BECKHOFF New Automation Technology

PC-based Control for Assembly and Handling
High-performance production technology is the key to success in global competition. Shorter innovation cycles and large model variety lead to high demands. Flexible automation solutions provide a significant competitive edge and reduce time to market.

Assembly or machining technology must keep up with shorter product cycles and adapt to changing production conditions. Modular systems with easily reconfigurable components guarantee maximum flexibility. Existing lines are designed for integration of additional modules with new functionalities, thereby increasing the reusability of the system. Modern systems achieve large capacity with top quality and low unit costs. In addition to constant demand for smaller production batches and higher production speed, traceability as well as extensive electronic process documentation and validation are becoming more and more significant.

A wide range of existing applications indicate that automation technology from Beckhoff can significantly enhance the productivity and flexibility of automatic assembly and handling systems. PC-based control technology from Beckhoff enables the whole process chain for individual processing machines and complete production lines to be controlled and monitored: Feeding, joining (welding, gluing, etc.), assembly, checking, handling and palletising can be implemented consistently with Beckhoff Industrial PCs as hardware platform and TwinCAT as automation software.

Integrated control platform for all processes
Highly dynamic handling devices with high repeatability require a system that guarantees minimum delays for all sub-processes including physical signal sampling, processing in the motion controller and response at a physical output. Beckhoff offers the required products and technologies: high-performance IPCs and Embedded PCs with Motherboards specially developed for industrial applications, Control Panels as control and display elements, fast and compact I/O components in IP 20 or IP 67, EtherCAT as open and ultra-fast communication system, versatile Servo Drive Technology, cost-effective stepper motor technology and the TwinCAT PLC and motion control software.

The functional safety of the application is ensured through Beckhoff TwinSAFE technology. Safe I/O components and drive-integrated safety functions that are linked to the safe Logic Terminal via a safe communication enable safe system operation.

TwinCAT: continuity with PC-based technology
TwinCAT integrates PLC and Motion Control functions and controls the individual process steps of the processing machines with high performance. Software PLC programming is based on the international IEC 61131-3 standard. A wide range of software modules for different tasks such as cams, synchronised and interpolating movements of several axes are available.

Solutions for different areas of application can be implemented due to the high flexibility in terms of combination options for master and slave axes and the high-performance and diverse motion functions. Powerful tools such as TwinCAT Cam Design Tool and TwinCAT ScopeView support system design and commissioning. PLC libraries with function blocks based on the PLCopen Motion Control standards simplify programming and enable the use of standardised components.

Open communication interfaces support integration into existing visualisation and control systems. Depending on the requirements of the automation devices, the Windows operating system enables further software components such as vision systems to be installed.
on the same hardware in addition to TwinCAT. The Industrial PC as a uniform platform enables communication between the selected components.

**EtherCAT: maximum performance even for systems with many axes**

The basis for the ultra-fast process communication is the EtherCAT Industrial Ethernet system, which is ideally suited for use in production machines. The fast communication between the controller and the I/O signals – without special hardware – offers the machine manufacturer undreamt-of possibilities: Motion Control with multiple axes, synchronised through distributed EtherCAT clocks, with nanosecond accuracy.

With XFC (eXtreme Fast Control Technology) from Beckhoff, any programmer is able to realise very fast and highly precise control solutions for automatic assembly machines, simply and elegantly based on standard components. Products of any size, including microcomponents, can be assembled with maximum precision and in a reproducible manner.

**Innovative products and a full range of services**

Since the foundation of the company in 1980, continuous development of innovative products and solutions using PC-based control technology has been the basis for the continued success of Beckhoff. Many automation technology standards that are taken for granted today were conceptualised by Beckhoff at an early stage and successfully introduced to the market:

- 1982: P1000 – single-board motion controller
- 1986: PC Control – first PC-based machine controller
- 1989: Lightbus – high-speed fieldbus utilising optical fibre
- 1990: All-in-one PC motherboard
- 1995: Bus Terminal – fieldbus technology in terminal block format
- 1996: TwinCAT – real-time software package under Windows with PLC and Motion Control functions
- 1998: Control Panel – remote IPC Control Panels
- 2002: CX1000 – modular Embedded PCs for DIN rail mounting
- 2003: EtherCAT – real-time Ethernet fieldbus system
- 2005: TwinSAFE – safety solution for the Bus Terminal system
- 2005: AX5000 – EtherCAT Servo Drive
- 2006: XFC – eXtreme Fast Control Technology
- 2007: Industrial Motherboards – Made in Germany

The Beckhoff PC Control philosophy and the invention of the Lightbus system, the Bus Terminals and TwinCAT automation software represent milestones in automation technology and have become accepted as high-performance alternatives to traditional control technology. EtherCAT, the real-time Ethernet solution, makes forward-looking, high-performance technology available for a new generation of leading edge control concepts.

**World-wide presence on all continents**

The central divisions of Beckhoff, such as development, production, administration, distribution, marketing, support and service are located at the Beckhoff Automation GmbH headquarters in Verl, Germany. Rapidly growing presence in the international market is taking place through subsidiaries in Austria, Belgium, Denmark, Finland, France, Italy, Poland, Russia, Slovenia, Spain, Sweden, Switzerland, Turkey, as well as in Australia, Brazil, Canada, China, India, South Africa, the United Arab Emirates and the USA. Through worldwide co-operation with partners, Beckhoff is represented in more than 60 countries.
Industrial PCs in different designs and with a range of optional features offer the right solution for any application. PCs with industrial design are equipped with high-performance components, based on open standards. A wide range of products and individual housing designs enables optimum adaptation to the specific control requirements.

The Embedded PCs of the CX series are designed for control tasks in the medium performance range. The compact Industrial PC can be mounted on a DIN rail, is modular and can be assembled depending on the required tasks. For optimum scaling the CX family offers several basic CPU modules that can optionally be extended with all main PC and fieldbus interfaces and I/O modules.

The Bus Terminal is the open and flexible I/O system for all common fieldbuses. The wide choice of electronic block terminals covers the full range of input and output channels required in automation – from the digital and analog world right through to the serial interface. It is possible to tailor a specific solution, as if from a toolkit.

EtherCAT is the real-time Ethernet system for industrial automation, offering flexible topology and simple handling, among other benefits. The high-performance system enables control concepts that could not be realised with classic systems. No special plug-in cards are required in addition to the standard Ethernet port.

The compact, robust Fieldbus Box modules function as decentralised I/Os right at the machine or plant. Their strong, sealed construction offers protection class IP 67: ideal for application in wet, dirty or dusty environments. The Fieldbus Box fits in with all common fieldbus systems and offers plug-and-play functionality in the field.

We reserve the right to make technical changes.
The Drive Technology rounds off the comprehensive control system product range. The Synchronous and Linear Servomotors, in connection with Digital Servo Drives, are particularly suited to positioning tasks that make high demands on dynamics and stability. The variable fieldbus connection of the Servo Drives facilitates integration into different control environments.

The TwinCAT automation software integrates real-time control with PLC system, NC axis control and programming environment in a single package. The software PLC/NC/CNC is embedded in the Microsoft operating systems Windows NT/2000/XP/Vista, NT/XP Embedded and Windows CE. Programming is based on the IEC 61131-3 standards. TwinCAT links to all common fieldbuses and PC interfaces for I/O signals.

Beckhoff is represented in over 60 countries around the world and offers comprehensive support and service, with fast and competent assistance guaranteed. The support department will not only advise you about technical questions, but also in the planning, programming and commissioning of complex automation projects. The comprehensive training options for Beckhoff system components are an important part of this support.
Mounting

PC-based control, with multiple parallel tasks and extremely short cycle times, possesses the performance necessary to simultaneously control many axes for automatic assembly machines. The automatic link identification offered by EtherCAT in conjunction with Hot Connect control functionality enables fast tool or module change-over.

Handling

TwinCAT NC offers Motion Control for up to 255 axes on the PC. Free paths can be defined with axis interpolation in three dimensions.
Checking

The connectivity property of the TwinCAT automation package assists in the checking of products. Devices with almost any fieldbus interface are connected either directly to the PC or, even simpler, via EtherCAT gateway. In this way, for example, test devices with Ethernet interface (vision systems, weighing equipment) can be integrated directly in the automation process.

for flexible handling of the end products. Additional axes and peripheral tools are simply integrated in the PLC.

TwinCAT
Automation software for PLC and Motion Control, choice of Windows XP or CE operating system with a uniform engineering tool for different processor platforms.
An assembly line is characterised by its modular design. PC-based control enables flexible control architectures for modular assembly lines. With its scalable and open hardware and software control technology, Beckhoff offers suitable solutions for central and decentralised architectures.

Central
In a central control architecture the PC-based solution from Beckhoff with its high-performance PC platform and high-performance EtherCAT communication can fully demonstrate its benefits: An Industrial PC with TwinCAT automation software handles all I/O, PLC and Motion Control tasks. Further advantages include central diagnostics, commissioning and maintenance and convenient PLC program management. EtherCAT eliminates fieldbus bottlenecks. Data from a large number of I/Os can be collected, and numerous axes can be controlled and synchronised.

Decentralised
In a decentralised control architecture each module has its own, stand-alone control system, which simplifies replacement and testing of individual modules. Since the control tasks are distributed, lower-performance CPUs, such as the Embedded PCs of the CX series, can be used. In addition to distributed controllers, such systems generally feature a central master PLC, which deals with management tasks such as logistics, parts tracking and central statistics. Communication between modules (e.g. via Ethernet TCP/IP), with the master computer and for synchronisation of the PLCs is more complex than in a central solution.
**Ethernet**

EtherCAT is the real-time Ethernet fieldbus for industrial automation, offering flexible topology and simple handling, among other benefits. With its high communication speed and high user data rates, EtherCAT features the basic qualification for fast control technology.

**Industrial PC**

With the Industrial PCs and Panel PCs Beckhoff offers PC technology with top performance.

**EtherCAT drives**

The AX5000 Servo Drive series sets new standards in drive performance. The AX5000 series is available with single- or multi-channel versions and is optimised with premium functionality that is still cost-effective when compared with competitive offerings. Integrated, high-speed control technology with a current control cycle of up to 31.25 µs supports fast and highly dynamic positioning tasks.
Windows operating systems
Beckhoff relies on the global Windows standard from Microsoft for the operating system. TwinCAT runs under Windows NT/2000/XP/Vista, NT/XP Embedded and Windows CE.

Software PLC and Motion Control
TwinCAT integrates real-time control with PLC system, Motion Control and programming environment in a single package. Programming is executed in accordance with the IEC 61131-3 standard.

Safety
With the TwinSAFE I/O terminals, secure input and output signals are linked with one another in a configurable, secure logic.

XFC – eXtreme Fast Control Technology
XFC is based on an optimised control and communication architecture comprising an advanced Industrial PC, ultra-fast I/O terminals with extended real-time characteristics, the EtherCAT high-speed Ethernet fieldbus, and the TwinCAT automation software.

EtherCAT I/O system
Industrial Ethernet in an electronic terminal block: The EtherCAT I/O system from Beckhoff offers full Ethernet compatibility, maximum utilisation of Ethernet bandwidth and outstanding real-time performance. PROFIBUS devices or DeviceNet, for example, can be integrated via fieldbus gateway terminals.

We reserve the right to make technical changes.
Beckhoff offers a scalable, modular control system that provides suitable solutions for any task in terms of computing capacity, complexity and costs. All Beckhoff controllers, irrespective of their performance class, are programmed in IEC 61131-3 via the TwinCAT automation software.
Software PLC and programming environment
The TwinCAT software system converts any compatible PC into a real-time controller featuring multiple PLCs, a programming environment and an operating station. TwinCAT runs under Windows NT/2000/XP/Vista, NT/XP Embedded or Windows CE. PC Control enables connection to all common fieldbuses and PC interfaces, as well as data interfacing via open standards such as OPC. TwinCAT PLC is an IEC 61131-3 PLC with four run-time systems for each PC and short cycle times from 50 µs. The stable real-time with a jitter < 2 µs enables central Motion Control with up to 255 axes in various master/slave combinations as well as interpolating. Engineering tools support the creation and maintenance of software.

PC Control
The Beckhoff Industrial PCs represent the most powerful hardware platform for PC-based control technology. Beckhoff supplies Industrial PCs constructed in a variety of forms and equipped in various ways. The PCs feature industrial design and are equipped with top-performance components. They are based on open IT and automation standards. Individual housing constructions ensure optimised adaptation to the control requirements.

Embedded PC Control
The Embedded PCs of the CX series are optimised for control tasks in the medium performance range. The modular, small-format Industrial PCs are DIN rail mountable and can be configured according to the task in hand. The CX controllers with compact design combine PLC, Motion Control, I/O interface and visualisation. The CPU modules with different processors operate without fan or rotating storage media. Optionally, all main PC and fieldbus interfaces and I/O components are expandable.

Embedded Control
The Bus Terminal Controller series BC and BX are small controllers for the Beckhoff Bus Terminal system. The modular I/O system consists of electronic terminal blocks for direct sensor/actuator wiring and a Bus Coupler for connection to the bus system. Tailor-made solutions can be configured from a wide range of signal options.

We reserve the right to make technical changes.
**High-end PLC**
- international IEC 61131-3 programming standard
- reusable software modules
- almost unlimited memory
- no restrictions in terms of number of blocks and variables
- minimum PLC cycle times through native code generation
- 1,000 instructions in < 1 µs (Core™2 Duo)
- high-speed software solutions for camming, controllers, etc.
- up to four run-time systems per PC, up to four tasks per run-time system

**TwinCAT NC**
- PC-based Motion Control for up to 255 axes
- support for a wide range of axis types:
  - electrical servo axes
  - stepper axes
  - DC motors
  - hydraulic axes
- support for a wide range of drive interfaces:
  - EtherCAT and Lightbus
  - SERCOS
  - ProfiDrive
  - CANopen
  - SSI
  - analog interfaces
- convenient commissioning and maintenance

www.beckhoff.com/TwinCAT/
Highly deterministic real-time capability
- pure software solution, developed by Beckhoff
- highly deterministic
- pre-emptive multi-tasking from 50 µs
- low jitter (< 2 µs with Core™2 Duo)
- open fieldbus interface

Motion Control functionality
- point-to-point motion
- gear coupling
- master/slave coupling
  - cam plates
  - Cam Design Tool
  - Motion laws can be modified from within the PLC.
- position-synchronous coupling (flying saw, flying shear)
  - synchronisation from any dynamic phase
- superposition
- axis interpolation in 3 dimensions
- programming according to DIN 66025
- PLC library for NC interpolation

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

We reserve the right to make technical changes.
EtherCAT is the Ethernet solution for industrial automation, characterised by outstanding performance and particularly simple handling.

The use of EtherCAT for assembly, handling and robotics offers decisive advantages:

- EtherCAT guarantees maximum performance based on Industrial Ethernet.
- Extremely short update times are possible for the process image (50 µs).
- Control loops (up to the current controller) can be closed via the bus. Control of the axes can take place centrally in the controller – including the coupled movement function.
- No subordinate I/O subsystems; each I/O terminal is an EtherCAT device. This makes extremely short reaction times possible.
- The application determines the topology, not the communication system: line, star, tree – anything is possible.
- Redundancy and Hot Connect options are integrated in the system.
- Safe transfer of data is possible with the Safety over EtherCAT protocol up to SIL 3 of IEC 61508.
- A standard Ethernet port can be used for the EtherCAT master; no special master interface card is necessary.

**EtherCAT Technology Group**

The EtherCAT Technology Group (ETG) is an association of automation users and manufacturers aiming to support the development of the EtherCAT technology. The consortium represents a wide range of sectors and application areas. This ensures that the EtherCAT technology functions and interfaces are ideally prepared for a wide range of applications. The organisation ensures that EtherCAT can easily and cost-effectively be integrated in a wide range of automation devices, and it also ensures interoperability of the implementations.

The EtherCAT Technology Group is the official IEC partner organisation for fieldbus standardisation. Membership is open to all companies.

For further information see [www.ethercat.org](http://www.ethercat.org)

At beckhoff.com/EtherCAT/

Freedom in the choice of topology | Maximum flexibility for wiring: with or without switch, line or tree topologies can be freely selected and combined. Address assignment is automatic; no IP address setting is required.
The I/O construction kit is extended “safely” | With the TwinSAFE Bus Terminals, Beckhoff offers the option of simply expanding the proven Bus Terminal system and to transfer the complete cabling for the safety circuit into the already existing EtherCAT cable. Safe signals can be mixed with standard signals without restriction. This saves design effort, installation and material. Maintenance is simplified significantly through faster diagnosis and simple replacement of only a few components.
With XFC technology (eXtreme Fast Control Technology) Beckhoff presents a fast control solution: XFC is based on an optimised control and communication architecture comprising an advanced Industrial PC, ultra-fast I/O terminals with extended real-time characteristics, the EtherCAT high-speed Ethernet system, and the TwinCAT automation software. With XFC it is possible to realise I/O response times $\leq 100$ $\mu$s. This technology opens up new process optimisation options for the user that were not possible in the past due to technical limitations.

WWW. beckhoff.com/XFC/
XFC: Optimised control and communication architecture for highest performance

**TwinCAT – The extreme fast real-time control software**
- real-time under Microsoft Windows down to 50 µs cycle time
- standard IEC 61131-3 programming in XFC real-time tasks
- Standard features of Windows and TwinCAT are XFC-compliant.

**EtherCAT – The extreme fast control communication technology**
- 1,000 distributed digital I/Os in 30 µs
- EtherCAT down to the individual I/O terminals, no sub bus required
- optimised use of standard Ethernet Controllers, e.g. Intel® PC chipset architecture
- advanced real-time feature based on distributed clocks
  - synchronisation
  - time stamping
  - oversampling

**EtherCAT Terminals – The extreme fast I/O technology**
- full range I/O line for all signal types
- high-speed digital and analog I/Os
- Time stamping and oversampling features allow extreme high timing resolution (down to 10 ns).

**IPC – The extreme fast control CPU**
- Industrial PC based on high-performance real-time motherboards
- compact form factors optimised for control applications

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**XFC EtherCAT Terminals: Time stamp**

**EL1252:**
- 2-channel digital input 24 V DC
- exact signal acquisition for edge changes
- system accuracy < 1 µs
- absolutely synchronised responses with EL2252

**EL2252:**
- 2-channel digital output 24 V DC
- exact signal acquisition for edge changes
- system accuracy < 1 µs
- absolutely synchronised responses with EL1252

**Time stamp terminals**

Synchronised responses can be realised with time stamp input and output terminals; in the past, precision of < 1 µs was impossible with bus systems. The new XFC technology replaces hardware wiring.

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**XFC EtherCAT Terminals: Fast I/Os**

**EL1202:**
- 2-channel digital input 24 V DC
- input delay $T_{ON/TOFF}$ 1 µs
- minimum response times without appreciable delay

**EL2202:**
- 2-channel digital output 24 V DC
- input delay $T_{ON/TOFF}$ 1 µs
- minimum response times without appreciable delay

**Fast I/O terminals 1 µs $T_{ON/TOFF}$**

With the EL1202 and EL2202 XFC terminals, delays in the terminal hardware are reduced down to < 1 µs and therefore become negligible. Input and output data are forwarded with maximum speed.
Beckhoff | System overview

Automation

TwinCAT

TwinCAT PLC: IEC 61131-3 multi-PLC
TwinCAT NC PTP: PTP axis positioning software
TwinCAT NC I: 3-D axis interpolation software

IPC

Industrial PC

Panel PC CP62xx
Panel PC CP63xx
Panel PC CP64xx
Panel PC CP65xx
Panel PC CP71xx
Panel PC CP72xx
Panel PC C93xx
Panel PC C96xx

Embedded PC

Embedded PC CX1010
Bus Terminals or EtherCAT Terminals
Embedded PC CX1020/CX1030
Bus Terminals or EtherCAT Terminals

I/O

PC Fieldbus Cards

PCI Ethernet FC90xx

Bus Terminal

Bus Coupler BK1120 (K-bus interface), Bus Terminals KL/KSxxxx

Fieldbus Box

Coupler Box IL230x-8110
Extension Box 8Exxxx

EtherCAT

EtherCAT

Coupler EK1xxx, EtherCAT Terminals EL/E5xxxx

Lightbus

Lightbus

Digital Compact Servo Drive AX5xxx
Digital Compact Servo Drive AX20xx
Digital Compact Servo Drive AX25xx
Synchronous Servomotors AM2xxx, AM3xxx

Motion

Drive Technology

We reserve the right to make technical changes.
Embedded PC CX9000, CX9010
EtherCAT Terminals

Embedded PC CX9000, CX9010
Bus Terminals

Canopen
DeviceNet

TwinCAT CNC:
CNC path control software

TwinCAT I/O:
I/O software interface

TwinCAT CP:
Control Panel driver

TwinCAT OPC:
Visualisation interface

K-bus extension

Compact Box
IPxxx-B5xx
Compact Box
IPxxx-B5xx8
Compact Box
IL230x-B5xx
Compact Box
IL230x-B5xx8
Compact Box
IPxxxx-B200
Coupler Box
IL230x-B90x
Coupler Box
IL230x-B90x
Coupler Box
IL230x-B200
Lightbus module
Mxxxx

Compact Box
IPxxxx-B5x 8

Bus Coupler BK5x0, Bus Terminals KL/KSxxxx

Bus Coupler BK3x0, Bus Terminals K/KBKxxxx

Bus Terminal Controller BK/BX3x5x0 (IEC 61131-3)

Bus Terminal Controller BK/BX3x9x0 (IEC 61131-3)

Bus Terminal Controller BK/BX3x200 (IEC 61131-3)

Industrial Motherboards CBxxxx

PCI DeviceNet FC520x

PCI CANopen FC510x

PCI Ethernet FC90xx

PCI Ethernet Switch CU20xx

Linear Servomotors
AL2xxx, AL3xxx

Stepper Motors
AS1xxx

We reserve the right to make technical changes.