BECKHOFF New Automation Technology

Scalable and powerful:
The open CNC solution for machine tools

PC-based control integrates all CNC functions on a single platform

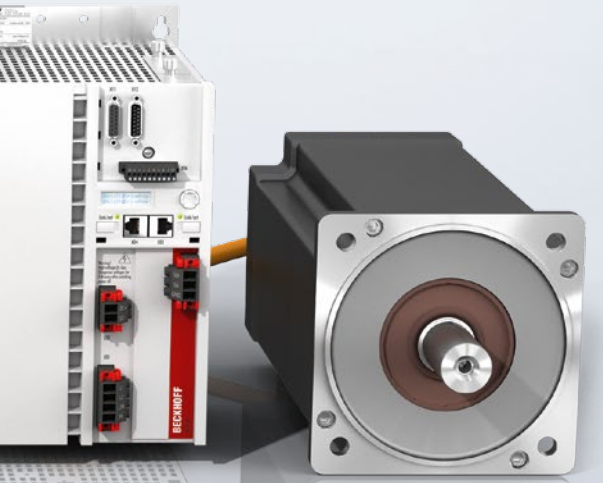
The productivity and efficiency of machine tools can be significantly increased using powerful PC-based control solutions from Beckhoff. Based on standard components, the hardware and software platform integrates all automation and CNC functionalities in one system. The platform is scalable for all performance classes and is universally suited to all types of machines. Since every function is mapped in software, new machine features can be easily retrofitted, and functions for intelligent production approaches are relatively simple to integrate. Open interfaces permit simple integration with existing systems and fieldbuses as well as flexible exchange of hardware components.

At the same time, machine tool manufacturers benefit from a maximum degree of freedom in machine design. With long-standing and comprehensive expertise in machine tool technology, we can guarantee performance-matched, industry-specific control solutions.

We understand that flexible processing, high speed, highest surface quality, energy efficiency and condition monitoring are among the most important engineering requirements in modern machine tool manufacturing. Regardless of whether the machine is designed for metal cutting, highly automated sheet metal working, the manufacture of high-precision surfaces in

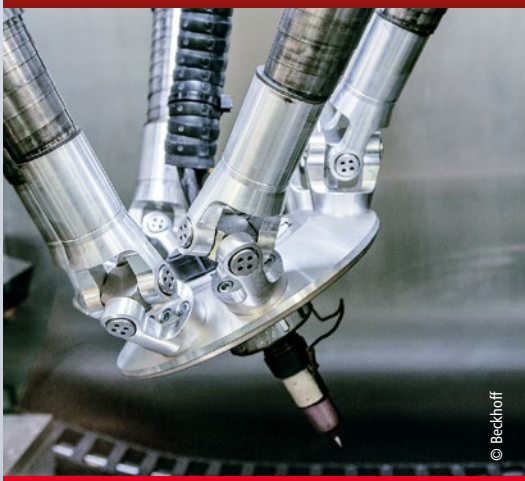
medical technology or next-generation additive manufacturing, the PC-based control solution from Beckhoff is universally applicable and harnesses the full potential of machine performance. As a scalable, powerful and open PC Control platform it also offers maximum flexibility to realize customer-specific solutions and specialized machines: Customers get tailor-made controllers for their machine tools that are actually cost-effective.

▶ **www.beckhoff.com/machine-tools**



Milling, turning, grinding

Electric discharge machining



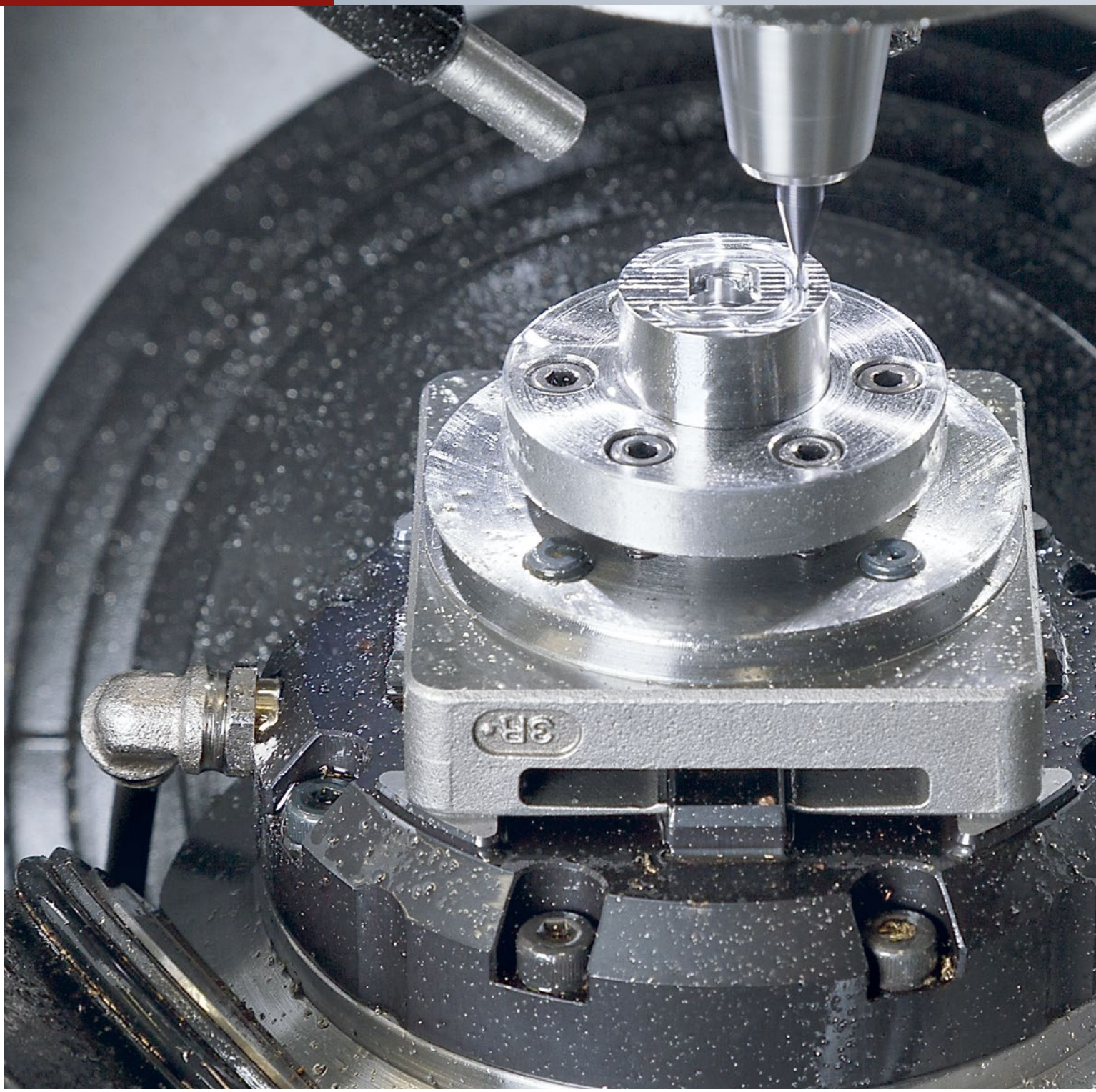
Forming, cutting, joining

Additive manufacturing

Highly scalable: The control solution for all machines and applications

Beckhoff supplies open and scalable control solutions in all performance categories and formats for machine tools: from compact embedded PCs with direct I/O connection, up to high-end industrial PCs with multi-core processors. A large selection of multi-touch panels guarantees an industrialized version of the convenience found in consumer technology advances on the machine. Around 1000 I/Os for more than 100 signal types serve the entire range of sensors and actuators. A universal safety concept is available in TwinSAFE, which integrates safety functionalities into the standard control platform. The drive technology product portfolio extends from space-saving servo terminals to powerful EtherCAT Drives and highly dynamic servomotors with One Cable Technology. The core of the Beckhoff solution is TwinCAT software, the universal engineering and control platform.

We meet the challenging requirements for market-driven machine tool concepts with open, modular software and hardware control solutions, which are scalable in terms of computing power, complexity and costs. As if from a fully loaded toolbox, you can assemble a control solution that ideally suits the machine type and dimension it in accordance with specific performance requirements. If desired, services and applications can



be outsourced to a private or public cloud. The modularity of the PC-based control system and its openness via a wide range of supported field-bus systems and communication protocols also enables step-by-step system migration and the extension of existing machines and equipment.

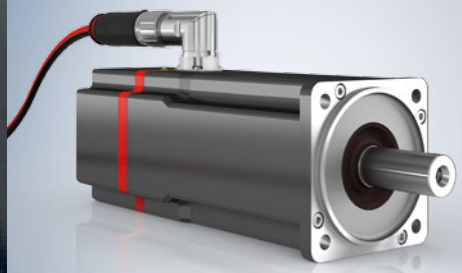
Control panels: Multi-touch displays and control panels

Industrial PCs: Control cabinet and panel PCs

Embedded PCs: IPCs with integrated I/O level

EtherCAT I/Os: Broad I/O spectrum in IP20 and IP67

EtherCAT P



Distributed servo drives

Servo terminals: Compact drive technology

Compact servo drives

TwinCAT: Software for engineering and runtime

TwinSAFE: Integrated safety solution

EtherCAT P: One Cable Automation for the field level

TwinCAT: The integrated engineering and control platform

TwinCAT automation software consists of a runtime system for the real-time execution of PLC, HMI, NC, CNC and robotic applications and is at the same time the development environment for programming, diagnostics and configuration. All main IEC 61131-3 programming languages are available for real-time applications. C/C++ and MATLAB®/Simulink® modules can be integrated into the IEC context via existing interfaces or operated independently in the TwinCAT 3 real-time environment. Moreover, open interfaces and support of the latest technological standards through current Windows operating systems open up a wide range of options, such as integration with existing visualization, control and database systems.

The engineering suite in TwinCAT offers a tool chain that is optimized for machine design in which all control applications, including HMI, IoT communication and analytics, can be implemented. Multi-core and many-core control technologies are fully supported by TwinCAT so that the above functions can be implemented alongside all other machine control elements. The object-oriented extensions of the IEC 61131-3 standard enable modular programming of code, the encapsulation of machine functions in software and, in conjunction, improved code struc-

turing, simpler maintenance, reusability and expandability of the software. Extensive software function blocks and libraries for industry-specific applications facilitate efficient engineering and implementation of machine functions. The TwinCAT Automation Interface supports you in the automatic generation of advanced machine configurations.

▶ **www.beckhoff.com/twincat**

Technological highlights for optimized machine tools

With PC-based control we offer a modular automation toolkit full of components that are precisely scalable in terms of performance: TwinCAT, the all-in-one CNC solution, maps all CNC functions in a single software platform. Applications such as predictive maintenance can be implemented through the integration of advanced measurement technology and cloud services into the control system/platform. TwinCAT TcCOM provides effective IP protection. Our highly scalable drive technology portfolio permits the implementation of cost-effective, performance-matched motion control solutions. The complete Beckhoff I/O toolkit not only supports all common fieldbuses and signals, it also offers a particularly efficient wiring solution for large-scale series production with the EJ plug-in I/O modules. Control panels with specific operating elements for machine tool applications guarantee solutions that meet individual requirements. Machine manufacturers and users can consistently strengthen their competitive advantage by leveraging each of these technological highlights.

On the basis of the scalable and open PC Control platform from Beckhoff, machine manufacturers can develop attractively priced control solutions, because only the performance required for the application in question needs to be pur-

1 TwinCAT: The all-in-one CNC

2 Integrated IP protection through TwinCAT TcCOM

3 Integrated cloud connection and IoT functions

4 Highly scalable and powerful industrial PCs

chased. At the same time, the PC- and EtherCAT-based control system optimizes all crucial production parameters: Short cycle times enable ultra-fast processing as well as quick tool and workpiece changes, increasing machine productivity and throughput. State-of-the-art control algorithms significantly improve the precision of workpiece machining while increasing process quality. The simple and secure integration of customer-developed functions via TcCOM modules allows you to securely integrate core expertise into the open controller. Standard programming tools are used for this, enabling a fast learning curve and development process. Enhanced availability and investment protection are other benefits which immediately increase the competitiveness of both machine builders and end users.

▶ **www.beckhoff.com/machine-tools**

5

Customer- and industry-specific control panels

6

Comprehensive and modular I/O portfolio

7

Highly scalable drive technology

The all-in-one CNC: From basic to high performance

TwinCAT NC Interpolation (NC I) is the CNC system for interpolated path movements and robotics that replaces conventional axis modules. CNC applications can be implemented for the most diverse processing machines through direct integration of the TwinCAT PLC and TwinCAT motion control functions. Powerful software libraries for various robot kinematics supplement TwinCAT NC I for various assembly and manipulation functions. All well-known fieldbus systems and programming standards in the CNC world, such as DIN 66025, are supported. TwinCAT NC I uses the processing power of current PC technologies to enable high-performance axis control under Windows.

TwinCAT CNC provides extensive CNC functionality as a pure software solution running on standard PC hardware. TwinCAT CNC covers the complete range of classic CNC path control, including high-end systems for complex motion and kinematics requirements. Up to 128 interpolated axes with up to 32 channels as well as a wide range of coordinate and kinematic transformations can be controlled. The necessary axis and spindle functions, interpolation and feeding functions, tool and help functions as well as

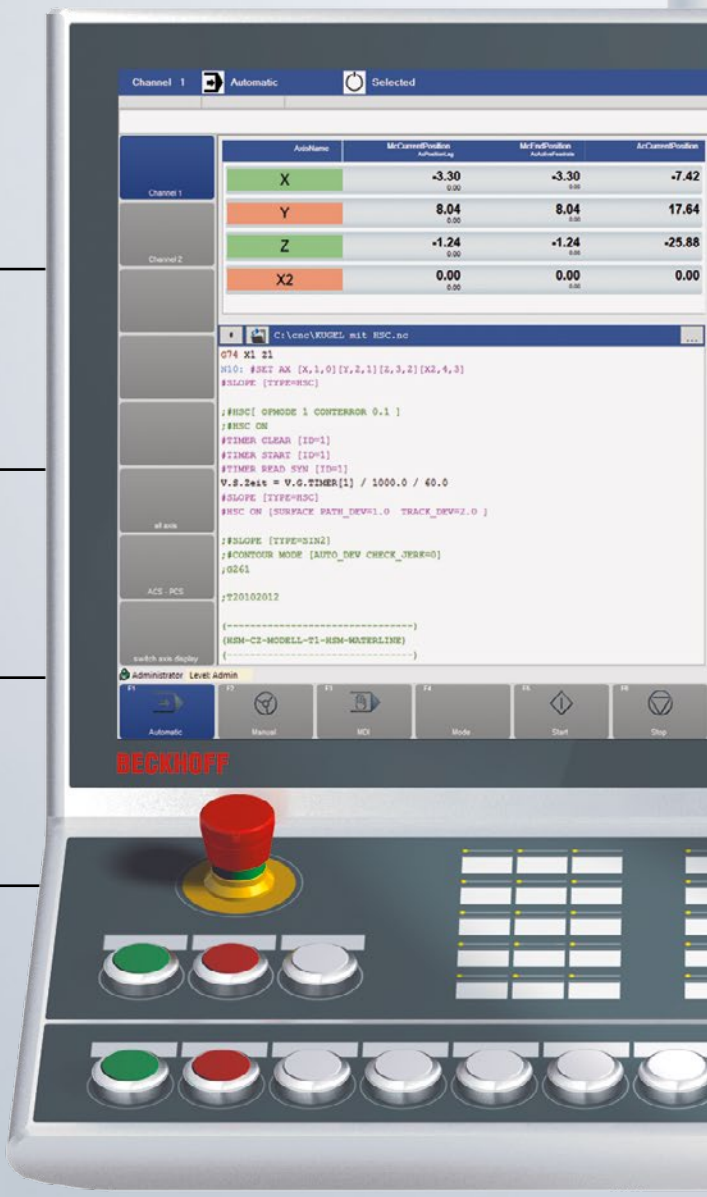
1 TwinCAT: The all-in-one CNC

Attractively priced entry-level software solution: TwinCAT NC I

For complex machines: powerful, scalable TwinCAT CNC software

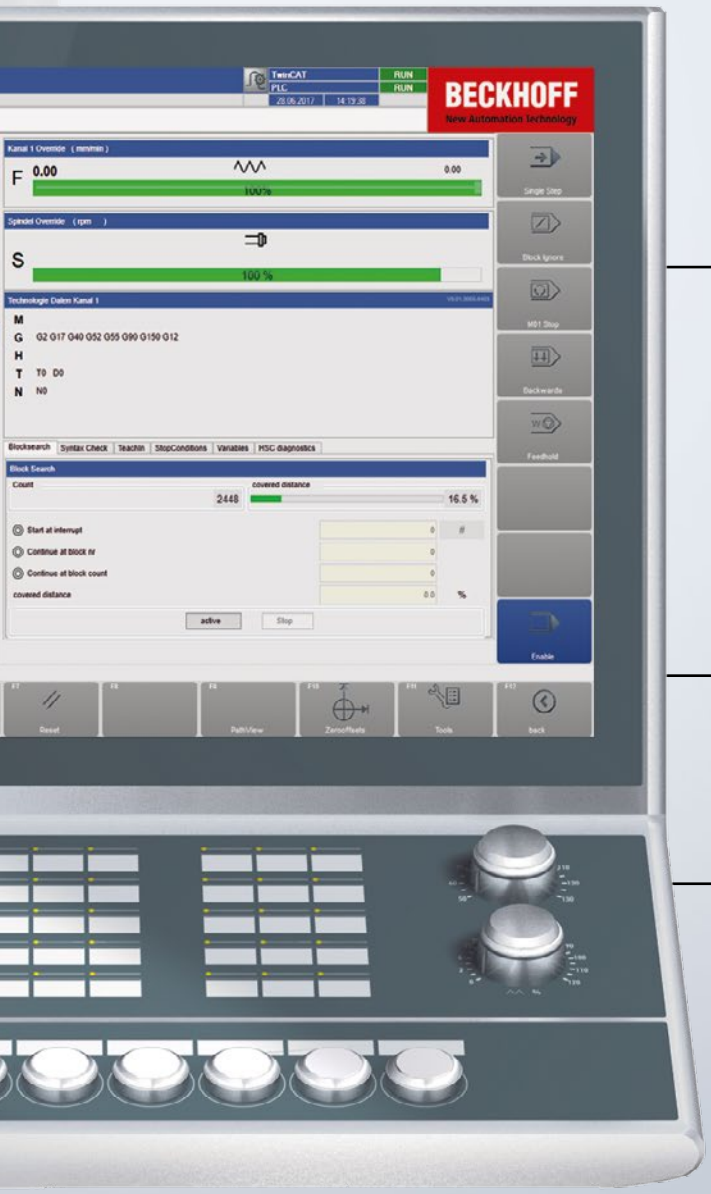
Up to 32 channels

Control up to 128 axes with multi-core support (of which 32 axes can be interpolated simultaneously)



cycle programming with specific extensions are available for all kinds of machining technologies (milling, turning, grinding, electric discharge machining, forming, cutting, additive manufacturing and specialized machines).

▶ **www.beckhoff.com/cnc**



Picometre interpolation (control resolution of 10 pm)

CNC features:

- fast cycle times
- high-speed cutting
- Kinematic Transformation
- technology packages
- 3/5-axis machining with TCP
- volumetric compensation
- cycle programming
- calibration and measurement functions
- spline functionality

Integration of customer-specific process expertise into the CNC software in hard real-time through TcCOM

TwinCAT TcCom: Integrate your existing process knowledge with ease

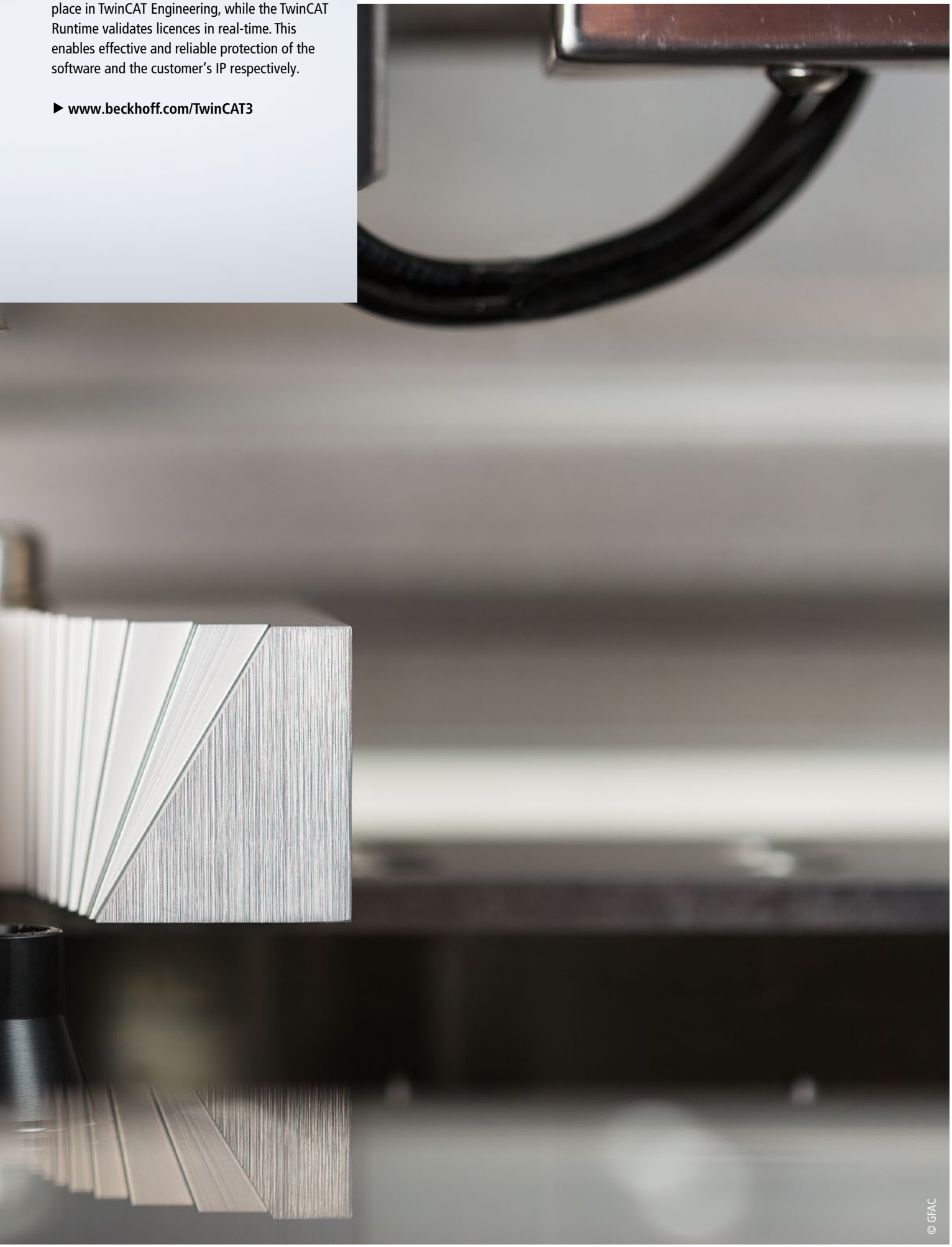
TwinCAT 3 provides a modular automation toolbox that is simple and cost-effective to extend. The TcCOM concept is a "Component Object Model" similar to the well-known Microsoft COM technology, but is adapted for use in a real-time context. Custom technology building blocks can be securely and flexibly supplemented and coupled directly to the Beckhoff components via TcCOM. This offers the option to choose the programming language best suited for the task at hand. The modules can offer and use proprietary methods, defined in interfaces. Therefore a method in a module that was implemented, for example, in C++ or MATLAB®/Simulink®, can be called up directly from another module, such as a PLC.

TcCOM offers an open interface with which you can integrate your own proprietary process knowledge and special self-developed functionalities into a standard control platform. The great advantage of this is that the core competences remain entirely in your hands and are protected against third parties. Modifications and adaptations can be carried out quickly and conveniently. The software written in-house can be licensed securely for the machine with industrially compatible hardware dongles. The configuration takes

2 Integrated IP protection through TwinCAT TcCOM

place in TwinCAT Engineering, while the TwinCAT Runtime validates licences in real-time. This enables effective and reliable protection of the software and the customer's IP respectively.

▶ **www.beckhoff.com/TwinCAT3**

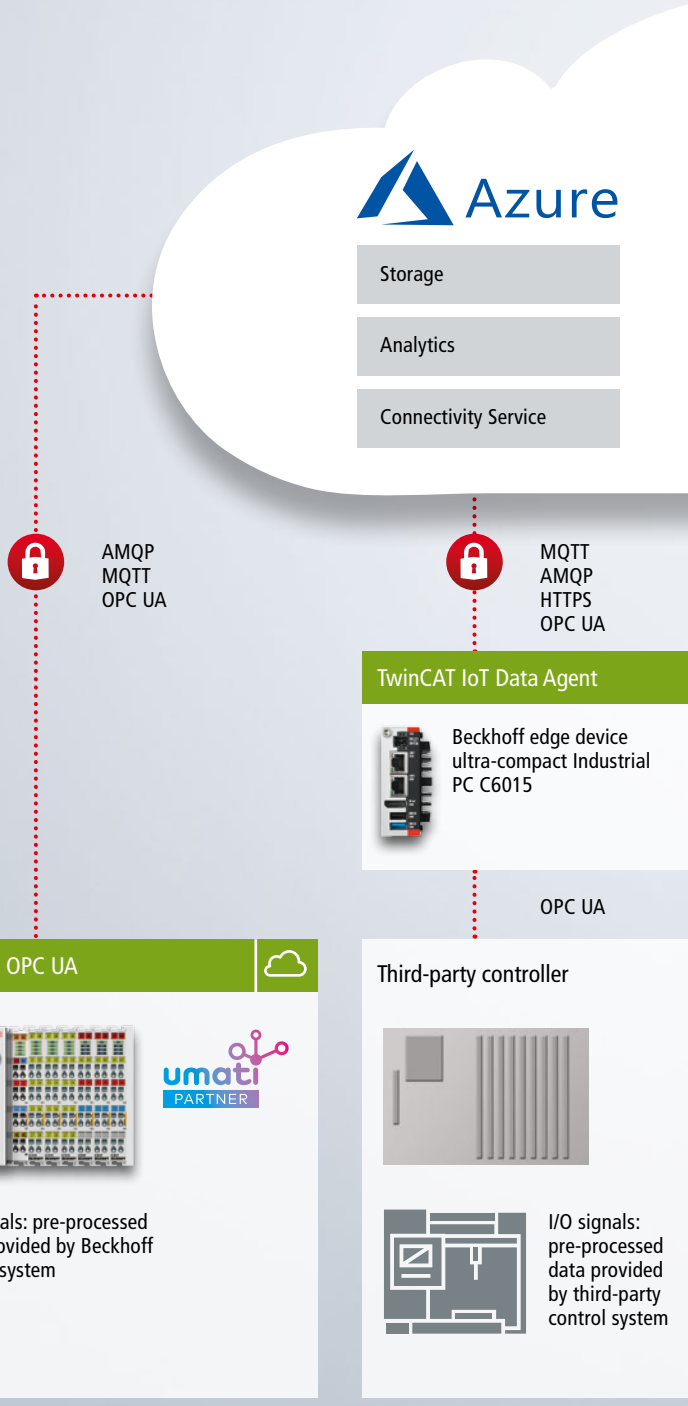


Industrie 4.0 for machine tools

Beckhoff has developed the TwinCAT IoT software library for system-integrated communication between machine controllers and cloud-based services. It supports the standardized protocols OPC UA, AMQP and MQTT for communication with common cloud systems, such as Microsoft Azure™, Amazon Web Services and as well as for private cloud systems in a company's own network. Built-in security mechanisms prevent the misuse of data through unauthorized access, further protecting your company's intellectual property.

Via TwinCAT Analytics process data are seamlessly logged and analyzed synchronously with the machine cycle to be used for applications such as predictive maintenance and machine optimization, among other enhancements. Using appropriate analysis tools, all necessary information can be derived from the stored data in order to optimize the machine in terms of energy efficiency or the process workflow. Post-mortem analyses, the diagnosis of sporadic errors, early detection of quality losses and recognition of production bottlenecks help increase plant reliability and availability. The

3 Integrated cloud connection and IoT functions



Beckhoff is involved in the development of various OPC UA Companion Specifications and is a supporter of the umati initiative of the VDMA:

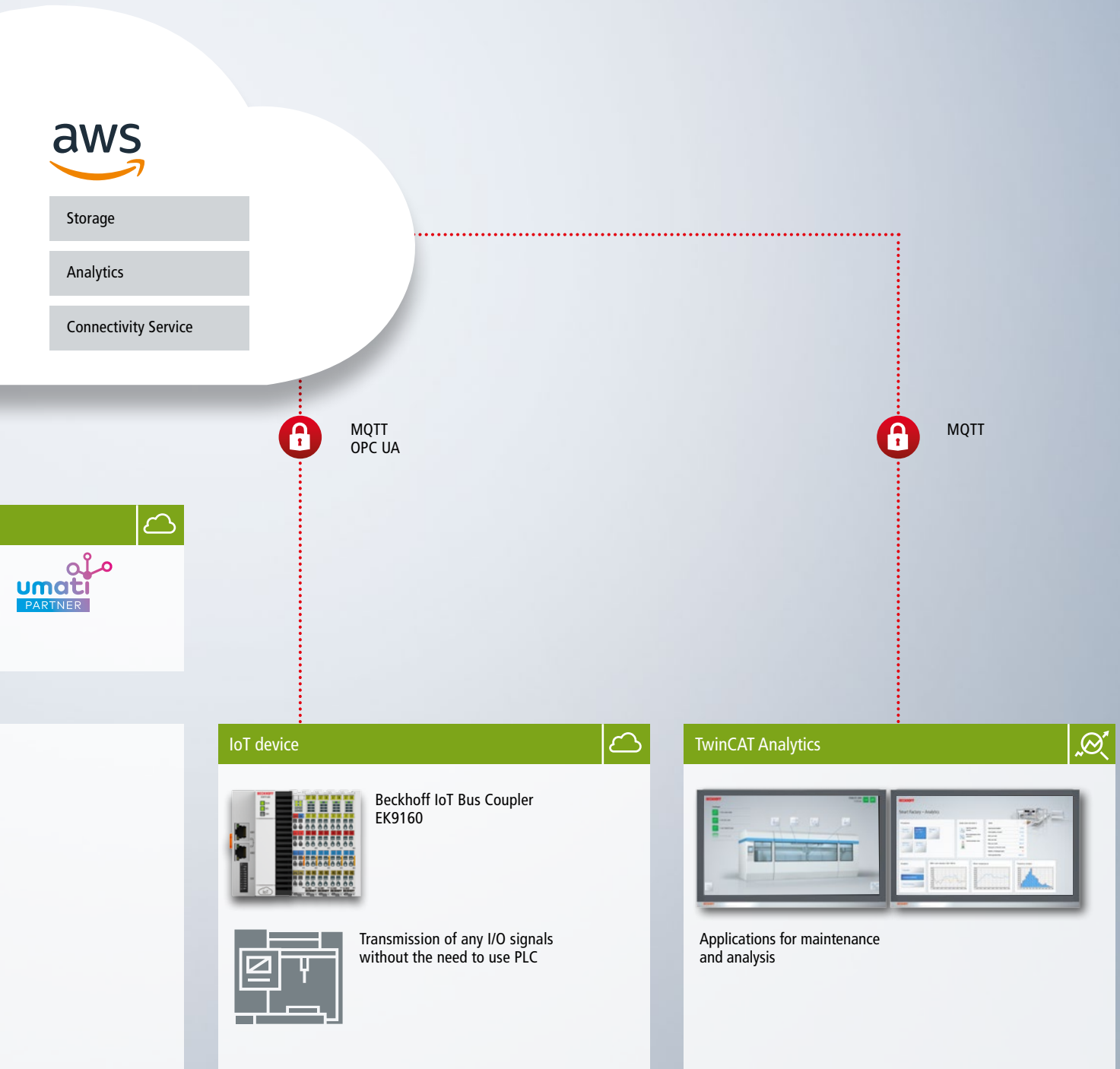
- The implementation of the Companion Specifications is based on the available TwinCAT OPC UA Server.
- A universal implementation supports integrated and edge-based scenarios.
- Each TwinCAT system can serve as a platform for value-added services complementary to the predefined Companion Specifications.

umati PARTNER

data analysis also provides extensive information about the operational performance of your machines, which can be used in future designs and manufacturing processes to reduce costs and achieve ideal machine layouts.

TwinCAT Cloud Engineering enables the instantiation and use of existing TwinCAT engineering and runtime products directly in the cloud. Easy access is provided via the Beckhoff website: As a registered user, you also have the option here to create TwinCAT Cloud Engineering instances. The physical control hardware is linked to the TwinCAT Cloud Engineering instance via a secure transport channel. This gives you access to all benefits of the TwinCAT architecture directly in the cloud, making it much easier for multiple developers to work together, to name just one of the advantages.

▶ **www.beckhoff.com/twincat-industrie40**



IPC solutions for the complete spectrum of requirements

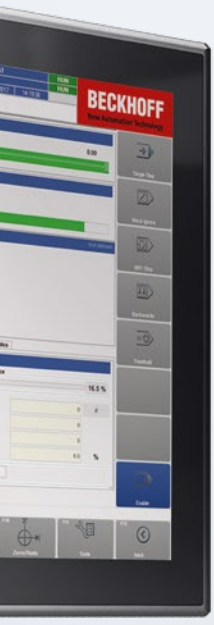
Beckhoff covers the full range of requirements in machine tool manufacturing with a broad portfolio of industrial PCs, embedded PCs, control panels and panel PCs with performance that is precisely scalable. For instance, the performance of the Beckhoff Industrial PCs extends from an ultra-compact industrial PC that offers up to four cores in a housing measuring just 82 x 82 x 40 mm, to embedded PCs from the CX series that can directly connect with the I/O level and are equipped with up to 12 CPU cores, and beyond that to the many-core machine controller that integrates up to 36 cores. Plus, there is a wide range of designs and housing variants: from the panel PC for control cabinet integration or mounting arm installation, to the embedded PC mounted on the DIN rail or the IPC for control cabinet installation. A wide range of housing designs, connector options and various interfaces round off the versatile Beckhoff Industrial PC offering.

Following modern processor performance increases, Beckhoff not only integrates an increasing number of functions within the automation platform, but can also offer high performance in increasingly compact designs. In this way control cabinets can be made smaller, the footprint of the machine tool can be reduced and valuable pro-

4 Highly scalable and powerful industrial PCs

duction space is saved. The scalable and powerful Beckhoff Industrial PCs are universally suited to all types of machine tools and performance requirements: from compact to complex, and from HSC milling machines to high-performance standard machines for different cutting tasks. A PC-based platform is available today from Beckhoff that is precisely scalable in terms of space requirements, performance and price.

▶ **www.beckhoff.com/ipc**

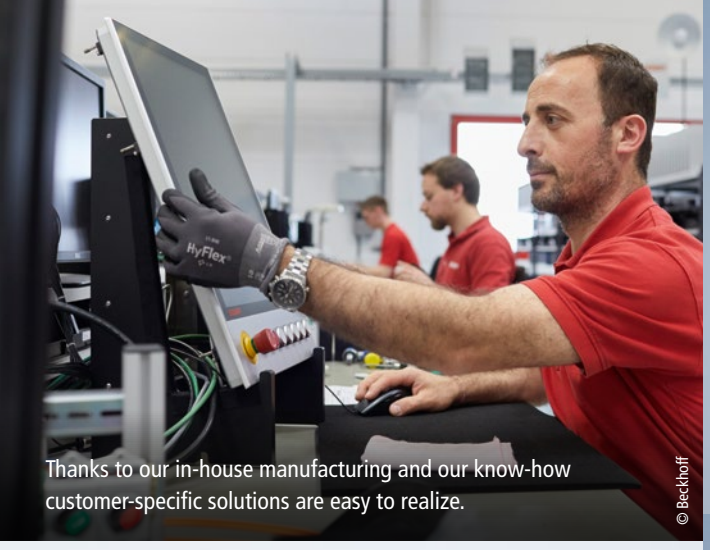


Robust panels and panel PCs with customer-specific designs

In addition to an extensive range of standard panels, we also offer control panels and panel PCs in customized designs. Customer-specific adaptations conforming to machine tool and CNC standards, such as key extensions and specific operating elements, enable ergonomic designs that are tailored precisely to the specific application, promoting optimized and intuitive machine operation. Customized control panels give the machine an easily recognizable visual appearance through an individualized housing design. This can include a company logo, a customer-specific membrane keyboard, and on up to customized housing construction and colour schemes according to your branding standards. Moreover, different interfaces from the control panel to the IPC enable a free choice in terms of connectivity, further increasing flexibility in production as a result.

▶ **www.beckhoff.com/customer-specific-ipcs**

5 Customer- and industry-specific control panels



Thanks to our in-house manufacturing and our know-how customer-specific solutions are easy to realize.

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Your label

Your configuration

Your features

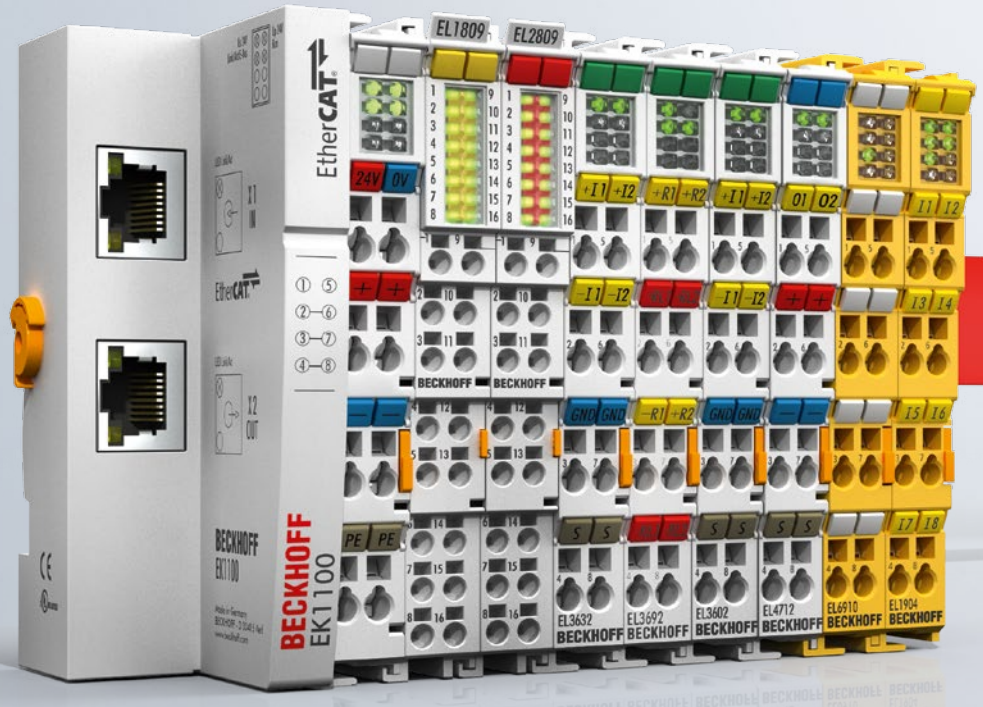
Your corporate design

Highly modular for any scale: The I/O components

The fieldbus-neutral bus terminal I/O system and high-performance EtherCAT Terminals are available for a wide variety of signal types, with varying channel density from 1 to 16 channels. Beckhoff supports all common fieldbus systems, including EtherCAT, PROFINET, EtherNet/IP and CANopen. As a result, you have optimal flexibility and openness to implement any desired I/O architectures for machine tools. When changing the fieldbus, only the fieldbus connection needs to be exchanged; peripheral systems are easily linked and machines can be integrated into existing production environments. Safety technology is seamlessly integrated into the I/O system via TwinSAFE I/O modules, whereby safe signals can be mixed with standard signals as required. Measurement technology can also be integrated directly: With the EtherCAT Terminals for energy management, a wide range of tasks in the areas of condition and power monitoring, process control and network monitoring or maintenance can be realized.

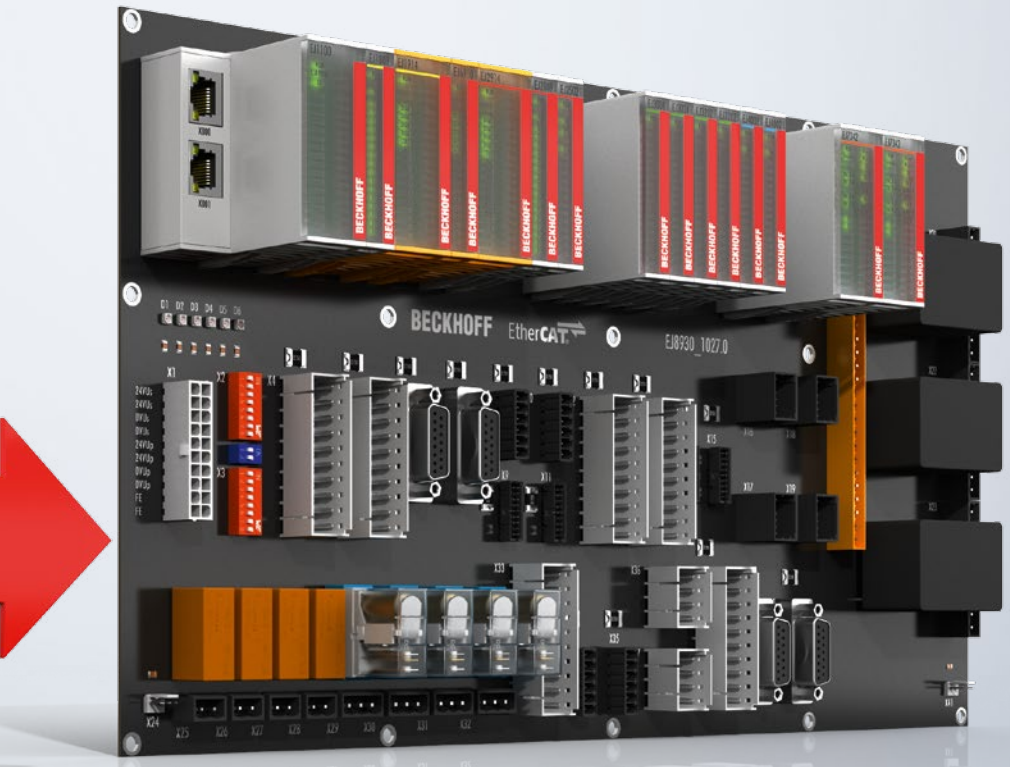
In addition, there are advantages provided by the One Cable Automation solution for the field level: EtherCAT P combines industrial Ethernet communication and power supply for the connected consumers in a standard Ethernet cable, enabling direct power forwarding via the devices.

6 Comprehensive and modular I/O portfolio



Flexible topologies can be implemented with EtherCAT P, which is maximally scalable and can be cascaded. The costs of materials, installation and interface connections are reduced and commissioning is simplified. Moreover, we supply the ideal solution for large-scale series production with the EtherCAT plug-in modules (EJ modules). Based on the proven EtherCAT I/O system, the EJ modules are plugged directly into a special PCB. Time-intensive manual connection of individual wires is replaced by the use of prefabricated cable harnesses, dramatically increasing production speed and efficiency – in particular in large-scale series production of machines in medium to high volume. Unit costs are lowered and the risk of incorrect wiring is reduced to a minimum by unmistakeably coded components.

▶ **www.beckhoff.com/io**



From compact to extremely powerful: The motion portfolio

In combination with the motion control solutions offered in TwinCAT automation software, our drive technology represents an advanced and complete drive system. It is modular and highly scalable, offering the right solution for every area of application and every performance requirement. This ranges from space-saving servo terminals for ultra-compact drive technology to the AX8000 and AX5000 EtherCAT Servo Drives for medium to upper performance classes. The integrated advanced control technology of the AX series supports fast and highly dynamic positioning tasks. The extensive range of linear and rotary servomotors is optimally tailored to the servo drives and is suitable for highly dynamic and accurate multi-axis positioning requirements.

The AM8000 servomotor series is distinguished by the One Cable Technology: It combines power and feedback signals in one standard motor cable to reduce hardware and commissioning costs, permitting the design of lighter and more compact machine tools. Further encoder signals (EnDAT 2.2) can be connected via an optional multi-feedback card. The EtherCAT servo terminals represent an inexpensive and compact alternative for applications with small forces. Solutions up

7 Highly scalable drive technology

to 8 A are available in the I/O system along with the option to connect stepper, servo, DC and AC motors with IP20 or IP67 protection.

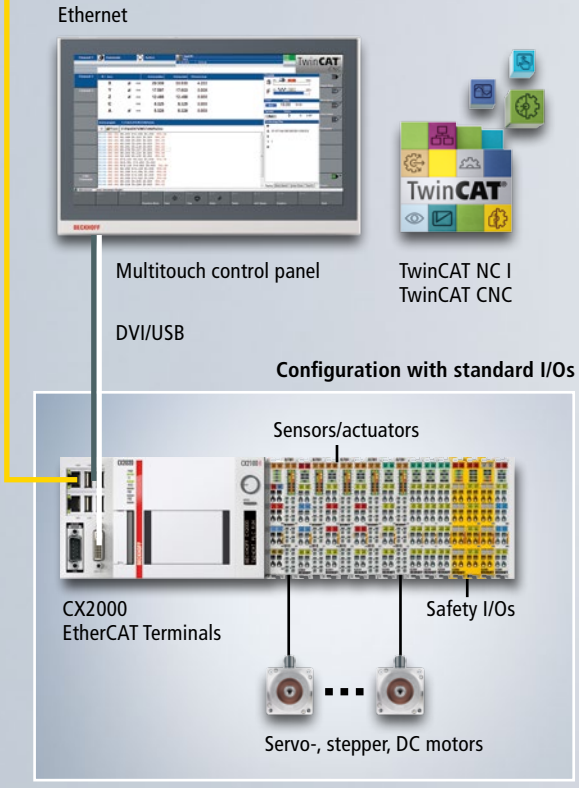
▶ **www.beckhoff.com/motion**

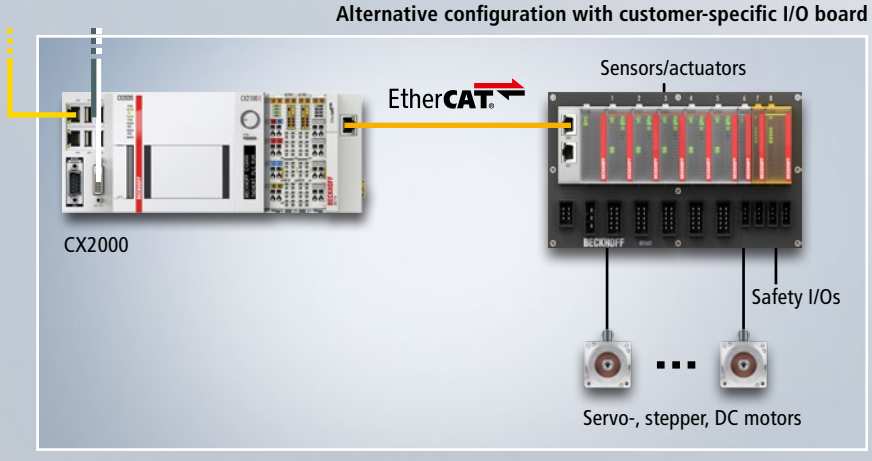
PC-based control: The scalable, application-oriented CNC solution

Example configuration for a compact metalworking machine

- DIN rail-mounted embedded PCs from the CX2000 and CX5100 series with integrated EtherCAT interface, plus optional communication and fieldbus interfaces
- control panel with DVI/USB interface for remote installation in up to 50 m, extensive range of products as well as industry and customer-specific solutions
- TwinCAT NC I/CNC software solutions with integrated TwinCAT PLC and IEC 61131-3 programming; TwinCAT NC PTP with extensive motion control functionality
- EtherCAT system with high performance, flexible topology and modular structure is suitable for all I/O and drive applications.
- eXtreme Fast Control (XFC) and condition monitoring functions can be integrated via EtherCAT Terminals.
- Drive technology up to 8 A directly in bus terminal format for stepper motors, DC motors and servomotors. The AX5000/8000 Servo Drive series is designed for higher power.
- As an integrated component of the modular I/O and TwinCAT systems, TwinSAFE makes safety technology universally available.

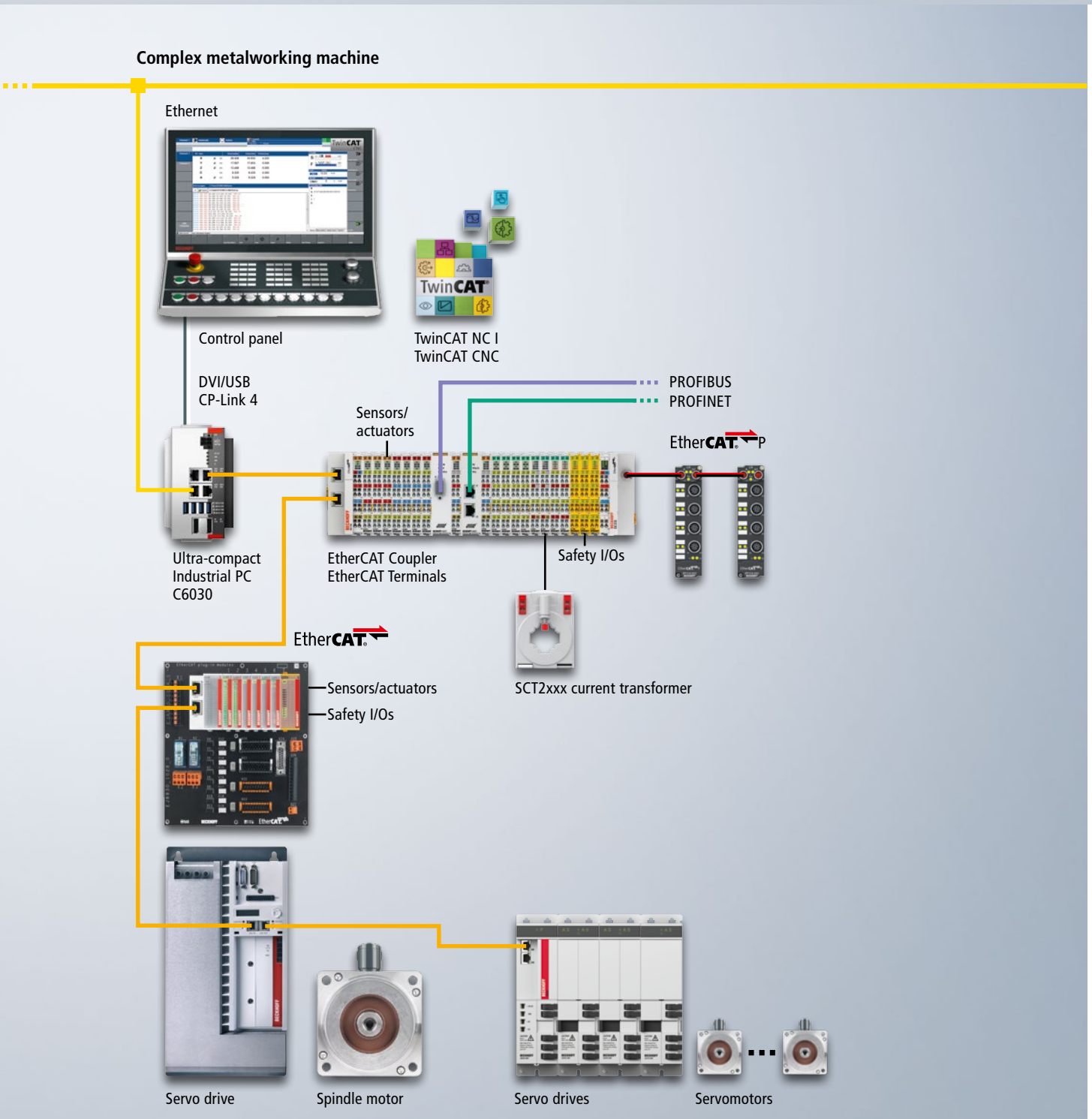
Compact metalworking machine





Example configuration for a complex metalworking machine

- TwinCAT NC I/CNC solutions with integrated TwinCAT PLC and IEC 61131-3 programming; TwinCAT NC PTP with extensive motion control functionality.
- industrial PCs with multi-core processors, integrated EtherCAT interface, optional communication and fieldbus interfaces, and extensive option list
- control panel with DVI/USB interface for remote installation in up to 50 m or with CP-Link 4 for distances up to 100 m from the PC; extensive range of standard products as well as industry and customer-specific solutions
- EtherCAT system with high performance, flexible topology, modular structure and simple configuration, is suitable for all I/O and drive applications. Implementation of XFC and condition monitoring functions via standard EtherCAT terminals. Master/slave gateway terminals ensure openness to other fieldbus technologies.
- Highly dynamic, fast motion control system with servo drives for synchronous servo and linear motors up to 118 kW, with spindle functionality
- As an integrated component of the modular I/O and TwinCAT systems, TwinSAFE is universally available to all control systems.
- Drive-integrated TwinSAFE functions enable the implementation of numerous safety functions in a simple way.



Our references

Dentsply Sirona, Switzerland

TwinCAT CNC controls grinding machine for dental drills.

▶ **www.dentsplysirona.com**

Rampf and Feldmann, Germany

TwinCAT HMI enhances operator interface for dispensing systems and robots.

▶ **www.rampf-group.com**
▶ **www.feldmannmediagroup.com**

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GF Machining Solutions, Switzerland

TwinCAT as powerful CNC solution for wire EDM machines improves flexibility and integrates intellectual property protection.

▶ **www.gfms.com**

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Power-Tech, Eagle Group, Poland

High-tech laser cutters rely on a powerful IPC platform and EtherCAT for maximized precision and speed.

▶ **www.eagle-group.eu**

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How can PC-based control improve your CNC application?
Contact us.

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