic floating technology found in the intelligent XPlanar transport system from Beckhoff as a leak detection solution in its latest IVB Flex packaging machine. The partnership between the two companies played a significant role in achieving the project goals.

In automatic packaging machines, quality control and product integrity do more than just ensure that production stays efficient: most importantly of all, they reliably meet legal requirements and assure traceability. This is particularly true for the pharmaceutical industry. Bonfiglioli Engineering, part of the TASI Test and Automation Group, has built up extensive expertise in this field over more than 50 years. Specializing in areas including leak detection, it has gradually expanded its technology portfolio in quality control and assuring the integrity of pharmaceutical packaging.

### Challenges posed by flexible bags

Davide Luisari, director of engineering at Bonfiglioli Engineering, explains that three complementary inspection technologies cover the quality control requirements that are typical of the industry: "The first technology, CCIT (container closure integrity testing), is used to check the integrity of the closure and that the containers are sealed. The second one, AVI (automatic visual inspection), identifies visual defects and discrepancies in appearance or function. The third technology is HGA (headspace gas analysis), which

measures the gases in the container headspace – a very important parameter in some packaging processes."

One or more of these technologies may be brought into play depending on the type of inspection involved. The key difficulty, however, lies in container handling. With medical bags, for example, there is a real risk of damage every time one of them is picked up and fed into the machine. This is precisely where Bonfiglioli Engineering's solution excels, as Davide Luisari explains:



Daide Luisari (second from left), director of engineering at Bonfiglioli Engineering, and the representatives of Beckhoff Italy: Massimo Veronesi (third from left), sales team leader; Marco Portuese (right), sales engineer; and Giovanni Paladini (left), XTS/XPlanar product expert, in front of the IVB Flex for leak detection in medical containers.

“We don’t just sell machines – we support the customer by providing them with a comprehensive consulting service. In a highly regulated sector such as the medical field, what makes you stand out is not only ensuring product quality, but also designing a reliable, repeatable, and truly productive process.” To meet this need, the IVB Flex packaging machine with XPlanar uses magnetic floating technology, which eliminates mechanical contact and therefore wear during product transport, as well as drastically reducing the risk of bag damage. What’s more, it ensures end-to-end traceability.

#### Intelligent, floating product transport

The solution aims to minimize transportation and handling of the product with the help of XPlanar movers. Inside the machine, the leak tests are carried out simultaneously using special bell systems developed by Bonfiglioli Engineering. To achieve this, the bags are placed on the XPlanar movers, each equipped with a suitable bag holder, and moved under the bell jars. Once the correct position is reached, the system grips the tool – the bag holder – and lifts it until it rests against the base of the bell jar, creating ideal conditions for the test.

A test takes around seven seconds; the bag is pressurized, which allows leaks to be detected based on the pressure difference. Depending on the inspection result, the bag is either forwarded to the station’s outgoing line or transported to the reject area. The entire process takes place without the need to handle the product directly. Once the bag is loaded onto the mover, it is gently transport-

ed between the various test stations, ensuring its integrity and guaranteeing highly reliable and repeatable tests. The machine has six bell jars as well as a loading station and an automatic unloading station, all of which are extremely compact: together, they have a footprint of just over 5 m<sup>2</sup>.

The system uses eight 155 x 155 mm APM4330 XPlanar movers, which float over a surface of 13 XPlanar tiles: seven measuring 320 x 320 mm (APS4244) and six measuring 320 x 160 mm (APS4242). This results in a high functional density in a relatively small space. The XPlanar movers are equipped with interchangeable bag holders that the operator can change manually to suit the product type. The format-changing process is quick and intuitive: all the operator has to do is remove the tool and replace it with one that is suitable for the new format. The replacement tool can easily be attached using centering pins, which ensure correct alignment and stability during movement. As Davide Luisari explains: “XPlanar provides a handling solution that allows unparalleled flexibility during format changeovers. This allows us to quickly switch from small containers with a capacity of 50 or 100 ml, for example, to bags with a larger capacity.” In addition to process flexibility, IVB Flex also guarantees excellent standards in terms of precision and quality thanks to the XPlanar movers’ high load capacity of up to 1.8 kg. This opens up more scope for reliable operation and extensive possibilities for developing the system in the future.

Daide Luisari,  
director of engineering at Bonfiglioli Engineering

“XPlanar provides a handling solution that allows unparalleled flexibility during format changeovers.”



#### A complex challenge with a simple solution

According to Davide Luisari, the XPlanar system made it possible to combine operational flexibility, process reliability, and traceability. However, Beckhoff’s technology went even further than this. Deploying automation based on a C6030 ultra-compact Industrial PC, Luisari explains, helped to simplify the IVB Flex architecture – notably due to implementing TwinCAT as the software platform: “As we were using these technologies for the first time, we took full advantage of the training offered by Beckhoff. We started with a basic course, then moved on to an advanced course that dealt specifically with the XPlanar system. We always had the option of contacting the product specialist if we came across any obstacles or doubts. The TwinCAT programming environment proved to be consistently user-friendly, however, and the prototype was created in just ten months or so – from design and software development all the way through to factory acceptance at the customer’s premises. That’s a record for us!”

There were also no problems with integration. “Despite a specification restriction imposed by the customer, which required the use of third-party PLCs, our technicians experienced no compatibility or interface problems,” explains Davide Luisari. What’s more, there are considerable advantages to be gained in the area of remote maintenance. The ultra-compact industrial PC from Beckhoff is designed for connection via VPN and allows secure access to the machine, regardless of the installation location. This supports advanced diagnostic activities, identification of any critical points in good time, and early and efficient intervention efficiently to resolve any problems.

#### Potential for the future

According to Davide Luisari, the productivity of the machine has exceeded the expectations of the customer, a medical manufacturer that operates plants abroad: “The contactless magnetic floating technology plays a significant role in this by minimizing mechanical wear, requiring less maintenance, and – crucially – ensuring aseptic operating conditions. However, here at Bonfiglioli Engineering, we’re already thinking outside the box. The development we are working on involves integrating optical inspection into the machine itself. Similar solutions already exist on the market, but their cost and space requirements make them impractical and economically unviable.” Another challenge lies in artificial intelligence: “We are looking into the use of neural networks to make leak detection and visual inspection even better and reduce the number of false rejects, especially with flexible products such as bags.” These are developments that require considerable computing power. Luisari adds that, in view of the CPU power that Beckhoff Industrial PCs offer, the aim is to integrate everything – both real-time control and AI – in a single piece of hardware.

More information:

[www.bonfiglioliengineering.com](http://www.bonfiglioliengineering.com)

[www.beckhoff.com/xplanar](http://www.beckhoff.com/xplanar)

PC-based control used in precision micro-cutting of semiconductor materials

# New generation of fully automatic dicing saws makes wafer singulation more efficient

The demand for electronic components is steadily increasing worldwide. To remain competitive in this dynamic market environment, companies must deliver high quality at competitive prices. Leddo Technology, based in China, successfully achieved this balance by implementing its automatic dicing saws with universal PC- and EtherCAT-based control technology from Beckhoff.

Founded in 2010, Wuxi Autowell Technology Co., Ltd. (ATW) is a well-known intelligent equipment manufacturer in the PV, Li-ion battery and semiconductor industries, and currently has more than 4,000 employees. Leddo Technology is a wholly-owned subsidiary of ATW specializing in the research, development, production, and sales of semiconductor dicing saws. With a laser focus on precision cutting technology for semiconductor materials, Leddo upholds a corporate spirit of "professionalism, unity, and relentless progress."

Recently, the company has successfully developed and launched the LAD5100 and LFD7100 series of high-precision dicing saws. These advanced solutions cater to a diverse range of product sizes, including 6-inch, 8-inch, and 12-inch wafers. The systems of Leddo Technology are primarily deployed in the fully automated dicing and processing of wafers and other semiconductor products, such as integrated circuits, power devices, compound semiconductor chips, optical communication devices, and LEDs. Leddo's devices excel in versatility and are suitable for cutting various materials and products, including silicon, lithium niobate, ceramics, glass, quartz, alumina, and PCB boards. They are complemented by a comprehensive suite of wafer cleaning equipment, essential consumables, and tailor-made dicing process solutions.



Dicing saws from Leddo Technology installed in a cleanroom

**For automating the LAD5100 single-axis semi-automatic dicing saw and the LFD7100 dual-axis fully automatic dicing saw, Leddo Technology has selected the universal PC- and EtherCAT-based control technology from Beckhoff.**

As a leading semiconductor equipment provider in China, Leddo aims to leverage cutting-edge products and technology as well as extensive industry expertise to consistently provide customers with practical and efficient product solutions.

**PC-based control technology**

For automating the LAD5100 single-axis semi-automatic dicing saw and the LFD7100 dual-axis fully automatic dicing saw, Leddo Technology has selected the universal PC- and EtherCAT-based control technology from Beckhoff. For machine control, they employ the C6030 ultra-compact Industrial PC measuring only 132 x 133 x 76 mm in size. Despite its compact dimensions, the controller delivers exceptional computing power, featuring

an Intel® Core™ i5-9500E processor capable of achieving minimum task cycle times of 50 μs. Additionally, the industrial PC for control cabinet installation provides four independent Gigabit Ethernet ports, meeting the requirements of EtherCAT real-time control while also supporting Modbus TCP and TCP/IP protocols. The PC-based control system runs on the Windows 10 IoT Enterprise operating system, with the HMI interface developed in C#. This approach of the PC-based control technology not only reduces equipment costs but also enhances communication capabilities and system stability.

**The open EtherCAT fieldbus system and its advantages**

EtherCAT is by and large the fastest Industrial Ethernet technology, but it also synchronizes with nanosecond accuracy. The rapid response times work to reduce the wait times during the transitions between process steps, which significantly improves overall application efficiency. EtherCAT offers virtually limitless freedom when it comes to network topology. Line, tree, star topologies and any combinations thereof are possible with a nearly unlimited number of nodes. Moreover, experience with customer equipment has shown that diagnostic capabilities play a major role in enhancing a machine's availability and commissioning time. In addition to error detection, fast error localization is vital for troubleshooting. Leddo Technology utilizes TcEtherCAT.lib in order to acquire the communication status of slave nodes, thereby enhancing the operational efficiency of the equipment.

The equipment employs a complete set of Beckhoff I/O solutions, including digital, analog, and communication modules in the comprehensive portfolio

of EtherCAT Terminals. Among them is the EL3702 analog input terminal with oversampling function, which meets the customers' requirements for particularly high-resolution scanning of the measurement range.

**Automation perfectly tailored to the application with TwinCAT**

From Leddo Technology's point of view, TwinCAT 3 software has redefined the well-known field of automation technology. TwinCAT 3 integrates all control functions, including TwinCAT PLC and TwinCAT NC, into a unified software platform that provides a development environment and a runtime environment. In this way, multiple task cycles can be set up for the equipment, with different tasks being assigned to different CPU cores. The software platform also offers flexible task priority settings for real-time multi-task processing.

For the high accuracy of the dicing saws, it is essential to achieve a well-coordinated and precise motion control of the cutting axes of the dicing blade as well as the spindle drive.

- The NC control cycle time of the equipment reaches 200 μs, meeting the technical specifications of a single positioning accuracy of up to 0.002/5 mm for the Y-axis, a full-range positioning accuracy of 0.003/310 mm, a travel resolution of 0.00005 mm for the Z-axis of the dicing blade, a repeat positioning accuracy of 0.001 mm, a maximum spindle speed of 60,000 rpm, and a radial runout of less than 0.1 μm.
- TwinCAT 3 Eventlogger manages target events and records customized alarm information, ensuring worry-free equipment maintenance.

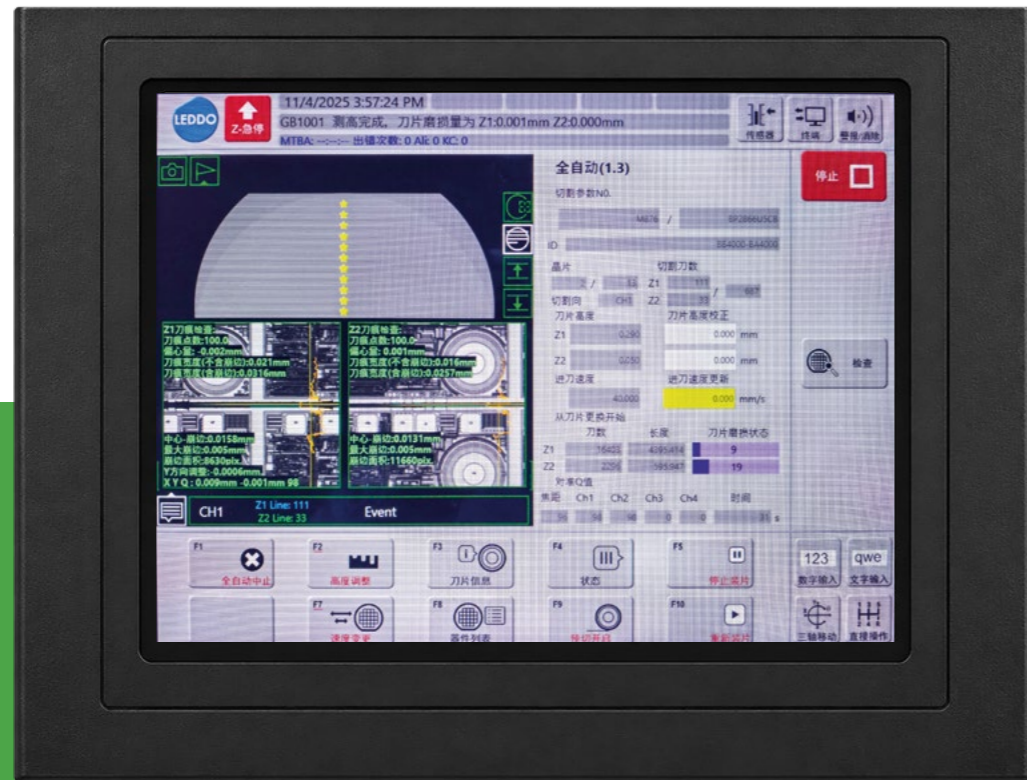
- TwinCAT 3 Scope Server automatically collects and stores real-time data, making data analysis effortless.
- TwinCAT 3 Condition Monitoring analyzes vibration measurement data to enhance equipment stability and in that way avoid any impact on the cutting quality.

**Conclusion**

The accuracy of ±1.5 μm already surpasses the equipment's accuracy of most small and medium-sized equipment manufacturers from China and, according to Leddo Technology, may even match the accuracy of machines from some leading international suppliers. The yield rate in the processing of the valuable semiconductor materials and products can exceed 99.9%, which benefits the competitiveness of end customers. From Leddo Technology's perspective, diverse TwinCAT Functions and EtherCAT's diagnostic capabilities also simplify maintenance and commissioning, enabling further optimization of the application during operation and ensuring high system availability. In addition, Leddo says that Beckhoff control technology saves space in the control cabinet and helps conserve costly floor space in cleanrooms.

More information:

[www.wxautowell.com](http://www.wxautowell.com)  
[www.beckhoff.com/halbleiterfertigung](http://www.beckhoff.com/halbleiterfertigung)



HMI with a visualization of the dicing process and machine parameters

© Leddo Technology



A C6030 ultra-compact Industrial PC with exceptional computing power and versatile interfaces is used as a machine controller for the dicing saws.

The compact I/O level equipped with EtherCAT Terminals saves space in the machine-integrated control cabinet.

PC-based control in minimally invasive surgery

# Miniature robot in PC-based and highly precise operation



The surgical robot developed as part of the MIRACLE II project at the University of Basel was also a highlight at the World Expo 2025 in Osaka, Japan.

MIRACLE II is the second phase of the MIRACLE project funded by the Werner Siemens Foundation. MIRACLE stands for Minimally Invasive Robot Assisted Computer-guided Laserosteotome, i.e., a modular laser robot for minimally invasive bone removal that is planned and supervised in virtual reality. The robotic elements of this system were developed by Prof. Dr. Georg Rauter and his team at the University of Basel, based on Beckhoff control technology and specifically TwinCAT 3 Target for Simulink®.



The CX2043 Embedded PC and, directly adjacent, a 130W CX2100-0014 power supply and EtherCAT and TwinSAFE Terminals provide the control hardware for this MIRACLE II project.

MIRACLE II is based at the Department of Biomedical Engineering (DBE) in the Faculty of Medicine at the University of Basel. "Researchers from the fields of computer science, engineering, robotics, laser physics, surgery, and other disciplines are coming together here to bring bone surgery into the space age," says Prof. Dr. Georg Rauter, head of the BIOMED Lab (Bio-Inspired RObots for MEDicine Laboratory) at the DBE. The corresponding miniature robot will perform functional incisions with unprecedented precision for customized bio-ink implants produced directly at the treatment site.

#### PC-based control as the technological foundation

As part of his research, the roboticist Prof. Dr. Georg Rauter has been working with PC-based control technology from Beckhoff since 2008. He describes the starting point as follows: "At the time, we needed a communication solution for several hundred components distributed over a large area. In addition, the majority of the measurement technology cards were PCI bus-based or PCI Express bus-based. To avoid the increasing difficulties associated with the number of interfaces and signal cable lengths, our search for a bus-based system led us to EtherCAT as a compatible solution and consequently also to Beckhoff as a suitable provider of the associated control technology."

As a doctoral student, Rauter's work in this field started with the development of a rowing simulator at ETH Zürich based on a cable-driven robot. The concept was built around the synchronized control of two cable-driven parallel robots, each with five drivetrains. The aim of the rowing simulator was to use an intelligent algorithm to teach people to move autonomously by providing personalized multimodal feedback on the execution of movements. Prof. Dr. Georg Rauter explains: "The intention was to research movement learning in sophisticated movements in healthy individuals. Safety was a central element of the simulator, because rowing can generate significant forces – when the oar is submerged, for example – which the simulator must be able to reproduce. The safety functionality was initially implemented with a separate safety controller. With TwinCAT 3, we are now using the system-integrated TwinSAFE safety technology, which also enables seamless integration into the human-machine interface, for example. An additional advantage of TwinCAT 3 is that we were able to retain the familiar workflow. This allows us to continue using a graphical programming surface as well as programming with MATLAB® and Simulink®. "I'm a big fan of the workflow with TwinCAT 3 Target for Simulink®, which delivers a C++ project, that can be integrated directly into TwinCAT, and the appropriate machine code following compilation." In addition, the TwinCAT workflow also benefits students on the Master's program and new employees: "We run a block course on this every year – twice in Basel and now once in Innsbruck as well, due to its great popularity. We also host workshops at our congresses. In principle, these courses are also open to industry participants who are specifically interested in the implementation of MATLAB® and Simulink® in TwinCAT 3."

#### Implementation in surgical robotics

As part of the MIRACLE II project, Prof. Dr. Georg Rauter has applied his robotics know-how and experience of PC-based control to surgical robotics. The project focuses on classic orthopedic applications in which an endoscope is used to insert a laser into the body via a small opening in a minimally invasive operation to precisely manipulate the bone or change its geometry and,



To perform operations correctly, flexible spiral spindles enable the miniature robot to be moved precisely inside the body.

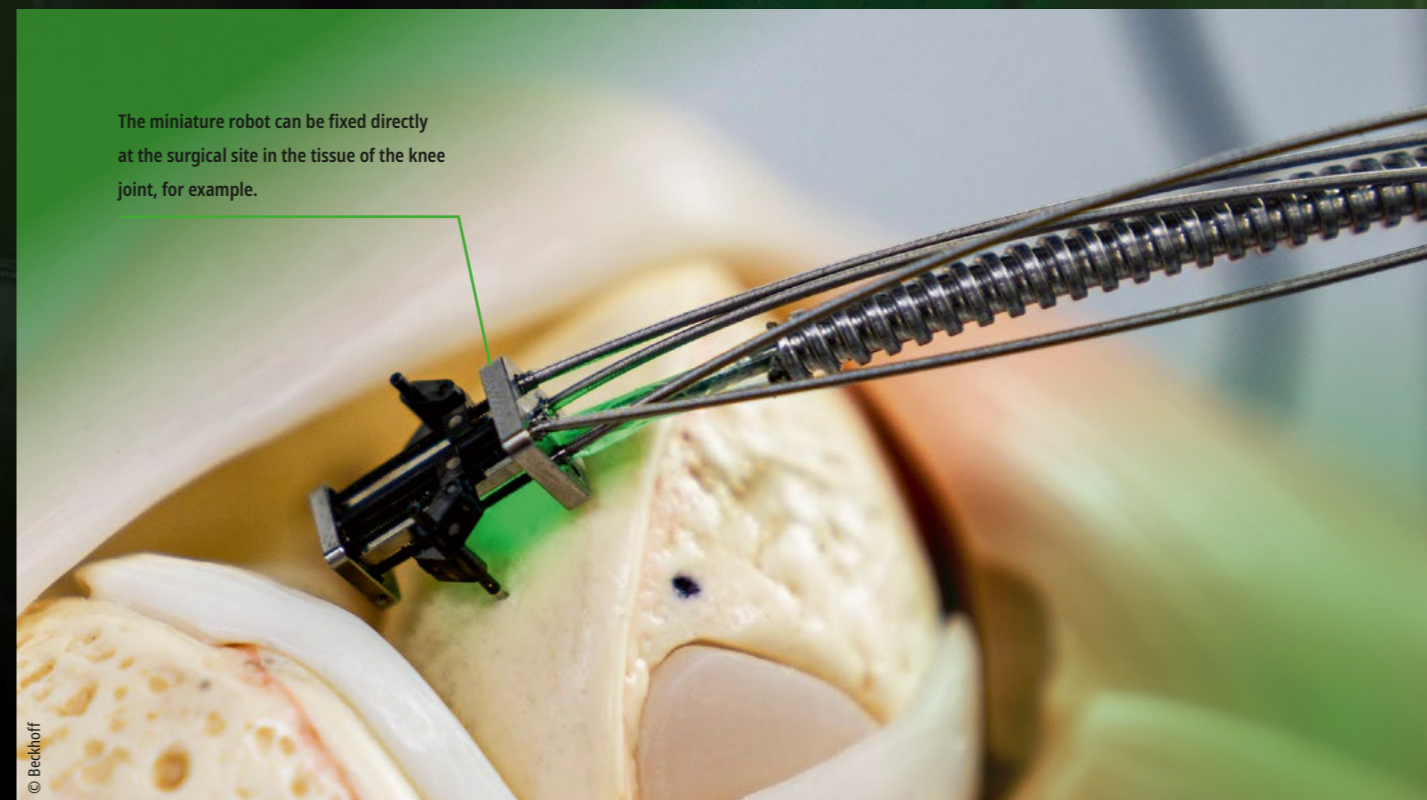


Prof. Dr. Georg Rauter (right), head of the BIOMED Lab at the Department of Biomechanical Engineering at the University of Basel, and Eric Schaller (left), area sales manager at Beckhoff Switzerland, with the successful implementation of the MIRACLE II surgical robot

therefore, stability. The research already carried out is now being expanded to include regenerative cartilage medicine. The platform for next steps is the miniature robot presented at several events including the World Expo 2025 in Osaka, Japan, which can be used to demonstrate interdisciplinary cooperation using a specific application in the knee – laser osteotomy or regenerative cartilage medicine.

Prof. Dr. Georg Rauter explains more: "Parallel robotics combined with lasers is our core focus in Basel and is also unique in its miniaturized dimensions. Currently, surgical robotics uses large devices anchored to the floor with correspondingly large kinematic chains that are complex to stabilize for sufficient

The miniature robot can be fixed directly at the surgical site in the tissue of the knee joint, for example.



precision. Our miniature robot, on the other hand, is supported locally on the tissue and also inserts the laser there, which itself has no interaction forces. This means that the system can be positioned very accurately without having to compensate for interfering forces. The required torque is applied from the outside via flexible spindles. Overall, this design results in a very small footprint with a cross-section of 7.5 x 7.5 mm."

#### High-performance technology required

The parallel drivetrains require powerful control technology for synchronization, as is available with TwinCAT, the CX2043 Embedded PC, and the EtherCAT and TwinSAFE Terminals from Beckhoff. This technology allows the planar system to reliably utilize its three planar degrees of freedom: forward/backward movement, lateral movement, and rotation. A total of four EtherCAT- and FSoE-capable small servo motors are used for this purpose, including redundancy, which move the robot to the desired position via flexible spiral spindles. Prof. Dr. Georg Rauter describes the special feature of the control system as follows: "Due to the redundant drive, rather than solving a linear system of equations, the control system solves a real-time optimization problem in order to achieve the best possible result not only iteratively but also multiple times every millisecond."

According to Prof. Dr. Georg Rauter, the high functionality of TwinCAT is used to a wide extent: "A good example is TwinCAT HMI, where I particularly like the data exchange across different logics – from C++ through PLC or hardware, and beyond to Safety. In addition, our kinematics can be conveniently integrated into TwinCAT and it is easy to communicate with third-party components like machine learning-based vision components via ADS. TwinCAT and EtherCAT

offer this openness and flexibility not least due to their widespread use. That's why components with the right interfaces are available for all requirements."

#### The benefits of close cooperation

According to Prof. Dr. Georg Rauter, the research undertaken at the University of Basel also benefits from close cooperation with Beckhoff Switzerland. Rapid response times when specific inquiries are submitted and the ability to test hardware on a short-term basis are important aspects in this regard. He explains that they were able to test the application potential of the XPlanar intelligent transport system over the course of a year, for example. In addition, the Department's own development proposals regarding control technology are openly listened to and reviewed.

"Ten years ago, secure and reliable communication and automation technology from Beckhoff – which we originally used on the rowing simulator at ETH – made a technology transfer possible: in the form of 'The FLOAT' – the world's first cable-based robot for free, weight-supported 3D gait rehabilitation on the ground – developed in collaboration with Reha-Stim Medtec AG, Schlieren, Switzerland, and the Center for Paraplegia at the University of Zurich in Balgrist. "We are now looking forward to taking this step toward commercialization in surgical robotics as soon as possible, thanks to robust automation technology."

More information:

<https://dbe.unibas.ch>

[www.beckhoff.com/science](http://www.beckhoff.com/science)

XPlanar on a filling and capping line for cosmetic products

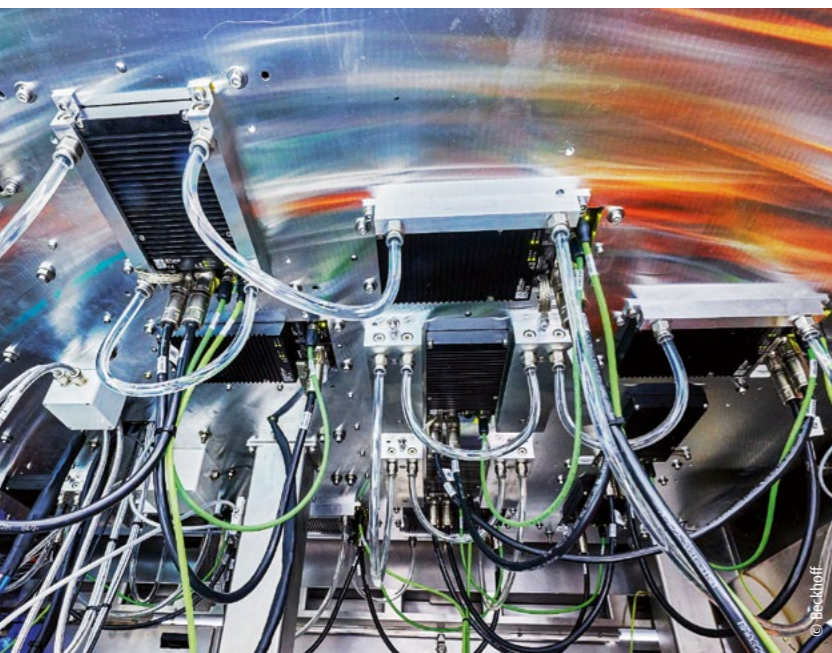
# From line to compact block layout with intelligent product transport

Space constraints in production environments, leaving no room for traditional system concepts, call for creativity and PC-based control. Along these lines, Pro Pharma Automation and Glanzer cosmetic engineering have created an innovative filling system with XPlanar and TwinCAT – a solution which, according to Managing Director Sigrid Glanzer, is going to set a benchmark in filling and designing multi-component cosmetics.

Right: A C6670 industrial control cabinet server (right) coordinates all machine processes – using the AX8000 multi-axis servo system (left), among other things.



The track management and collision avoidance features in TwinCAT 3 XPlanar prevent the XPlanar movers from causing accidents within the small space and ensure they approach the process stations with high precision.



View under the machine frame: The water cooling for the aluminum baseplate adheres to the temperature specifications for the cosmetic products being dispensed.



XPlanar increases the flexibility of the filling and capping line from Glanzer cosmetic engineering and Pro Pharma Automation to a high degree.



Sigrid Glanzer (Glanzer cosmetic engineering) with a filled jar, plus Gerhard Holzer and David Kittl (both Beckhoff) with Walter Steinauer, Hellwig Mallinger (both Glanzer cosmetic engineering), and Christian Haslmair (Pro Pharma Automation) in front of the filling line (left to right)

Glanzer cosmetic engineering has been producing cosmetic products for international brands and retailers for over 90 years. Around 100 employees develop, produce, dispense, and package high-viscosity oils, emulsions, creams, and liquids on a total of ten lines. "As the leading contract manufacturer in Austria, we offer a full service in the cosmetics sector, from product development and production according to product specifications to filling and packaging," says Managing Director Sigrid Glanzer. The challenges that the company faces lie in increasingly shorter product life cycles and, in some cases, highly dynamic variations in production batches. It also has to cater to trends such as multi-phase filling and customized patterns in jars. "Things get pretty creative in cosmetics," confirms Walter Steinauer, Plant Manager and co-owner of the company, which is certified to the IFS HPC and GMP for cosmetics standards.

To meet the requirements of an increasingly dynamic market, a new filling and capping system was designed together with machine builder Pro Pharma Automation in Elsbach, Austria, which specializes in the pharmaceutical and cosmetics industries. The biggest priority in the project was achieving flexibility in jar sizes, process flows, and product ranges, which demanded a completely new approach to the production line. For Pro Pharma, things were complicated further by the limited space provided by the existing production line for high-end cosmetics, an area subject to strict hygiene requirements. "We're talking about a footprint of about 3 x 1.8 m – barely a line, really," says Christian Haslmair, Managing Director of Pro Pharma Automation, outlining the concept.

#### XPlanar – a compact, scalable solution

The filling system is based on the XPlanar planar motor system from Beckhoff. "Where the system really stands out is that it maximizes the space available and has a customizable layout," states Walter Steinauer. This means that it can accommodate much more stations within a smaller area than systems with conventional conveyor belts can. In addition, the XPlanar movers support

an entirely free process flow decoupled from the mechanical design. Thus, depending on product specifications, individual stations in the process can be omitted or run through several times. Systems with XPlanar can also be scaled to almost any size by parallelizing individual stations and adding more movers. "The current layout with 20 XPlanar tiles and 16 movers is designed for around 30 units per minute," says Christian Haslmair.

A total of 13 process stations and three robots were accommodated in a very confined space. The first robot takes the jars from the infeed and places them on the XPlanar mover in the transfer area using special brackets, which secure the jars in exactly the right place. The brackets are also automatically released before the robot inserts the jars. The next step is the extraction or blow-out station, which ensures that there are no particles or cardboard residue in the jars. Next is the filling process: Glanzer has the option of filling the jars with two components at the same time or just one. When it comes to product dispensing, Pro Pharma relies on servo-controlled auger fillers instead of piston fillers, traditionally a popular choice. "They allow us to dispense highly viscous liquids and water-based emulsions, and withdraw or add more if necessary," says Christian Haslmair.

#### Mover rotation and precision generate USP

As Glanzer cosmetic engineering intends to add small flacons to the containers it fills in the future, it relies on precision. "We need a positioning accuracy of 0.1 mm," says Walter Steinauer. "XPlanar boasts far more precision, thanks to its position resolution of 1 µm and typical repeatability of 5 µm," says David Kittl, who works in sales at Beckhoff Austria, explaining another function that the solution provides. For products with two components, the mover can rotate the jar in sync with the dispensing process. "This results in a beautiful spiral pattern in the different components, something that gives our customers an opportunity for product differentiation and catches the consumer's eye at the

point of sale," says Sigrid Glanzer of this attractive system feature. "PC-based control and XPlanar certainly don't place any restrictions in the way of creativity in the cosmetics industry," confirms David Kittl.

After filling, the next stage is a sealing and closing station involving a second robot and its special gripper mechanism. The brackets and precise positioning of the movers are crucial in this process. "If the jars are not exactly centered, the robot cannot position the lid correctly, which makes screwing it into place properly almost impossible. There isn't much room for error here," says Walter Steinauer. Finally, the movers proceed to the third robot, which places the filled jars on a conveyor belt for final inspection.

#### Everything under control with TwinCAT 3

TwinCAT 3 XPlanar (TF5890) coordinates all movements. "Even though there are several movers in a very confined space, the system's integrated track management and collision avoidance features stop them from bumping into each other," states David Kittl. Christian Haslmair relies on TwinCAT 3 PLC/NC PTP (TC1250), the AX8000 multi-axis servo system, and AM8000 synchronous servomotors to control process stations and drive axes, and to coordinate the robots. All these processes are carried out on a C6670 control cabinet industrial server, which also handles visualization and data acquisition during all production steps.

In the cosmetics and pharmaceuticals sector, it is important that process control and documentation comply with ISO 13485 requirements. This is why every APM4330 mover has an XPlanar ID bumper, which is used to read out the mover's individual serial number at all stations. With this information, each jar's journey through the system can be logged and documented if required – even after a power supply failure. In addition, there is no homing required at system startup if programming has been carried out accordingly.

Alongside operating smoothly, the system has to be easy to clean. This is where the XPlanar system offers clear advantages over other systems: the XPlanar tiles are mounted on an aluminum plate and covered with FDA-certified film without restricting functionality or accuracy. Pro Pharma has developed an intriguing solution for maintaining the specified processing temperatures for the cosmetics in the closed system. "We have installed a water cooling system on the underside of the work surface on the XPlanar electronics to keep the temperature in the system low," says Christian Haslmair. Cooling surfaces of different sizes are used to accommodate different tile sizes.

#### Small batches, short set-up times

With batches becoming increasingly smaller, set-up time is becoming a key factor in efficiency considerations. "If the next batch needs to be processed or a different jar size needs to be filled in three hours' time, we can't have a changeover process that takes half a day," summarizes Walter Steinauer. The two transfer stations make sure this is not the case – as does the largely automated product changeover process, which is initiated by the customer-specific CP3921 stainless steel multi-touch Control Panel and TwinCAT HMI. "It's still too early for exact figures, but we expect set-up time to drop by a third compared to our existing lines," states Walter Steinauer. Sigrid Glanzer is certain that the investment will pay off: "Our sales department is practically snatching the samples out of my hand so it can get them to our customers!"

More information:

[www.glanzer.pink](http://www.glanzer.pink)

[www.pro-pharma-automation.at](http://www.pro-pharma-automation.at)

[www.beckhoff.com/xplanar](http://www.beckhoff.com/xplanar)

XPlanar aids innovation in laser processing

## Floating product transport for more efficient and sustainable production of metal parts

Aalborg University states that it is one of the first in the world to test the XPlanar intelligent transport system from Beckhoff in advanced laser processes. The aim is to meet industry requirements for more flexible and sustainable production. The result is a fast and precise production concept under software control that can transform the development and manufacture of metal parts.

Lecturer Dr. Morten Kristiansen has spent more than 15 years researching laser processes in the Department of Materials and Production at Aalborg University (AAU). His mission is to develop new methods for faster shaping of metal parts in small and medium-sized series using lasers: "Laser technology represents a completely new way of thinking about production – precise, flexible, and under digital control from the very first second. While traditional manufacturing requires big presses, complex tools, and long setup times, laser processes can produce the same – or even more advanced – components without physical tools."

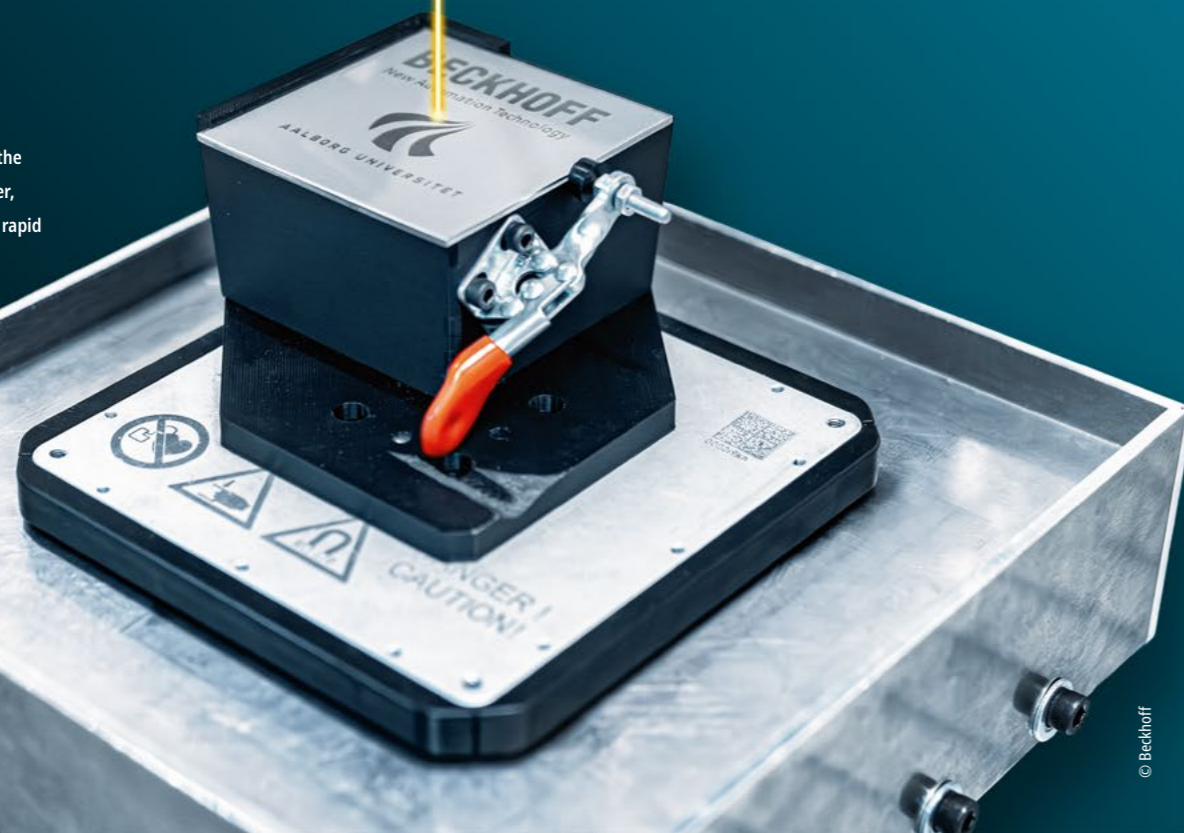
Flexibility, cutting waste, and significantly reducing production costs will be crucial in the smart factories of the future. The research team at the AAU is therefore working on replacing traditional, tool-based processes with digital methods that free up both time and capital and facilitate rapid adaptation to market needs.

### Rotation with micrometer precision

The XPlanar planar motor system heralds a venture into new territory for the AAU: this modular transport system uses movers to position and rotate workpieces in six degrees of freedom with micrometer precision above the XPlanar tiles, which function as highly compact, fully integrated drive units.

In the AAU system, a small metal plate is attached to the XPlanar mover via a workpiece carrier, which is moved under the laser with rapid movements. The laser bends, shapes, and engraves the metal. Dr. Morten Kristiansen explains: "When we saw XPlanar for the first time, we recognized its potential immediately. Instead of moving the laser head with an expensive robot, we can simply control the XPlanar mover to move the workpiece. This ensures far greater precision, flexibility, and a smoother process. At the same time, we can combine multiple processes in a single machine."

The small metal plate is attached to the XPlanar mover via a workpiece carrier, which is moved under the laser with rapid movements.



Precision is crucial, and with repeatability of  $\pm 5 \mu\text{m}$ , XPlanar is more precise than even the most advanced robots, according to Dr. Morten Kristiansen. This allows XPlanar to be integrated directly into an overall production system in which the workpieces are automatically transported between the stations. "Where conventional production requires separate machines and manual handling, our system can handle everything – quickly, precisely, and under software control," he says. The system can easily be expanded by adding stations, and each mover can be customized for a specific product. This means that several individual products can be designed in parallel. "It's like having a digital production laboratory where we can test several different products simultaneously and see the differences in real time," he continues.

### Suitable as an all-in-one laser platform

The XPlanar technology was tested for twelve months and is the subject of a thesis by Mads Holm Andersen and Mads Augustinus Frøhlich under the supervision of Dr. Morten Kristiansen. Their work concludes that magnetic levitation technology has great industrial potential in laser-based processes and can form the basis for an integrated all-in-one laser platform for the sheet metal industry. "The processing time per workpiece is kept to a minimum, as XPlanar can set workpieces aside to cool down while other workpieces are processed by the laser. The processing times for the workpieces we produce are five minutes and the total time from design to finished workpiece is between one and two hours due to the cooling time. This production time can be compared with traditional manufacturing techniques, which can have a lead time of four to six weeks if tools have to be made first before the workpiece can be produced," explains Mads Augustinus Frøhlich, research associate at the AAU's Department of Materials and Production.

"XPlanar is ideal for prototypes, small and medium quantities, and on-demand production. Only the required number of workpieces is produced and workpiece waste can be reduced by at least 10 percent. This corresponds approximately to the quantity that is typically overproduced on a press brake with a conventional production line," explains Mads Augustinus Frøhlich.

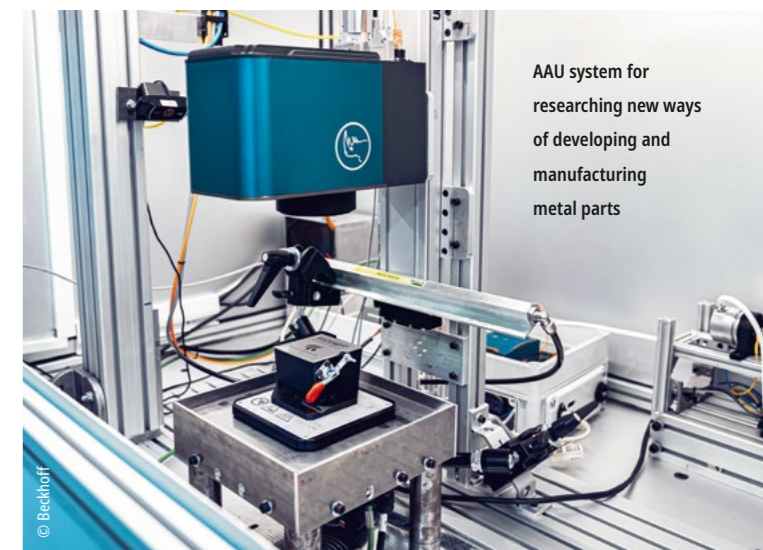
### From experiment to industrial potential

"The industry has not yet exploited the full potential of lasers. With XPlanar, we may be able to set a new industry standard for digital, precise, and modular production in a continuous workflow. This is quite unique," explains Dr. Morten Kristiansen. The AAU is already working with industrial partners to bring the technology to market maturity. The aim is to test the solution in real production environments within a few years – in the metal, electronics, and medical technology industries, for example, where work involves small precision components and frequent design changes.

According to Dr. Morten Kristiansen, TwinCAT as an open software platform and the close technical cooperation with Beckhoff are key to unlocking the ability to think experimentally and develop new innovations. The open standards, flexible software, and multiple interfaces make it possible to integrate everything from sensors and image processing through to laser systems – without being tied to one manufacturer. "The technology from Beckhoff is extremely accessible. We can download the software, test the solutions, and connect to a huge ecosystem of components. This means that both researchers and students can try out ideas in practice and build on them without having to start from scratch. The combination of precision,



The project team (from left to right): Michael Byskov (support engineer, Beckhoff Denmark), Dr. Morten Kristiansen (lecturer at Aalborg University), Mads Faaborg Frøhlich (research associate at Aalborg University), and Jakob Nørskov Pedersen (student in the Department of Materials and Production at Aalborg University)



AAU system for researching new ways of developing and manufacturing metal parts

speed, and software freedom makes Beckhoff an ideal partner for research environments where innovation comes from experimentation," he explains.

The collaboration between the AAU and Beckhoff dates back more than 15 years and is based on a shared curiosity to explore the limits of automation. The experts from Beckhoff were directly involved from the first proof of concept and provided rapid personalized support when new ideas needed to be implemented. "They always get back to us quickly, share their knowledge, and help us to understand the solution rather than just making corrections. This helps us to improve," says Dr. Morten Kristiansen.

More information:

[www.en.aau.dk](http://www.en.aau.dk)

[www.beckhoff.com/science](http://www.beckhoff.com/science)



The ETG joint booth at its new location in Hall 27 for the first time



EtherCAT receives cybersecurity certificate from UL Solutions.



Martin Rostan presents EtherCAT technology and the ETG as part of "Experience Beckhoff".



Technology meets personal dialogue.

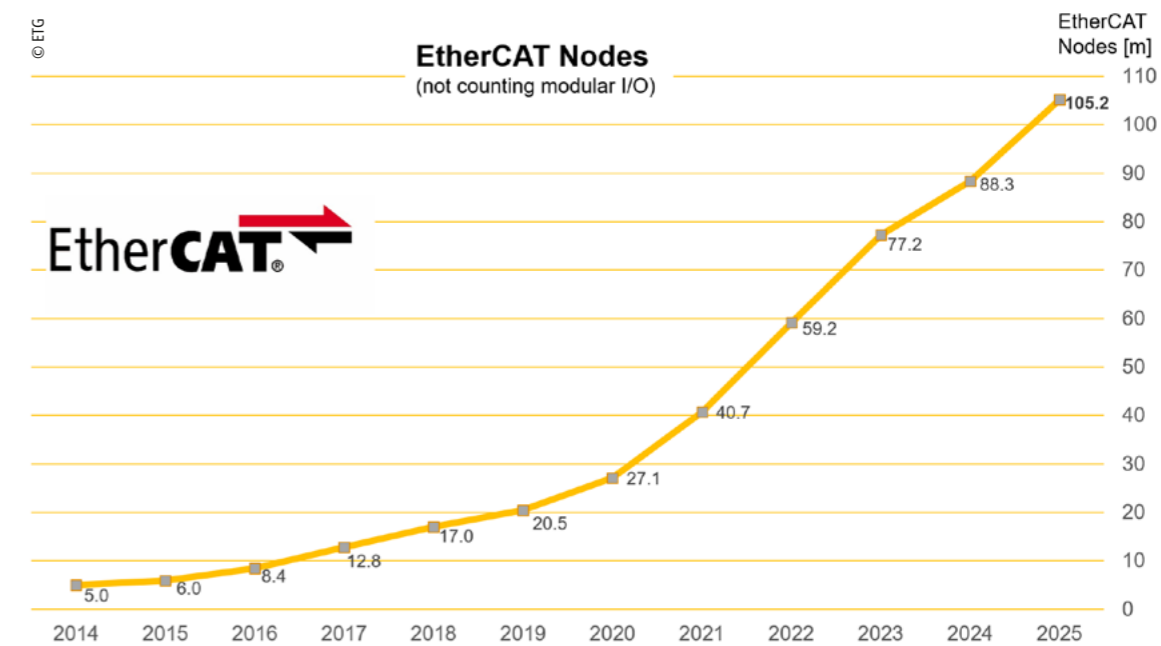
## Hannover Messe 2026: EtherCAT impresses with certified cybersecurity

At Hannover Messe 2026, the EtherCAT Technology Group (ETG) not only showcased the EtherCAT technology at a new, prominent location – it also received significant recognition: UL Solutions certified the cyber resilience of EtherCAT. This positions the technology well for the future of industrial networking and means it already meets key requirements of international standards such as IEC 62443.

From April 20 to 24, 2026, the global industry gathered in Hannover for the world's largest trade fair for industrial innovation. Under the motto "THINK TECH FORWARD," the focus was on technological advances and industrial transformation. More than 109,000 trade visitors from around the world learned about the latest developments. For the ETG, the fair brought a double premiere: The joint booth moved to a strategically advantageous location in Hall 27, Booth G59, and presented well over 500 products on 125 square meters together with 44 co-exhibitors. EtherCAT technology was once again made accessible to numerous international visitor groups as part of the "Experience Beckhoff" program (formerly the VIP program).

A central topic at the fair was cybersecurity in industrial applications. This was precisely where ETG was able to announce special news. UL Solutions officially confirmed that EtherCAT already today – without any adjustments to the protocol or hardware – meets the requirements of the international standard IEC 62443 for Security Level 2. In its European form, this standard will also form the basis for the European Cyber Resilience Act (CRA) in the future. UL's investigations also show that only targeted software enhancements are needed to achieve even higher security levels. More than 100 system requirements from IEC 62443-3-3 were mapped to three typical EtherCAT systems with different threat scenarios and evaluated – with

impressive results. "We at UL Solutions were delighted to work with an industrial protocol which has security capabilities and enablement-by-design as well as hardware implemented security, which is second-to-none in the category of industrial protocols," explained Alexander W. Köhler, S&S Principal Security Advisor Cybersecurity. At the ETG booth, Köhler presented the cybersecurity certificate to Martin Rostan, Executive Director of the EtherCAT Technology Group, and Torsten Förder, cybersecurity expert at Beckhoff. With this confirmation, EtherCAT underscores its leading role as a future-proof technology – powerful, flexible, and secure.



Thanks to precise chip statistics, there is a reliable data basis: The ETG reports around 105 million EtherCAT nodes worldwide for 2025.

## EtherCAT surpasses the 100-million mark

With over 105 million installed nodes, EtherCAT is further expanding its leading position in the market for industrial real-time Ethernet systems. In 2025, almost 17 million new nodes were added – a clear indication of the end of the chip crisis and the continued success of the technology.

The figures are based on unit numbers reported by chip manufacturers and are deliberately determined conservatively. Multi-protocol chips are only counted proportionally, FPGA implementations contribute only ten percent to the statistics, and modular input and output terminal blocks (such as classic DIN-rail terminal blocks) are not counted at all. This creates a realistic picture of the EtherCAT market and avoids potential overestimation.

Martin Rostan, Executive Director of the EtherCAT Technology Group, emphasizes that actual usage of multi-protocol chips in practice is likely even higher. The sustained demand is primarily due to EtherCAT's technical strengths – such as short cycle times, high determinism, and low latency – combined with simple commissioning and a flexible, scalable topology. In addition, the technology covers a wide range of applications,

from manufacturing automation and robotics to packaging and semiconductor technology, and on to medical technology and transportation.

The EtherCAT Technology Group expects growth to continue to accelerate in the coming years. Contributing factors include both the rising importance of cybersecurity and new applications in robotics, manufacturing automation, and intralogistics.



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