BECKHOFF New Automation Technology

PC-based Control for Robotics in Handling, Production and Assembly

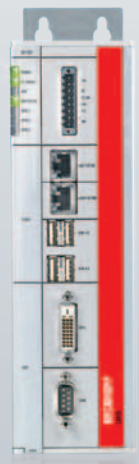
IPC
I/O
Motion
Automation

PC-based Control: the universal control platform …

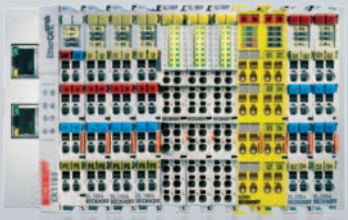
For over 30 years Beckhoff has delivered automation solutions on the basis of PC-based control technology. These innovations have been proven in the most diverse industries and applications by leveraging system openness and exceptionally high performance. The globally operating company, with headquarters and production facilities in Verl, Germany, is represented by 33* subsidiaries and distributors in over 60 countries and employs around 2510* people worldwide.

The constant technological development, strong economic growth, and great depth in production capacities at Beckhoff guarantee long-term availability and delivery reliability of PC-based control technology. A team of specialists for robotics and handling applications makes Beckhoff a reliable partner with considerable solution expertise as well as worldwide customer service and support.

(*As of April 2014)



IPC



I/O

Motion

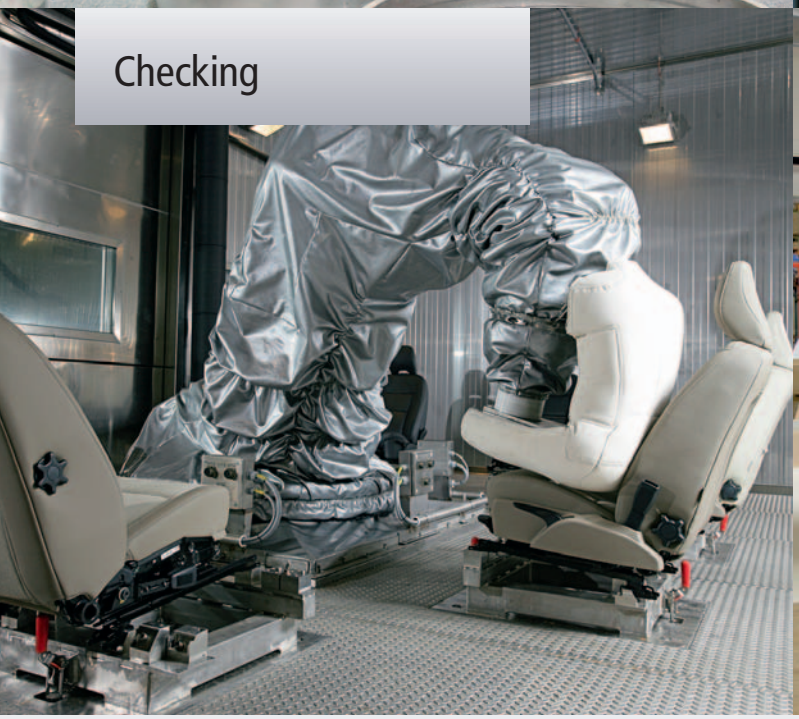
Automation

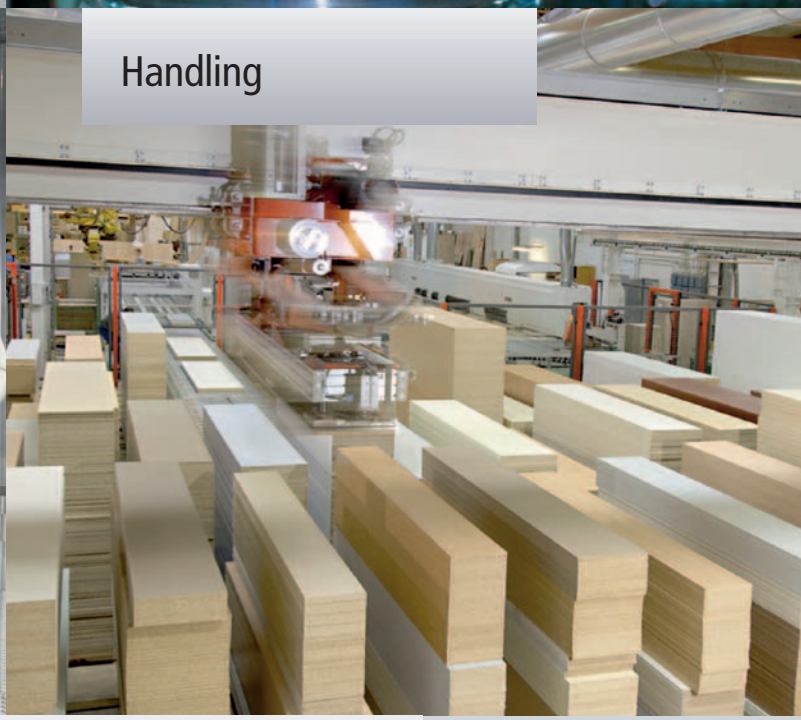
… for the complete production line.

PC- and EtherCAT-based control technology from Beckhoff enables the control and monitoring of the entire manufacturing enterprise, from individual processing machines to complete productions lines. Feeding, joining (welding, gluing, etc.), assembly, checking, handling and palletising can be implemented universally with Beckhoff Industrial PCs as the hardware platform, TwinCAT as the automation software, and EtherCAT as the communication system. Maximum flexibility is ensured if production cells or production lines can be adapted to changing requirements without a great deal of implementation effort, or if new functionalities can be easily integrated. At the same time, PC technology continually makes more computing power and memory space available to users in order to meet their growing requirements for increasingly complex machines and plants with more robust functionality.

PC-based control can integrate robotics and Condition Monitoring into one standard controller …

'Scientific Automation' from Beckhoff blends different control elements such as PLC, HMI, motion control, safety and robotics with advanced measurement functionality and condition monitoring – all on a standard PC-based control platform. Making this convergence of technologies possible are: high-performance Industrial PCs with motherboards specially developed for industrial applications, multi-touch Control Panels as operator interfaces, high-speed and compact I/O modules, EtherCAT as an open and ultra-fast communication system, flexible and dynamic servo drive technology as well as TwinCAT PLC and Motion Control software. By fully utilising the multi-core technology in modern processors, TwinCAT enables, on separate cores, the calculation of complicated mathematical algorithms for the analysis of measured values or for robotic applications – without compromising PLC performance. The user benefits not only regarding synchronisation and process optimisation, but also from cost efficiencies gained by reducing the amount of required hardware and lowering engineering expenses.



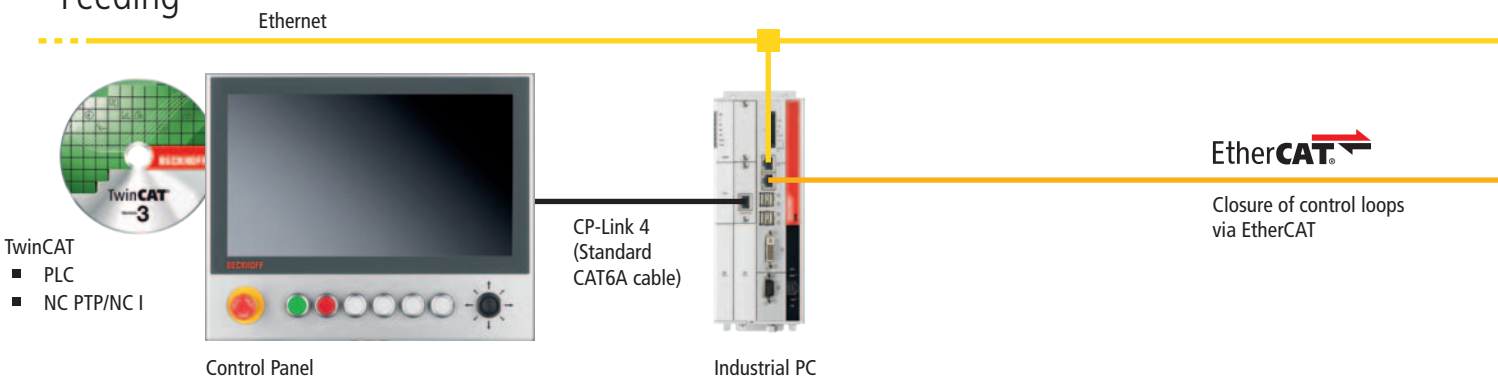


… optimising manufacturing processes and reducing costs.

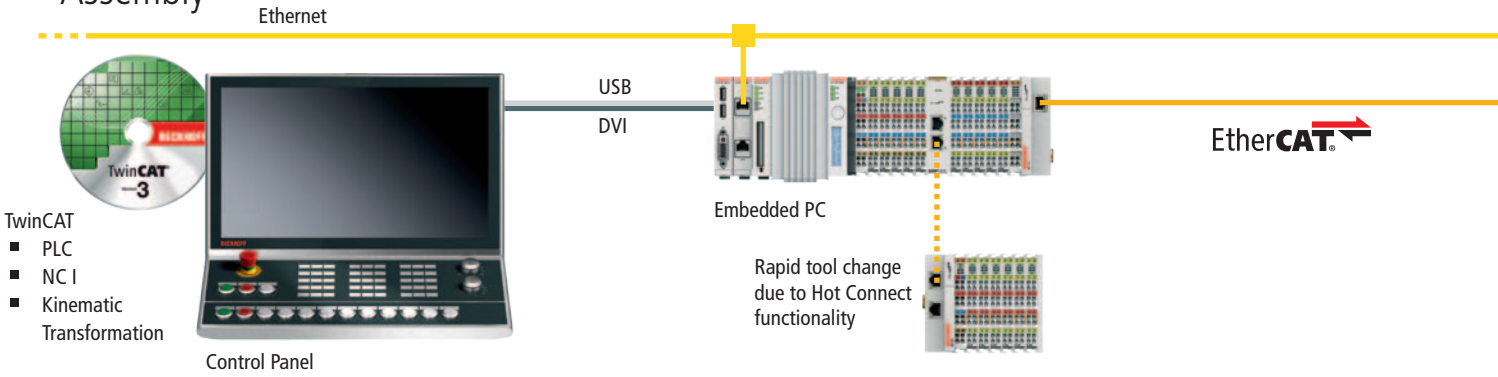
From gantry robots to 6-axis kinematics – a universal automation platform for different robotic applications is available in PC-based control. The seamless integration of robotics into the machine control system avoids friction losses or latency times that occur in the communication between different systems. This way the high dynamics and repeatability demanded in handling processes can be achieved simply and the manufacturing process is optimised. The integration of Condition Monitoring into the controller via measuring terminals enables the implementation of machine monitoring even in price-sensitive applications: measured variables are acquired in the EtherCAT Terminal system and processed in the central controller. This equally efficient and cost-effective solution ensures a longer service life of the machine and increases its availability by means of preventive maintenance.

PC-based control for all robot types

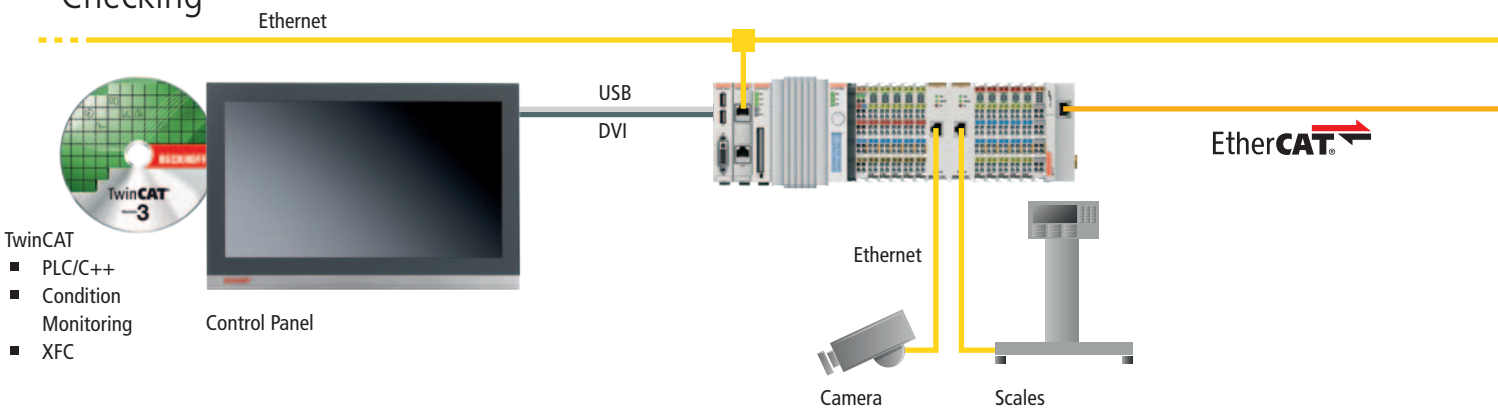
Feeding



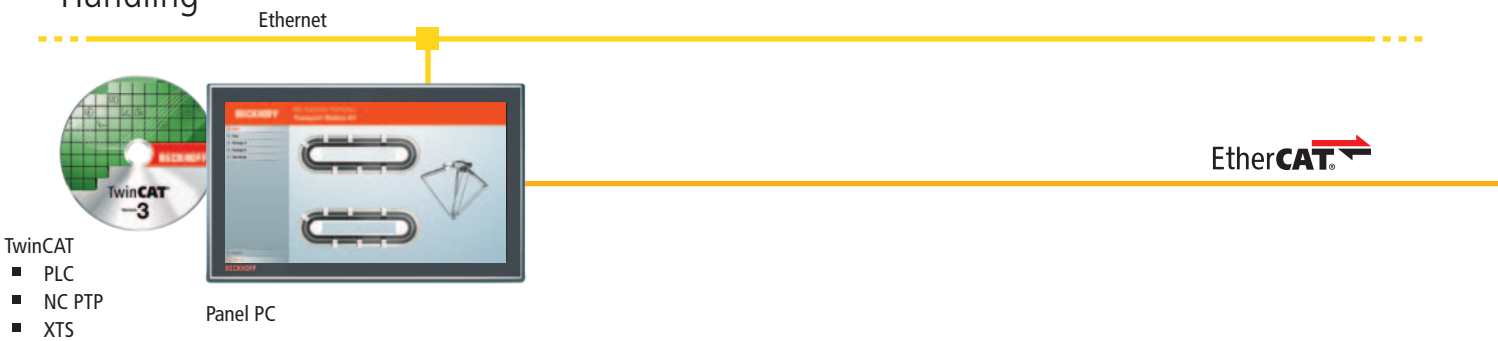
Assembly



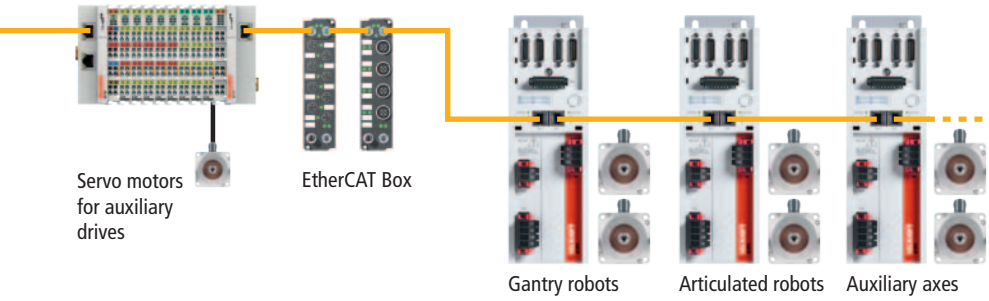
Checking



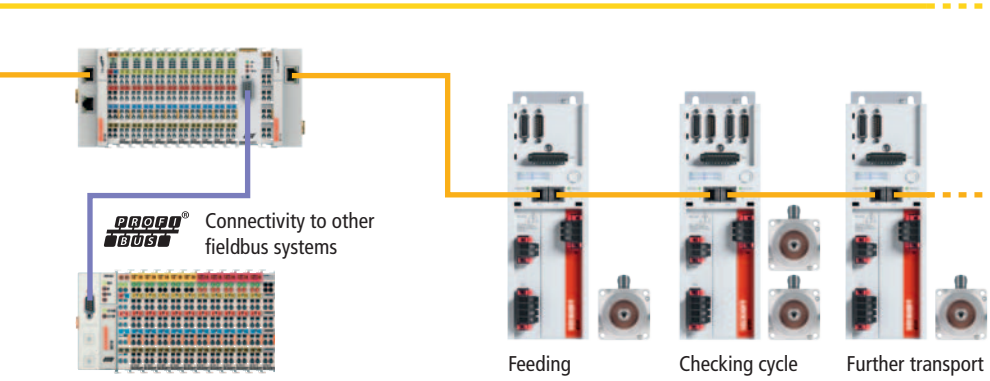
Handling



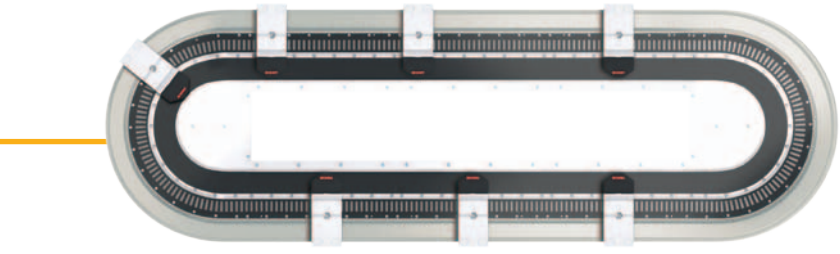
Speed is primarily called for when feeding material into the production facility. The precise guidance of multiple coupled axes is one of the strengths of TwinCAT automation software from Beckhoff. For example, the four axes of a gantry robot can be implemented in a space-saving manner using two 2-channel servo drives from the AX5000 series. The TwinSAFE safety solution is available both for safe inputs and outputs and for drive technology with integrated safety.



Gantry or articulated robots are frequently used for assembly steps such as joining, gluing, screwing, welding, etc. The PC- and EtherCAT-based controller, with multiple parallel tasks and extremely short cycle times, has the performance necessary to simultaneously control a large number of axes. Fast tool changes can be achieved via the EtherCAT Hot Connect function.



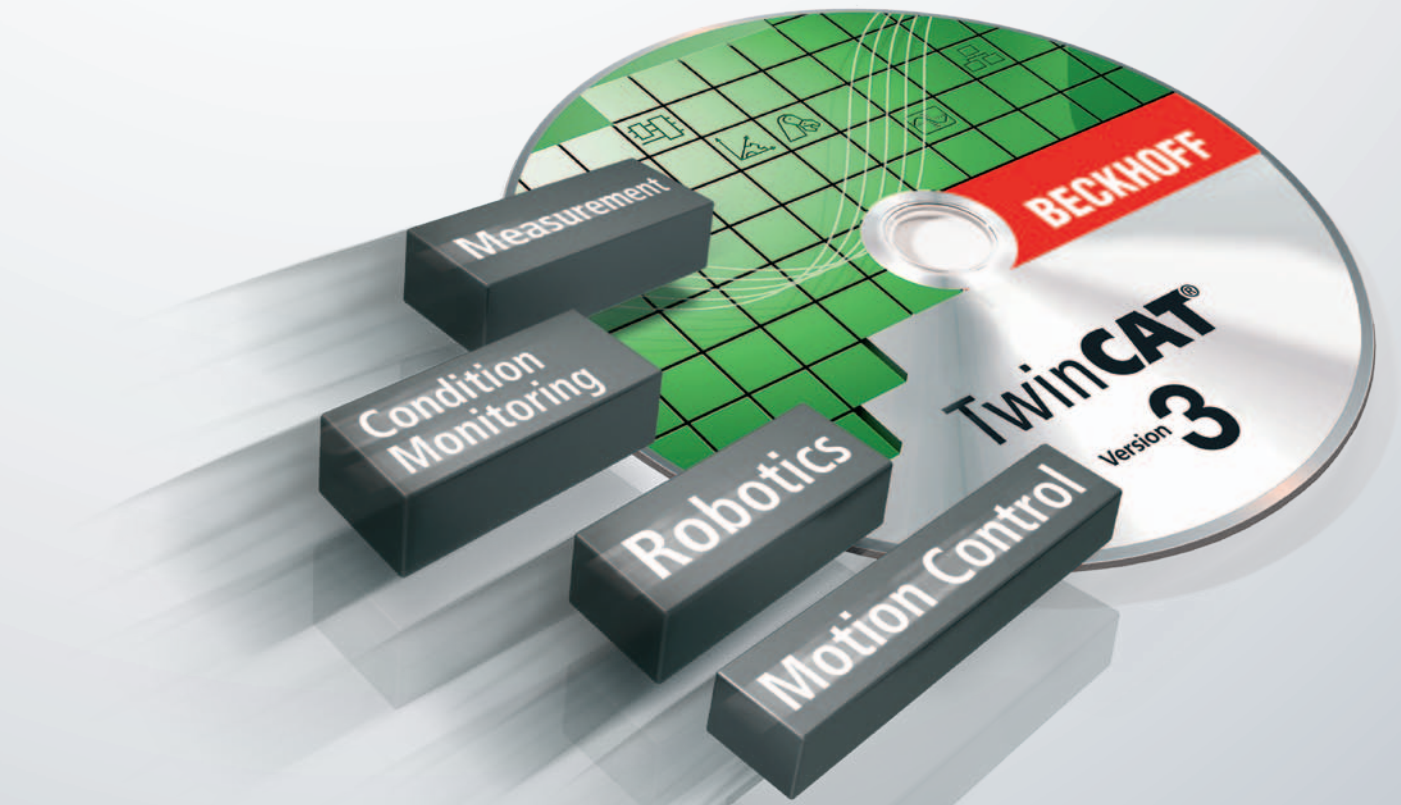
A prerequisite for consistent production quality is the connection of suitable auxiliary systems to the controller. On account of its wide variety of interfaces, TwinCAT enables the connection of devices with almost any desired fieldbus interface. Condition monitoring for machines and plants is integrated simply and cost-effectively into the controller via Condition Monitoring terminals – without the use of stand-alone hardware.



XTS – eXtended Transport System

The linear transport system (XTS) enables individual product transport, i.e. different travel commands can be executed at the same time. The movers – wireless carrier modules – move at up to 4 m/s and transport the products/workpieces very accurately to the respective processing station. The small size of the XTS helps machine manufacturers design their machines with considerably smaller dimensions.

▶ **www.beckhoff.com/XTS**



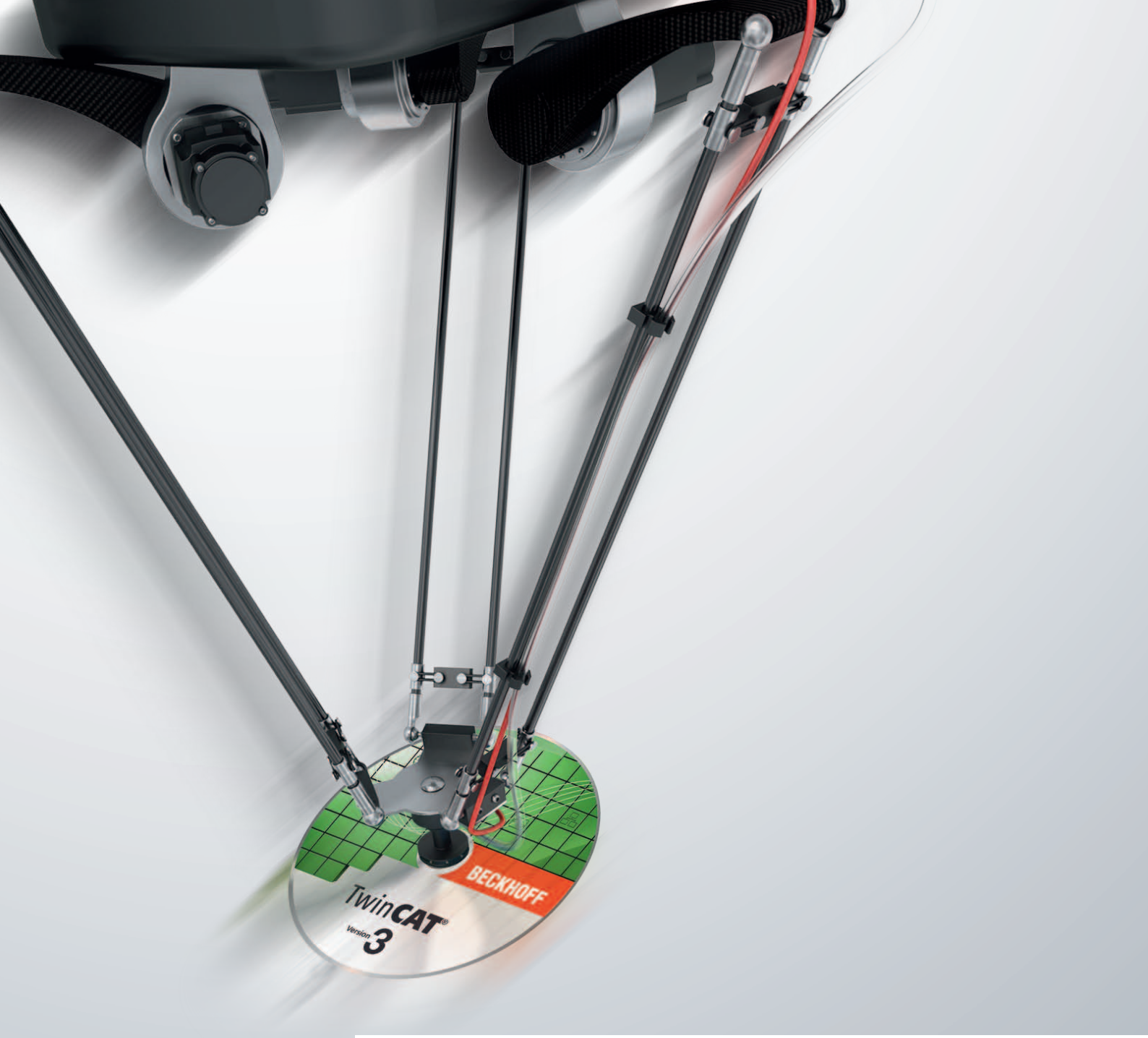
TwinCAT, the open automation software, …

TwinCAT, the open and scalable automation software platform from Beckhoff, is based on Windows operating systems and is at the heart of PC-based control. It replaces conventional PLCs and motion controllers and transforms almost any compatible PC into a real-time controller with a multi-PLC system, Motion Control, programming environment and operation station. A connection to all common fieldbuses is integrated. With IEC 61131, C/C++ and MATLAB®/Simulink®, the appropriate programming language is available for every task using TwinCAT. Numerous PLC libraries with function blocks according to the PLCopen Motion Control standard facilitate programming. Due to the multi-core capability of TwinCAT 3, all cores can be optimally used, leading to a significant increase in performance.

▶ **www.beckhoff.com/TwinCAT**

… integrates engineering and runtime on a single platform.

TwinCAT provides the user with a uniform software tool for universal configuration, programming and diagnostics, considerably simplifying engineering. Robotic and Motion Control functions can be synchronised optimally using TwinCAT NC PTP (point-to-point axis positioning) or NC I (axis interpolation in three dimensions). All NC characteristics such as „cam plate" or „flying saw" can be combined as desired on the standard hardware and software platform. Using TwinCAT, almost any type of robot kinematics can be programmed in normal PLC programming languages – without special robotic tools and languages. This guarantees efficient engineering and lowers costs. The integration of C and C++ code makes the continued use of existing robot kinematics possible; MATLAB®/Simulink® facilitates the use of existing models for controllers or simulations.



TwinCAT integrates robot kinematics into a standard controller …

TwinCAT Kinematic Transformation integrates robot control into TwinCAT software so that PLC, Motion Control and robotics can be executed on a single Industrial PC. 6-axis kinematics is also available in addition to the Cartesian gantry, serial 2-D kinematics, 2-D parallel kinematics and 3-D delta kinematics. The respective kinematics can be selected and parameterised conveniently in the TwinCAT System Manager. The kinematic channel is used to parameterise the type (e.g. delta or SCARA) as well as the bar lengths and offsets. Mass and mass inertia values can be specified for dynamic pre-control. In addition, the software library includes tracking functionalities. This means that the robot is synchronised with a moving object, so that it can pick up workpieces from conveyor belts or inclined turntables, for example.

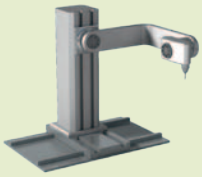
▶ **www.beckhoff.com/TF5110**

The 'TwinCAT Kinematic Transformation' function requires TwinCAT NC I and is subdivided into four levels:

Level 4: includes level 3 as well as
- Serial 6-axis kinematics
- Hexapod
- 5-D kinematics


Serial 6-axis kinematics


Hexapod


5-D kinematics

Level 3: includes level 2 as well as more complex kinematics such as
- 3-D kinematics
- SCARA
- 3-D delta


3-D kinematics


SCARA


3-D delta kinematics

Level 2: includes level 1 as well as additional, simpler kinematic transformations:
- Shear kinematics
- Roller kinematics (H-Bot)
- 2-D parallel kinematics


Shear kinematics


Roller kinematics (H-Bot)


2-D parallel kinematics

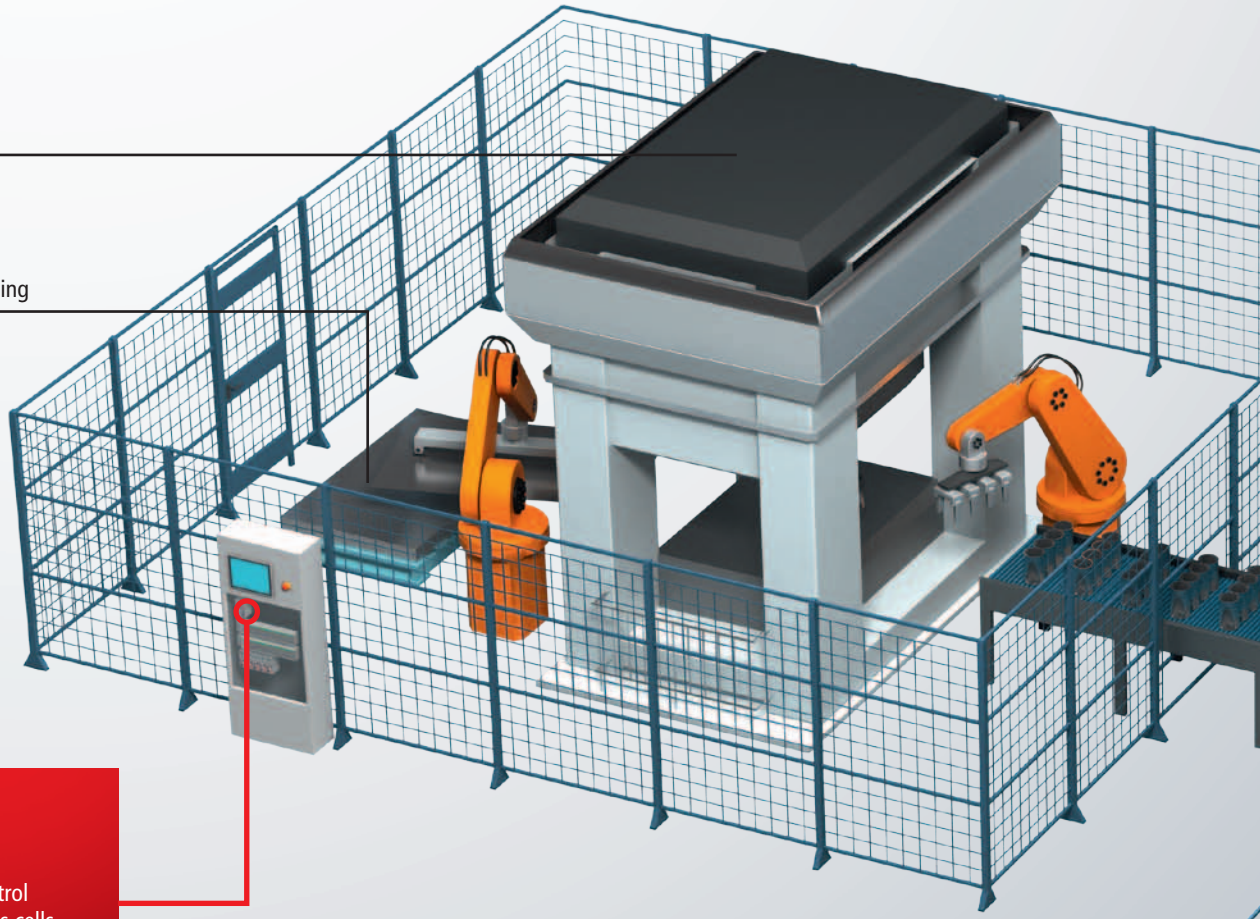
Level 1: static transformation (translation and rotation) and various compensations
- Cartesian portal


Cartesian portal

… and ensures maximum performance and accuracy.

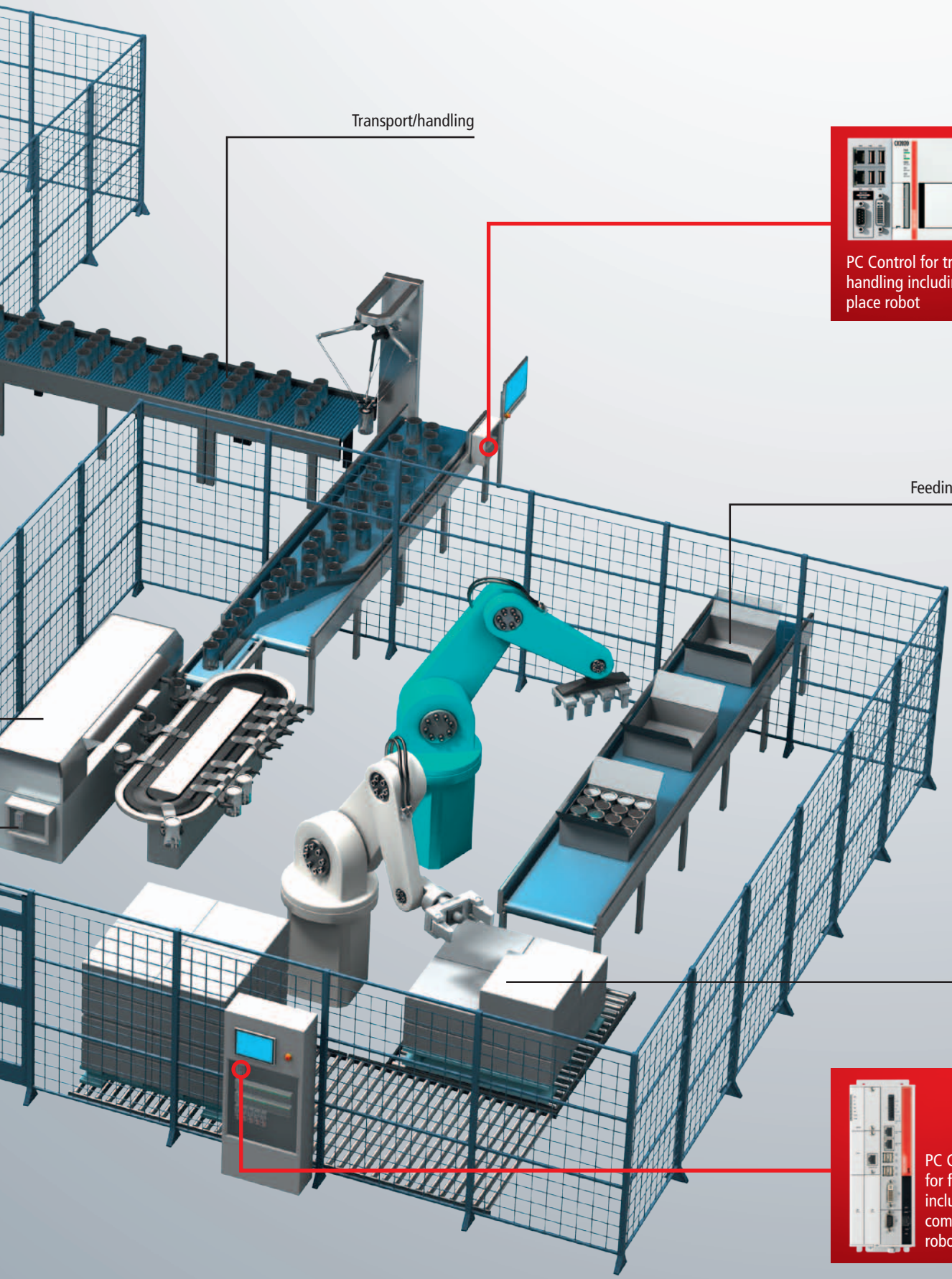
Using 'TwinCAT Kinematic Transformation', various parallel and serial kinematics such as those used for pick-and-place tasks, for example, can be implemented more simply. The robot acts as an EtherCAT Slave; i.e. communication to the Beckhoff controller takes place over EtherCAT. The seamless integration of the robot kinematics into the controller not only eliminates an additional robot CPU, it also establishes optimum interaction and synchronisation with the PLC and the existing Motion Control functions: direct interfaces replace the complex communication between different controllers and systems. This results in high performance and improved accuracy.

PC-based Control: One control platform for the entire production line



PC Control
for press cells
including
communication to
robots

Transport/handling



PC Control for transport/ handling including pick-and-place robot

Feeding/packaging

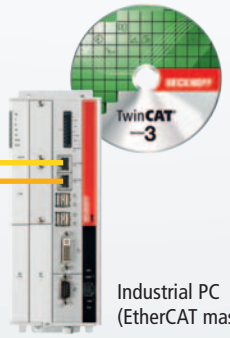
Packaging

PC Control for filling cell including communication to robot and XTS

EtherCAT – Ultra fast process communication for robot controllers

EAP (EtherCAT Automation Protocol)

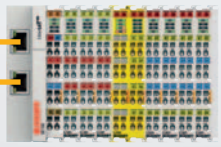
Direct Control of robot kinematics



TwinCAT NC I,
Kinematic
Transformation

Industrial PC
(EtherCAT master)

EtherCAT



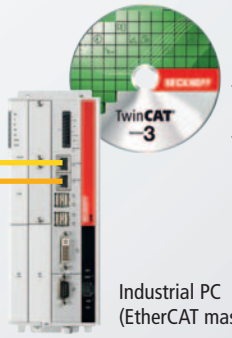
EtherCAT Terminals (IP 20)

EtherCAT Servo Drives

EtherCAT Box
(IP 67)

6-axis articulated robot

Direct control of robot and XTS



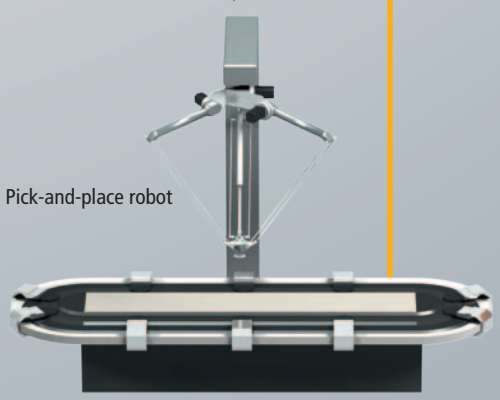
TwinCAT NC I,
Kinematic
Transformation

Industrial PC
(EtherCAT master)

EtherCAT

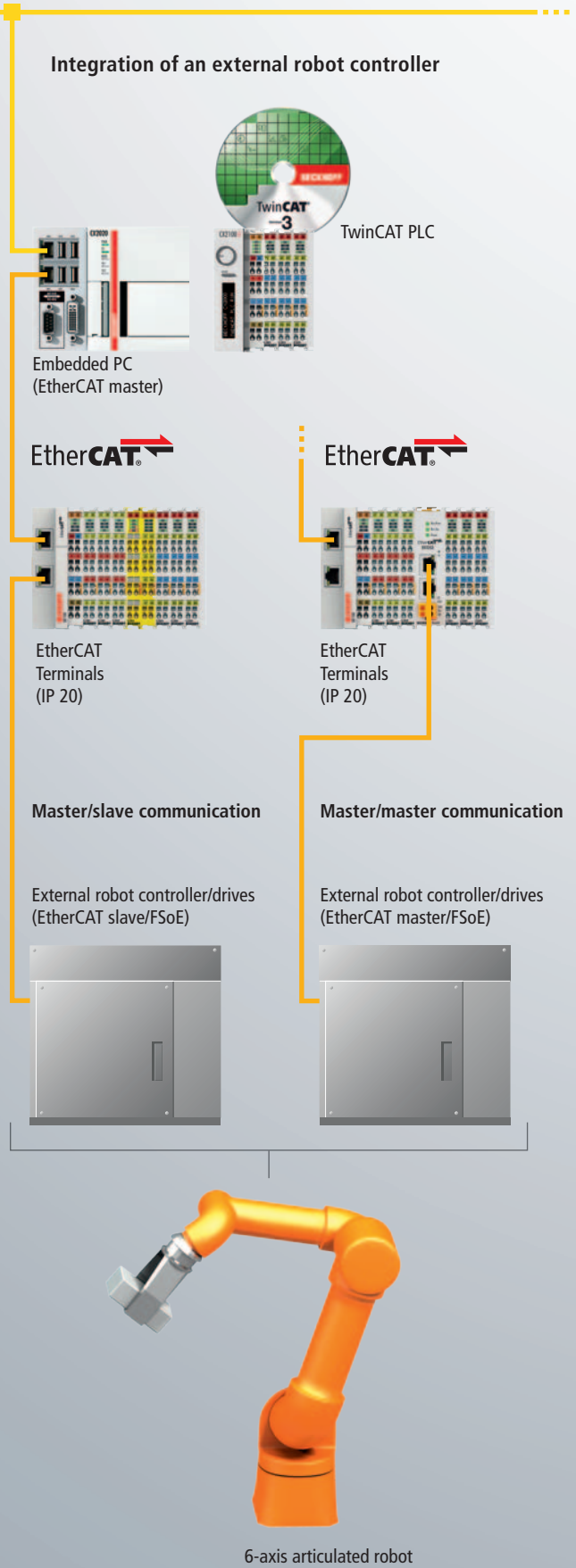
EtherCAT Terminals (IP 20)

EtherCAT Servo Drives



Pick-and-place robot

XTS (eXtended Transport System)



Direct control of robot kinematics
With TwinCAT Kinematic Transformation (TF511x) various robot kinematics can be controlled directly from TwinCAT. The path planning and kinematic transformations for this take place directly in TwinCAT.

As a result, no special external robot controller is required in order to control a SCARA or a 6-axis articulated robot, for example. A large number of kinematics is already available. The integration of further customer-specific mechanical constructions is also possible. The development of customer-specific transformations and models guarantees the protection of know-how.

Pick-and-place movements can be programmed directly from the TwinCAT PLC; various time-saving libraries are available for this. Path movements are implemented with TwinCAT NC I according to DIN 66025, i.e. contours are described that are run by the robot.

Direct control of pick-and-place robot and XTS
One CPU for everything: TwinCAT controls the XTS and at the same time a delta robot. In TwinCAT the user has an all-in-one programming environment for controlling the entire plant. Cycle times are optimised because complex communication between different controllers is a thing of the past. Various robot kinematics are supported.

Integration of external robot controllers in TwinCAT
TwinCAT PLC (TC1200) is the basis for the control of a 6-axis articulated/SCARA robot. The travel commands for the robot are sent directly to the robot controller via the PLC. The measured values of the robot are then sent to the PLC.

In mxAutomation KUKA Robotics offers a defined interface for commanding the movements of the robot directly from TwinCAT PLC. To do this, a PLC library is integrated which, based on PLCopen Part 4 (Coordinated Motion), communicates directly with mxAutomation from KUKA via EtherCAT.

Interfaces to other robot manufacturers are in preparation. For the user this variant is also advantageous because learning a special robot language is no longer required since everything can be programmed via PLC modules. The entire operating philosophy is independent of the robot manufacturer. The robot can thus be set up with the aid of TwinCAT PLC. Path points can be programmed and run subsequently.

Control communication with the EtherCAT Automation Protocol
The horizontal communication between robots and machines or a connection to a central host computer can be carried out very efficiently with the EtherCAT Automation Protocol (EAP). EAP enables real-time communication – even every millisecond. It uses a conventional Ethernet infrastructure and can thus be transmitted via any Ethernet medium and also via radio.

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