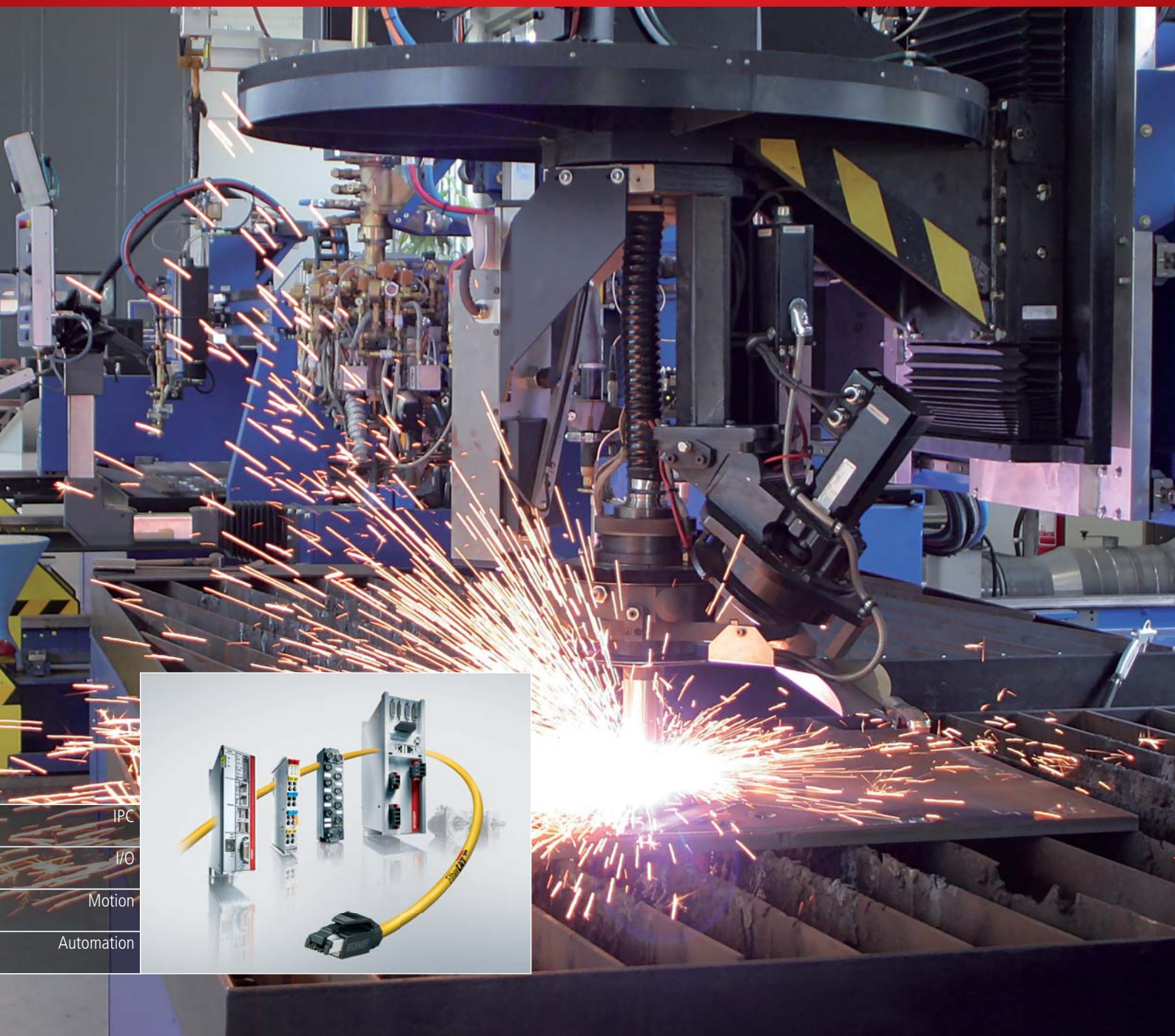


BECKHOFF New Automation Technology

PC-based Control for CNC Machining



IPC
I/O
Motion
Automation

Beckhoff CNC solutions

The PC- and EtherCAT-based CNC solution from Beckhoff integrates all machine functions into one hardware and software platform. This powerful system is characterised by high performance, openness and flexibility. The universal TwinCAT automation software and the fast EtherCAT fieldbus system, Industrial PCs, Control Panels, I/O components and drive technology combine to offer a complete solution for CNC machining. This way, the productivity of manufacturing facilities can be increased, the controller design becomes 'leaner' and the costs for hardware, engineering, commissioning and maintenance are lowered considerably. The Beckhoff CNC platform is suitable for all industries, processing technologies and machine kinematics: from compact dental machining centres and woodworking machines to complex plasma cutting and welding machines. The CNC solution from Beckhoff is scalable and modular, meeting the exact requirements of modular and multifunctional machine concepts.

► www.beckhoff.com/CNC

Scalable PC Control platform

Beckhoff offers CNC solutions for all performance classes: from compact Embedded PCs with integrated I/O interface to Industrial PCs with powerful multi-core processors. The user can choose between optional functions and scalable hardware platforms, ensuring an efficient and economical CNC controller that is ideal for the performance required. There is also a wide range of operating devices: from multi-touch panels to CNC panels for machine tools and customer-specific versions. All Beckhoff controllers

are universally configured and programmed using TwinCAT automation software.

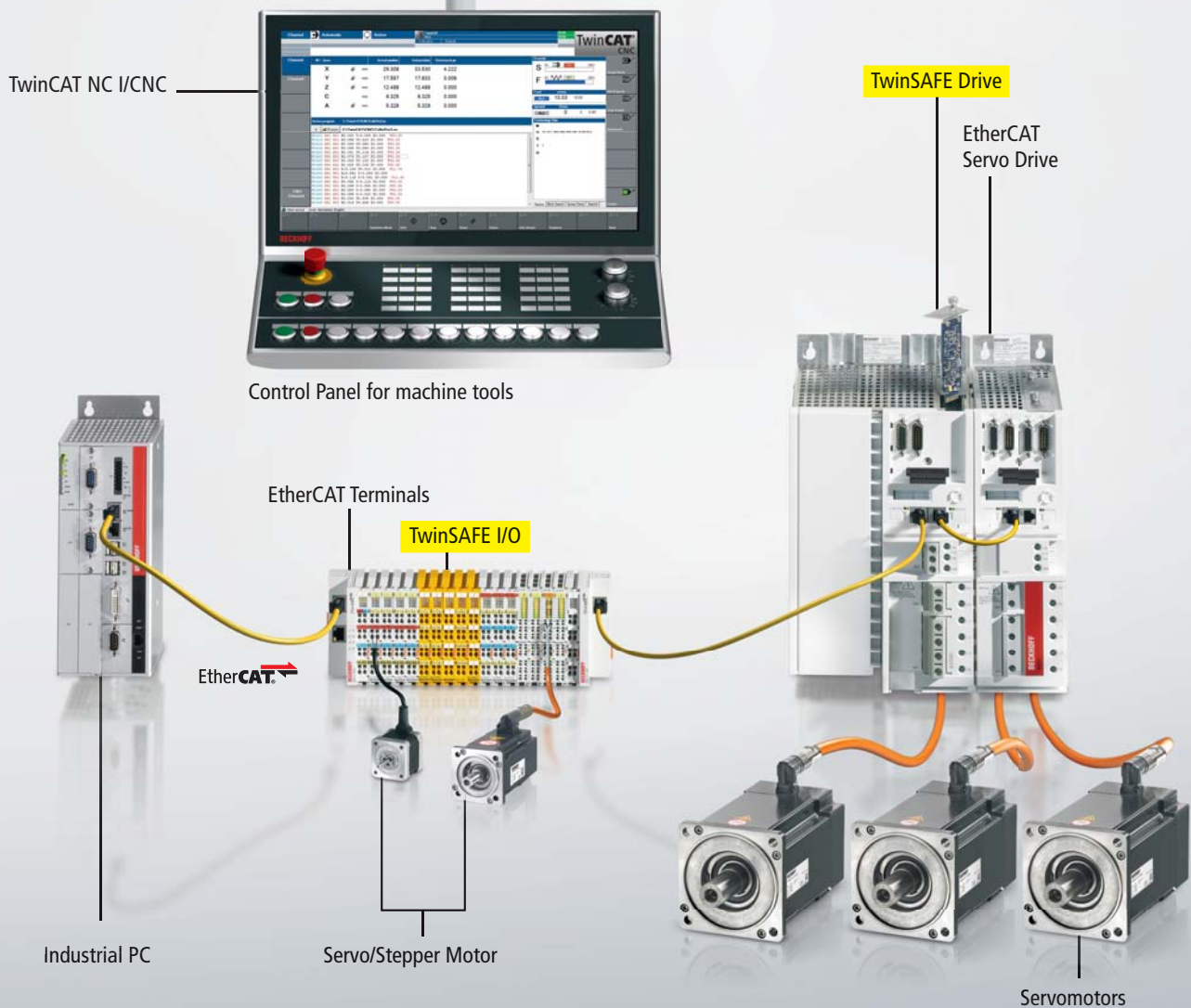
Consistent use of fieldbus technology

EtherCAT, the ultra-fast real-time Ethernet technology for industrial automation, is the integrated communication system for I/O, drive and safety technology. With update and response times of the order of less than a millisecond, EtherCAT is ideally suited to fast switching functions coupled with high machining speeds, as required for

cutting and welding machines, for example. Gateways allow the connection of an extensive range of peripheral devices and fieldbuses. Expensive special hardware is replaced by the Beckhoff EtherCAT I/O components with IP 20 and IP 67 protection, significantly reducing planning effort and costs.

Drive technology for all applications

For the mid to upper performance range, Beckhoff EtherCAT drives are available in single and multi-channel versions and with a variable motor



interface up to 118 KW. Integrated control technology supports fast and highly dynamic positioning tasks. For applications where only small forces are required, compact and economical I/O terminals for control of stepper motors, DC motors and servo motor solutions can be used.

TwinCAT – universal software platform

TwinCAT automation software forms the universal platform for the control of PLC, motion and CNC functionalities, visualisation, safety technology,

measurement technology, Condition Monitoring and robotics. TwinCAT NC I/CNC covers the entire range of classic CNC path controllers up to the high-end system for complex motion and kinetic requirements. TwinCAT NC PTP makes extensive motion functions available for positioning tasks. The TwinCAT Kinematic Transformation library enables the mapping of robot kinematic systems in software for seamless and cost-effective integration into the control system.

Integrated safety technology

With TwinSAFE, Beckhoff offers an open, scalable safety solution that is entirely integrated in TwinCAT and combines safe I/O technology with safe drive technology in one system. Traditional stand-alone Safety PLCs and dedicated safety networks can now be eliminated. The TwinSAFE safety modules are incorporated flexibly into the complete I/O system with IP 20 or IP 67 protection. The engineering can be carried out efficiently and comfortably – like all other control functions – in TwinCAT.

Areas of application for the Beckhoff CNC solution

Beckhoff offers a complete solution for CNC applications: from traditional metalworking to continuous processing in the timber industry and the manufacturing of high-precision surfaces in medical technology.

Wood processing machines

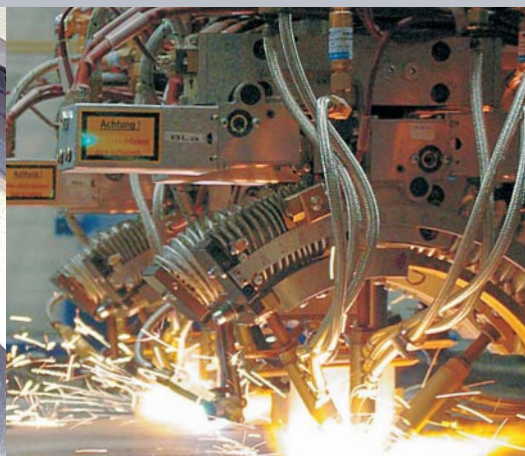
The extensive range of automation tasks in wood processing extends from: cutting boards to size, transport and material handling tasks and the complex machining of profiles and edges in continuous operation, through to stationary drilling machines and CNC machining centres. The innovative and open CNC solutions from Beckhoff provide security of investment even in large wood production lines where maximum flexibility, high throughput and minimum setup times are required.

Cutting and welding machines

Beckhoff CNC controllers are used in autogenous, plasma, laser and water jet machining for cutting and welding. TwinCAT NC I/CNC automation software is ideally suited to technology-specific functions such as adaptive jet control, reverse driving or resetting on the path. EtherCAT and XFC (eXtreme Fast Control) technology from Beckhoff serve as the basis for fast switching functions coupled with high machining speed.

Punching/nibbling machines

The Beckhoff CNC solution implements highly dynamic axis movements and quick control functions in punching and nibbling machines for sheet metal processing. The precisely programmable strokes, automatic tool changes as well as the possibility to change the programming and settings of the machine during operation lead to a significant increase in productivity.





Machine tools

Flexible processing, high speed, perfect surface quality, energy efficiency and Condition Monitoring are among the most important control requirements in modern machine tool manufacturing. As an integrated, open automation platform, the Beckhoff CNC package offers the optimum solution for all classic CNC processing technologies, such as milling, turning and grinding.

Handling/robotics

The integration of handling/robotics modules in production facilities is increasingly in demand, ideally with CNC/robotics, motion control and PLC on a uniform platform. The prerequisites for this are flexible and open automation solutions. Using the TwinCAT Kinematic Transformation software library, parallel and serial kinematics such as those required for pick-and-place tasks can be integrated into the controller.

Medical technology

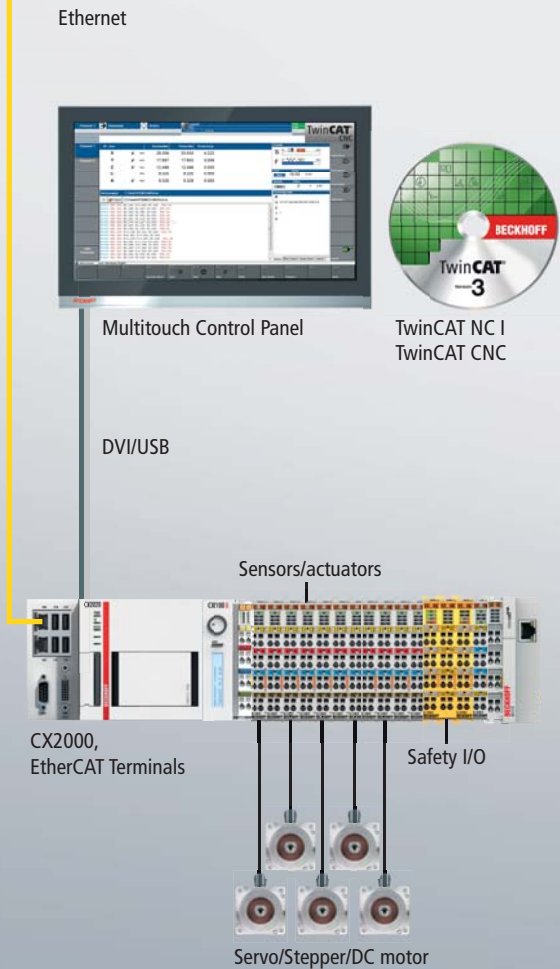
Apart from the high requirements with regard to precise and fast motion control, medical technology also requires sophisticated processing of the process data by the CNC controller. By means of cross-block velocity and acceleration control, TwinCAT Spline Interpolation and TwinCAT HSC enable the creation of high surface qualities by means of a smoothed dynamic curve and effective control of the specified contour tolerances.



- scalable solutions from mid-size to high-end CNC
- from individual machines to highly complex production plants
- high-performance, open PC-based architecture
- comprehensive functions for complex interpolations

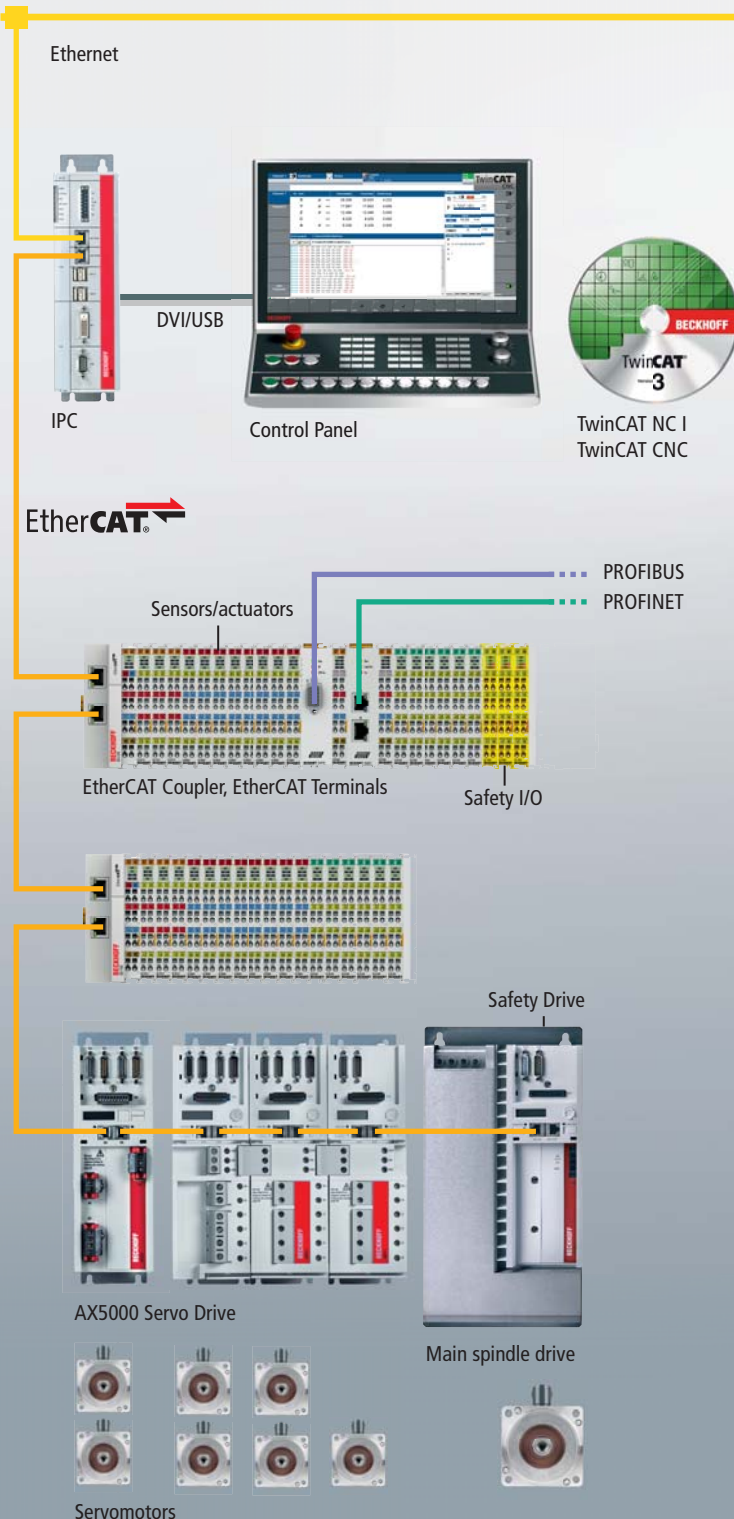
Beckhoff PC-based control: the scalable CNC solution

Mid-size CNC



- DIN rail Embedded PCs from the CX2000 series with Intel® Celeron® (single-core), Intel® Core™ i7 (dual-core) or Intel® Core™ i7 (quad-core), integrated EtherCAT interface and optional communication and fieldbus interfaces
- Control Panel with DVI/USB interface for distances up to 50 m from the PC or with CP-Link 4 for distances up to 100 m from the PC, extensive range of products as well as industry- and customer-specific solutions
- TwinCAT NC I/CNC solutions with integrated TwinCAT PLC with IEC 61131-3 programming, TwinCAT NC PTP with extensive motion functionality. Up to 32 interpolating path axes can be implemented on the CX2000 with TwinCAT CNC solutions.
- EtherCAT system with outstanding performance, flexible topology, modular structure and simple configuration, suitable for all I/O applications and drive technology. XFC and Condition Monitoring functions can be integrated via EtherCAT Terminals.
- Drive technology up to 8 A implemented directly in a Bus Terminal for stepper motors, DC motors or servo motors. The EtherCAT AX5000 Servo Drive series is designed for higher power, up to 118 KW.
- As an integral component of the modular I/O and TwinCAT system, TwinSAFE is universally available to all control systems.

High-end CNC



- TwinCAT NC I/CNC solutions with integrated TwinCAT PLC with IEC 61131-3 programming; TwinCAT NC PTP with extensive motion functionality. A total of up to 255 axes, up to 32 interpolating axes and up to 12 CNC channels for CNC and up to 31 CNC channels for NC I can be implemented on a high-performance Industrial PC with TwinCAT CNC solutions.
- Industrial PCs with high-performance multi-core processors, integrated EtherCAT interface, optional communication and fieldbus interfaces, and an extensive list of other options (storage media, UPS, etc.)
- Control Panel with DVI/USB interface for distances up to 50 m from the PC 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 outstanding performance, flexible topology, modular structure and simple configuration, suitable for all I/O applications and drive technology. Implementation of XFC/ Condition Monitoring functions via standard EtherCAT Terminals. Master/slave gateway terminals ensure openness to other fieldbus technologies.
- Highly dynamic, fast drive system with Servo Drives for synchronous servo and linear motors up to 118 KW with spindle functionality
- As an integral component of the modular I/O and TwinCAT system, TwinSAFE is universally available to all control systems.



PC-based control technology with TwinCAT

- everything in one system – from the I/Os to CNC
- one configuration interface
- integrated Scientific Automation
 - measurement technology
 - Condition Monitoring
 - energy optimisation
- open platform
 - supports many fieldbuses
 - supports various drive manufacturers

Highly deterministic real-time capability

- basis for fast, precise controllers
- pure software solution, developed by Beckhoff
- increase in performance through multi-core support (TwinCAT 3)
- pre-emptive multi-tasking from 50 µs
- low jitter (< 2 µs)

High-end PLC

- internationally accepted programming standard
 - IEC 61131-3, support of all languages
- convenient debugging
- Motion Control interface
 - standardised libraries conforming to PLCopen

Motion Control with TwinCAT NC PTP

- up to 255 axes on one PC
- support for a wide range of axis types
 - electrical servo axes
 - stepper axes
 - DC motors
 - hydraulic axes
- support for a wide range of fieldbuses
 - EtherCAT and Lightbus
 - SERCOS
 - ProfiDrive
 - CANopen
 - SSI
 - analog interfaces
- convenient commissioning and maintenance with TwinCAT System Manager
- graphic display of all values with TwinCAT Scope

Motion Control functionality

- point-to-point motion
- gear coupling (linear coupling)
- cam plate couplings
 - graphic design with TwinCAT CAM Design Editor
 - cam plates modifiable from the PLC
- position-synchronous coupling (flying saw, flying shear)
- synchronisation from any dynamic phase
- superposition

Interpolating axis movement with TwinCAT NC I

- axis interpolation with 3 path axes
- programming according to DIN 66025
- PLC library for NC interpolation

Interpolating axis movement with TwinCAT CNC

- axis interpolation with up to 32 path axes
- programming according to DIN 66025
- optional integration of customer-specific C/C++ code
- optional transformation packages
- optional high-speed cutting package

Interpolating motion for robotic control with TwinCAT

Advantages of integrating robotic control in TwinCAT:

- configuration, parameterisation, diagnostics and programming in TwinCAT
- optimum synergy between PLC, Motion Control and robot control system
- high performance and precision through direct interfaces

Kinematic calculation process:

- forward transformation
- backward transformation
- calculation of the dynamic model

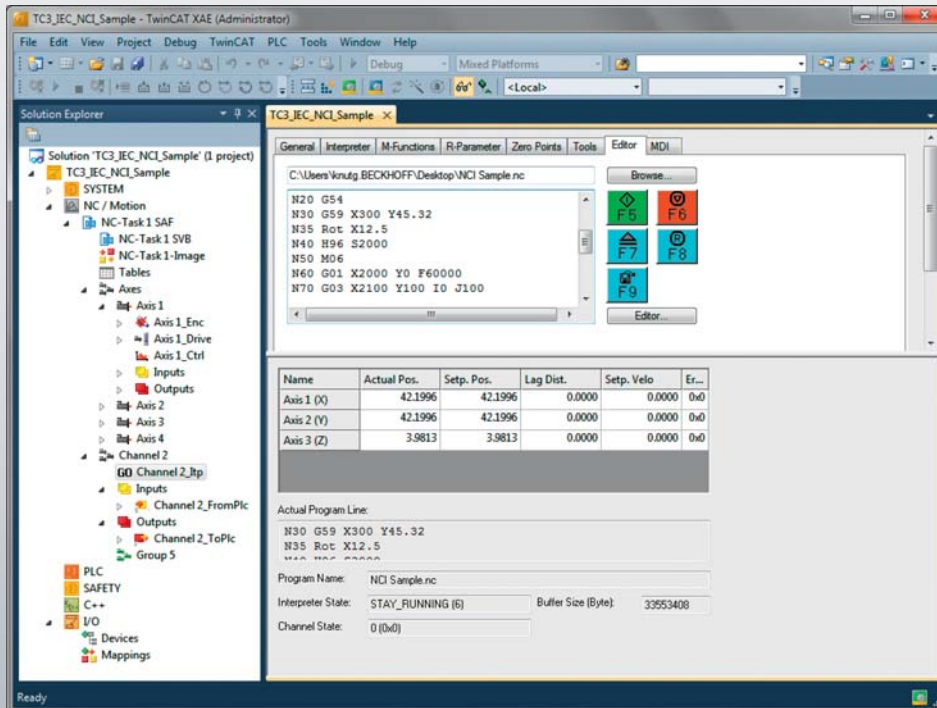
TwinCAT software libraries

- wide range of TwinCAT libraries available
- PLCopen Motion Control blocks
- serial coupling
- control technology

TwinCAT: The modular CNC software

	TC1260 TC3 PLC/NC PTP 10, NC I	TC1270 TC3 PLC/NC PTP 10, NC I, CNC
Integrated TwinCAT levels	TwinCAT PLC, TwinCAT NC PTP	TwinCAT PLC, TwinCAT NC PTP, TwinCAT NC I
PC hardware	standard PC/IPC hardware, no extras	standard PC/IPC hardware, no extras
Operating systems	Windows NT/2000/XP/Vista, Windows 7, NT/XP Embedded, CE*	Windows NT/2000/XP/Vista, Windows 7, Windows NT/XP Embedded*
Real-time	Beckhoff real-time kernel	Beckhoff real-time kernel
I/O system	EtherCAT, Lightbus, PROFIBUS DP/MC, Interbus, CANopen, DeviceNet, SERCOS, Ethernet	EtherCAT, Lightbus, PROFIBUS DP/MC, Interbus, CANopen, DeviceNet, SERCOS, Ethernet
Programming	DIN 66025 programs for NC interpolation, access via function blocks from TwinCAT PLC according to IEC 61131-3	DIN 66025 programming language with high-level language extensions, access via function blocks from TwinCAT PLC according to IEC 61131-3
Run-time system	NC interpolation, including TwinCAT NC PTP and PLC	CNC, including TwinCAT NC I, NC PTP, PLC
Number of axes	max. 3 axes and up to 5 auxiliary axes per group, 1 group per channel, max. 31 channels	8 path axes/controlled spindles, max. of 64 axes/controlled spindles (optional), max. 12 channels (optional)
Axis types	electrical servo axes, stepper motor drives	electrical servo-axes, analog/encoder interface via fieldbus, digital interface via fieldbus
Interpreter functions	subroutines and jumps, programmable loops, zero shifts, tool compensations, M and H functions	subroutines and jumps, programmable loops, zero shifts, tool compensations, M and H functions, mathematical functions, programming of parameters/variables, user macros, spindle and help functions, tool functions
Geometries	straight lines and circular paths in 3-D space, circular paths in all main planes, helixes with base circles in all main planes, linear, circular, helical interpolation in the main planes and freely definable planes, Bezier splines, look-ahead function	linear, circular, helical interpolation in the main planes and freely definable planes, max. 32 interpolating path axes per channel, look-ahead function
Axis functions	online reconfiguration of axes in groups, path override, slave coupling to path axes, auxiliary axes, axis error and sag compensation, measuring functions	coupling and gantry axis function, override, axis error and sag compensation, measuring functions
Operation	automatic operation, manual operation (jog/inching), single block operation, referencing, handwheel operation (motion/superposition)	automatic operation, manual operation (jog/inching), single block operation, referencing, block search, handwheel operation (motion/superposition)
Options	<ul style="list-style-type: none"> ■ TwinCAT Kinematic Transformation supports various parallel and serial kinematics, e.g. for pick-and-place tasks: <ul style="list-style-type: none"> ■ 2-D parallel kinematics ■ 3-D Delta ■ SCARA ■ Cartesian portals ■ crane and roller kinematics <p>* version-dependent</p>	<ul style="list-style-type: none"> ■ TwinCAT CNC Axes Pack expansion to a total of 64 axes/controlled spindles ■ TwinCAT CNC Channel Pack a further CNC channel, extendable up to a maximum of 12 channels, channel synchronisation, transfer of axes between channels ■ TwinCAT CNC Transformation transformation functionality (5-axis functionality), kinematics selection from kinematics library, RTCP function, TLC function ■ TwinCAT CNC HSC Pack cross-block velocity and acceleration control for the optimum utilisation of the axis dynamics for higher path velocities ■ TwinCAT CNC Spline Interpolation path programming via splines
	► www.beckhoff.com/TC1260	► www.beckhoff.com/TC1270

Convenient embedding of functions in an integrated system



Interaction of CNC with PLC

- cyclic transmission of control and status information to the PLC
- function blocks for commanding the CNC
- diagnostic information available in the PLC

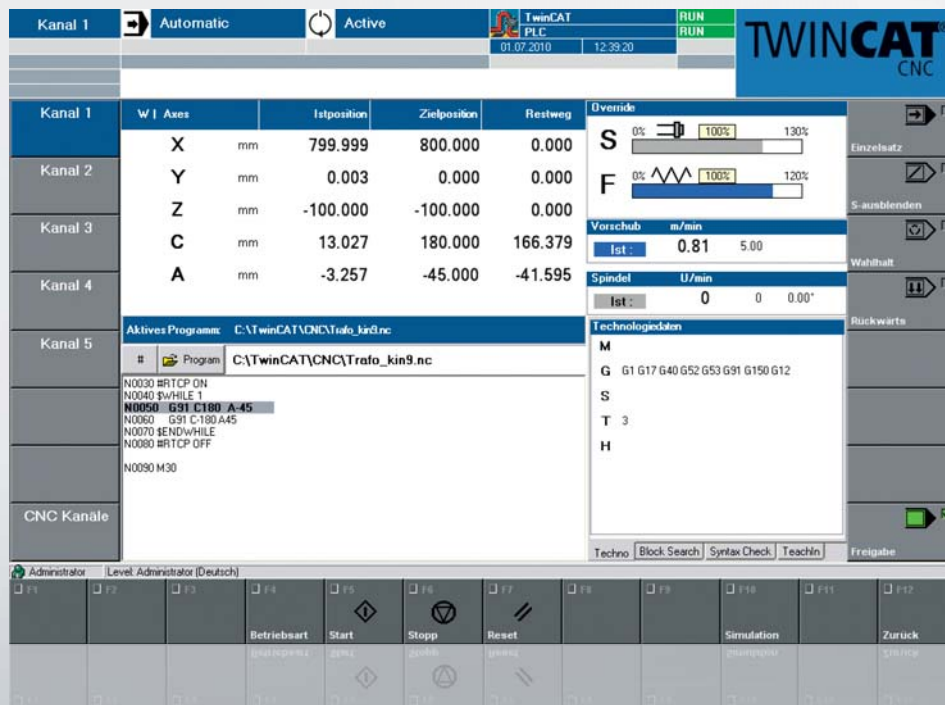
NC PTP

- Motion Control for point-to-point axes
- with gearing, camming, flying saw and superposition
- function blocks for the interaction of CNC and NC PTP

Safety

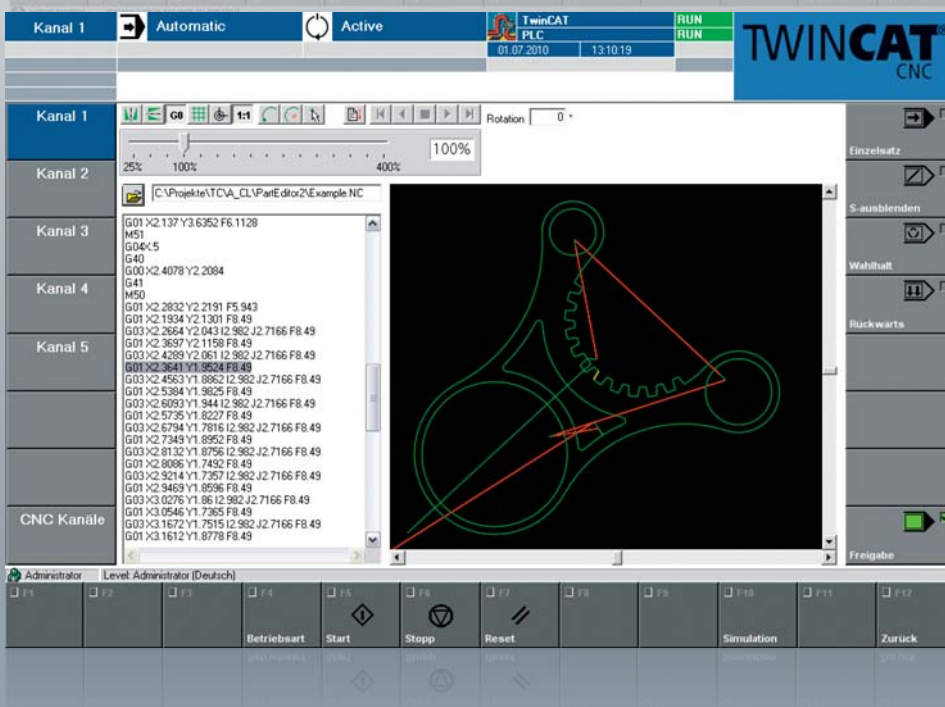
- integrated programming of the safety controller
- integration of safe axis functionalities
 - **STO** Safe Torque Off
 - **SS1** Safe Stop 1
 - **SS2** Safe Stop 2
 - **SOS** Safe operating stop
 - **SLS** Safely limited speed
 - **SDI** Safe direction
 - and others

Flexible CNC user interface: Standard or customer-specific



Standard-HMI

- Microsoft Visual Studio® .NET
- Innovative HMI concept
- Comprehensive basic functionality, including:
 - keyboard, mouse or touch operation
 - online language change
 - machine data, set-up functions
 - global messaging system
 - user administration
 - help system
- flexibility in configuration and project planning



Application-specific HMI

- programming via Microsoft.NET standards
- simple implementation and handling
- extensive range of standard interfaces
- modular, open concept

Industrial PCs for CNC machining

Beckhoff supplies the ideal Industrial PC for every application. The high-quality components, based on open standards, and the durable housing construction mean that the Industrial PCs are exceptionally equipped for all control requirements. Embedded PCs make modular IPC technology available in a compact format for DIN rail mounting.

Control cabinet Industrial PCs

- scalable size ("paperback" format up to the ATX PC)
- scalable performance class (Intel® Atom™ up to Core™ i7, quad-core)
- impressive balance between the latest PC technology and long-term component availability
- designed for machine-oriented use

► www.beckhoff.com/IPC

Multi-touch panels

- Control Panels or Panel PCs
- display sizes from 7- to 24-inch
- landscape or portrait orientation
- built-in or mounting arm models

► www.beckhoff.com/Multitouch



Control Panel for machine tools

The U-shaped arrangement of the control keys (i.e. control keys arranged on the sides and function keys below the display) matches that of the Transline concept commonly used in the automotive industry.



CNC push-button extension

A push-button extension that has been optimised for CNC applications is available for simple and convenient machine operation.

Control Panel

- human-machine interface (HMI)
- built-in Control Panel or mounting arm system IP 65
- display size 15-inch (other Control Panels between 5.7- and 24-inch)
- customer-specific designs possible

Panel PCs

- Control Panel + PC = Panel PC
- built-in Panel PCs for mounting arm system
- display size 15-inch (other Panel PCs between 5.7- and 24-inch)
- processors from Intel® Atom™ to Core™ i7, quad-core
- customer-specific designs possible

Embedded PCs

- the convergence of the worlds of Industrial PCs and hardware PLCs on a DIN rail
- scalable performance classes from ARM to quad-core processor
- direct I/O interface for Beckhoff I/O systems

► www.beckhoff.com/Embedded-PC



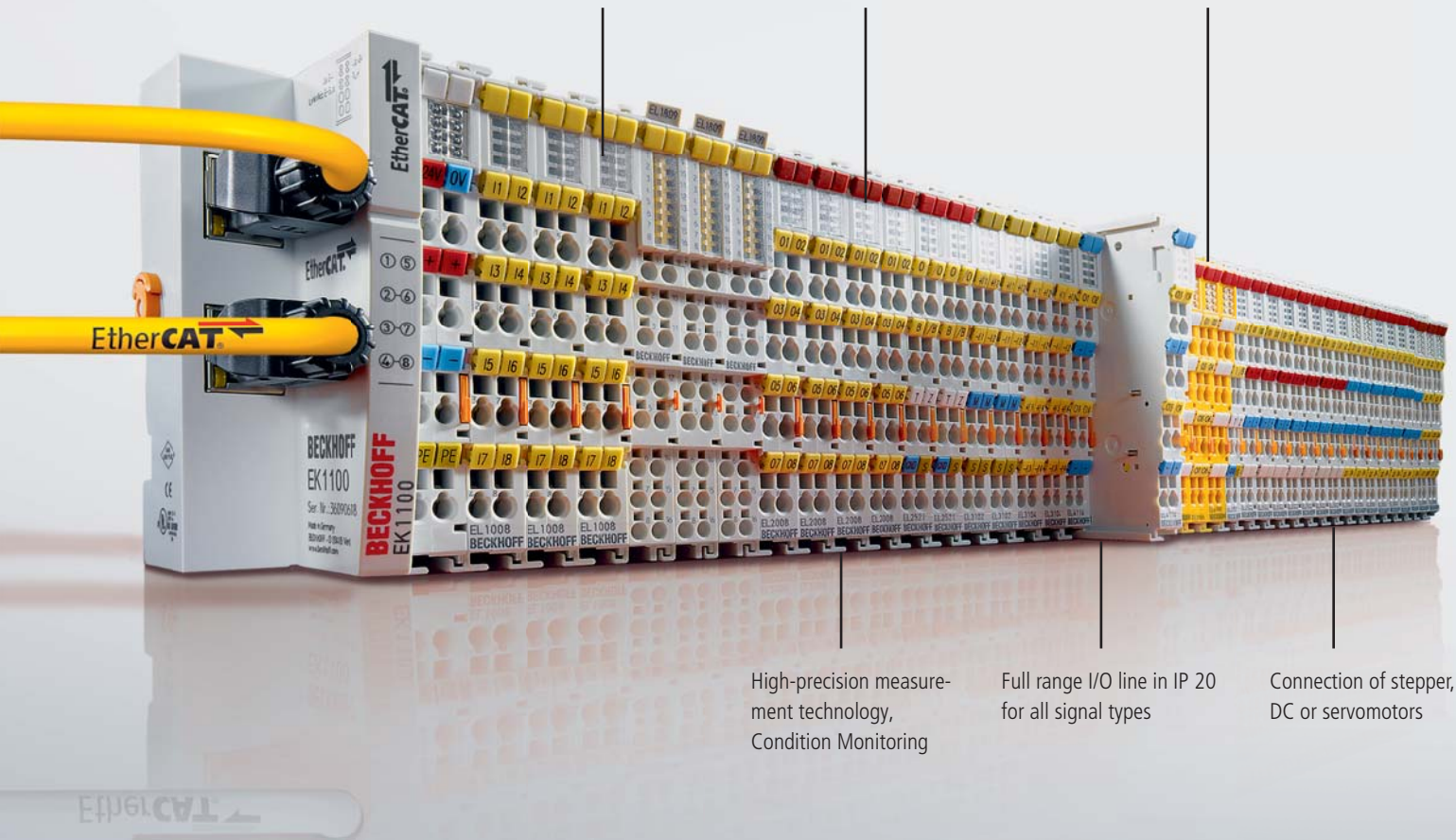
- the right Industrial PC for every controller
- individual housing construction for optimum adaptation to controller requirements
- designed for machine-oriented use
- long-term availability of components
- optimum solution for retrofitting of plants and machines

EtherCAT Terminals

EtherCAT down
to each terminal

Almost unlimited network size:
up to 65,535 devices

TwinSAFE PLC and
safety I/Os



High-precision measure-
ment technology,
Condition Monitoring

Full range I/O line in IP 20
for all signal types

Connection of stepper,
DC or servomotors

TwinSAFE

- integrated safety system from I/Os to drives
- compact safety PLC in a 12 mm terminal block for EtherCAT Terminal system
- standard and safety I/Os in one system
- fieldbus-neutral communication with Safety over EtherCAT

- certified for solutions up to IEC 61508 SIL 3 and DIN EN ISO 13849-1:2008 PLE
- graphical programming editor
- Safety Engineering integrated into TwinCAT 3

► www.beckhoff.com/TwinSAFE

EtherCAT drives

- highly dynamic Servo Drives up to 120 KW
- integrated, fast control technology
- axes control centrally in the controller, incl. coupled movement functions

► www.beckhoff.com/AX5000



EtherCAT: One high performance bus for drives and I/O

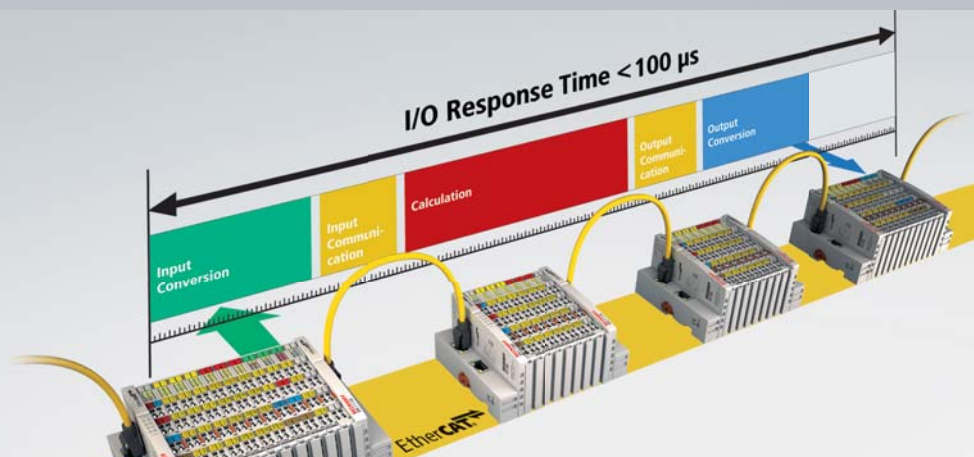
Beckhoff offers a comprehensive range of fieldbus components for all common I/Os and fieldbus systems. And in addition EtherCAT: the Ethernet solution for industrial automation, which is characterized by outstanding performance and simple handling. The result: faster signals transfer times from the PC to the field and back. For an even more precise machine and plant control, leading to significantly higher production efficiency.

- ▶ www.beckhoff.com/IO
- ▶ www.beckhoff.com/EtherCAT
- ▶ www.ethercat.org

XFC (eXtreme Fast Control)

- XFC increases the speed of reaction of a machine controller by a factor of 10 compared to market standards.
- Depending on the machine type, this can make the machine faster and more efficient, resulting in a significant increase in productivity.
- XFC is entirely based on standard components: IPC, fast I/Os, EtherCAT and TwinCAT.
- XFC enables I/O response times of $< 100 \mu\text{s}$.

▶ www.beckhoff.com/XFC



EtherCAT

- real-time Ethernet for automation
- flexible topology
- maximum performance
- easy configuration
- fully Ethernet-compatible
- distributed clocks for synchronous set value outputs with absolute precision
- maximum contour precision

Scalable Drive Technology



Compact Drive Technology

- solutions up to 8 A in the I/O system
- connection of stepper, servo, DC or AC motors
- IP 20 or IP 67 connection options
- matching motors and gearboxes

► www.beckhoff.com/compact-drive-technology

Digital Compact Servo Drive AX5000

- 1- or 2-channel servo drives
- high-speed EtherCAT communication
- wide range of rated current types of up to 120 KW
- flexible motor type selection
- optimised for multi-axis applications

► www.beckhoff.com/AX5000



In combination with the Motion Control solutions offered by the TwinCAT automation software, Beckhoff Drive Technology represents a complete drive system. PC-based control technology from Beckhoff is ideally suited for single and multiple axis positioning tasks with highly dynamic requirements. The AX5000 Servo Drive series with high-performance EtherCAT system communication offers maximum performance and dynamics. Servomotors with One Cable Technology (OCT), which combines power and feedback system in a standard motor cable, reduce material and commissioning costs.

► www.beckhoff.com/Drivetechnology

Synchronous Servomotors

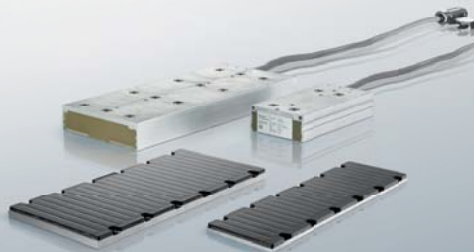
- for positioning task with high demands on dynamics and performance
- brushless three-phase motors with permanent magnets in the rotor
- torques from 0.2 to 180 Nm

► www.beckhoff.com/Servomotors

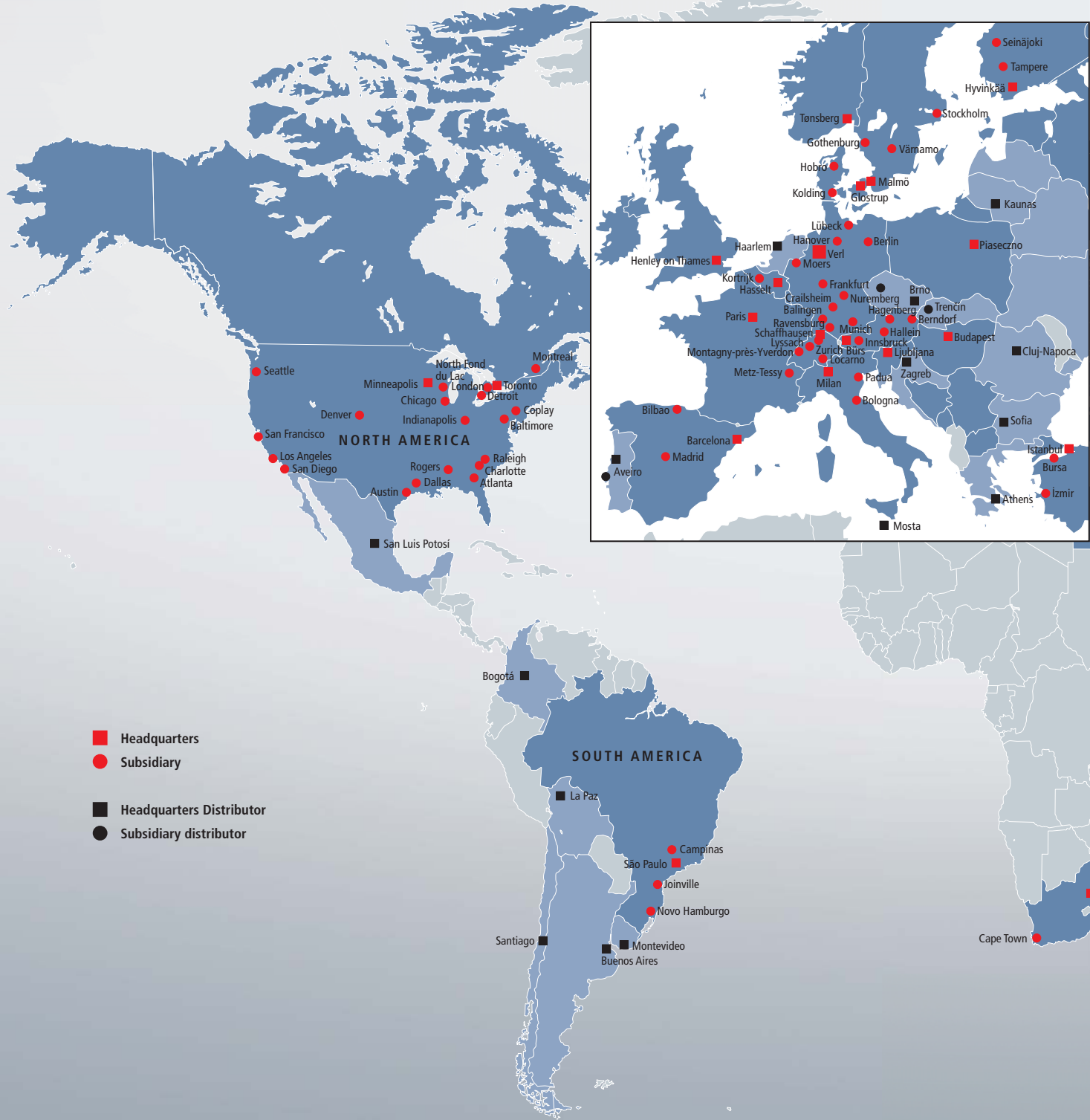
Linear Servomotors

- for the highest requirements with regard to dynamics and acceleration
- up to quadruple overload capacity
- no mechanical wear
- maximum positioning accuracies achievable

► www.beckhoff.com/Linear-motors



- Servo Drives: from ultra-compact servo terminal with 200 W to high-power EtherCAT drive up to 120 kW
- servo, linear and stepper motors
- TwinCAT software: standard development environment as well as NC and CNC runtime
- integrated safety: restart lock, TwinSAFE
- versatile thanks to simultaneous interpolation of different drive types such as stepper and servomotors



Beckhoff – New Automation Technology

Beckhoff implements open automation systems based on PC Control technology. The product range covers Industrial PCs, I/O and Fieldbus Components, Drive Technology and automation software. Products that can be used as separate components or integrated into a complete and seamless control system are available for all industries. The Beckhoff "New Automation Technology" philosophy

represents universal and open control and automation solutions that are used worldwide in a wide variety of different applications, ranging from CNC-controlled machine tools to intelligent building automation.

► www.beckhoff.com

Beckhoff at a glance

- Headquarters: Verl, Germany
- Sales 2012: € 408 Million
- Staff worldwide: over 2,200
- Branch Offices Germany: 11
- Subsidiaries/Branch Offices worldwide: 30
- Distributors worldwide: in more than 60 countries (as of 04/2013)



Worldwide presence on all continents

The central divisions of Beckhoff, such as development, production, administration, distribution, marketing, support and service, are located at Beckhoff Automation GmbH headquarters in Verl, Germany. Rapidly growing presence in the international market is taking place through 30 subsidiaries. Through worldwide co-operation with partners, Beckhoff is represented in more than 60 countries.

Further information

The web pages "PC-based Control for CNC Machining" offer further information, e. g. application reports and industry-specific solutions.

► www.beckhoff.com/cnc

Beckhoff catalogs and flyers are available for download on the Internet.

► www.beckhoff.com/media

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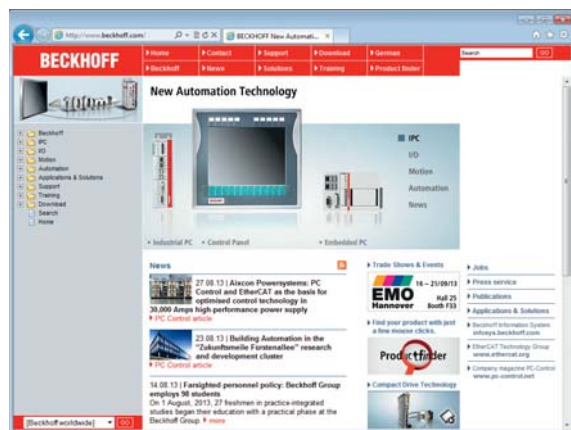
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Products online

At www.beckhoff.com you can get detailed information on the range of products from Beckhoff. Animations, videos and interactive online presentations supplement the large variety of information.

► www.beckhoff.com



Print media online

The Beckhoff catalogs and flyers are available for download on the Internet. Printed copies are available on request. Please use our online order form to specify your requirements.

► www.beckhoff.com/media



Main catalog



News catalog



PC Control magazine

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