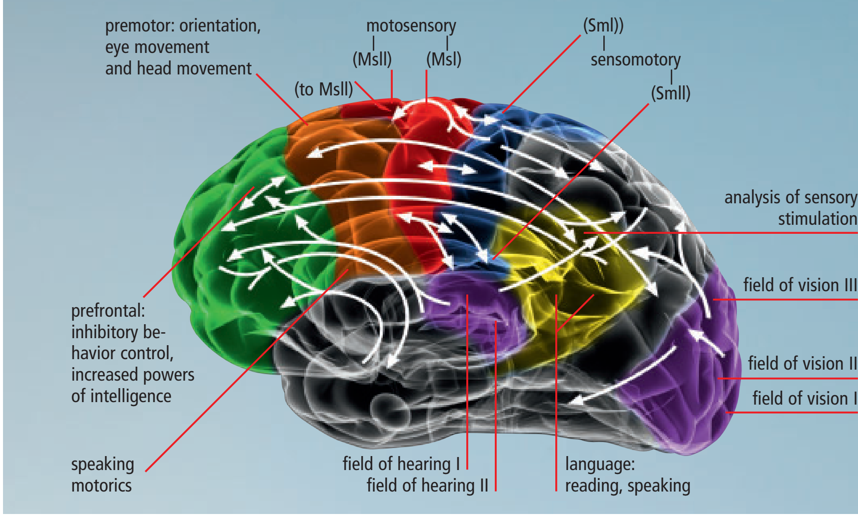
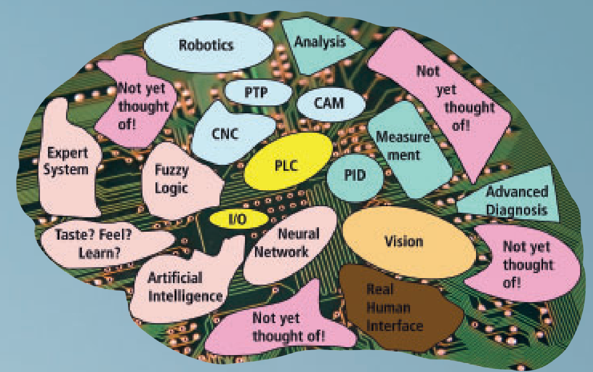
Condition Monitoring and Robotics become an integral part of PC-based control

Additional solutions for Scientific Automation

The concept of Scientific Automation is being constantly pursued and advanced with innovative hardware and software products. Additional solutions were presented at Hanover Fair 2009. Various new EtherCAT Terminals expand the Beckhoff system with high-precision measurement technology and Condition Monitoring. With TwinCAT Kinematic Transformation software, robotics also becomes an integral part of the PC-based control solution from Beckhoff.





Functions for Scientific Automation: The separation into areas of the functions of an automation task is comparable to the illustration of separate function areas in the human brain. This corresponds to a central control technology with optimal, fast communication between the individual technology components.

The power of the PC Control philosophy offers sufficient capacity to integrate numerous advanced functions beyond standard control. Scientific Automation complements the conventional areas of control technology such as PLC, Motion Control and control technology, for instance, with precise and fast measurement technology and the associated engineering algorithms.

The Beckhoff PC-based control technology provides the necessary basic foundation with powerful CPUs, fast I/O, the fast EtherCAT bus system and TwinCAT software.

The concept of Scientific Automation serves as the prerequisite to enable functions such as Condition Monitoring or robotics for a wide range of PLC programmers in a familiar format. The aim is to integrate the functions from the traditional "black box" into a standard PC-based software environment.

Since machine concepts will undoubtedly change in coming years, Scientific Automation is reaching out even further to the future. Developing trends are moving towards increasingly complex PLC programs and ever shorter cycle times. The number of axes to be controlled synchronously will increase further, and the type of coupling between the axes will become more complex. Moreover, the number of electronic cam plates and electronic gearboxes will increase. In the future, many axes will be operated based on interpolation. However, in a few years' time, an advanced CPU will easily be able to cope with this. Integrated vision and robotics systems are implemented in software. With sufficient CPU power, advanced and familiar control algorithms – such as neural networks – may become suitable for industrial applications. However, more complex machines require more diagnostics and maintenance. More advanced systems with sophisticated diagnostics will make life easier for the end user. New input and output options such as voice input will simplify machine operation.

Another developing area is artificial intelligence. Until now, no intelligence to equal human intelligence has been replicated. It might certainly be possible to come closer to achieving this dream in the future with several cores and extreme computing power. In future computer generations, gestures, voice and image recognition procedures will be able to access terabytes of local data and at least provide support as highly sophisticated systems. In industry, this can be used for improving process operation, more human interaction, faster troubleshooting and ensuring product quality. Each system component or machine module could be allocated to a core, so that parallel processing with high clock frequencies might become possible.

Scientific Automation from Beckhoff is available in products in real terms and offers enough further potential for future developments and visions.

Scientific Automation is the integration of automation software with findings from engineering science which go beyond the limits of conventional control. The basis for this is the continually increasing performance of PCs.

www.beckhoff.com/Scientific-Automation

Scientific Automation:
full utilization of PC capacity

In the interview, Dr. Josef Papenfort, TwinCAT Product Manager and Michael Jost, EtherCAT Product Manager, give an overview of new products and the next milestones in Scientific Automation.

From the "black box" into the PC

What does Beckhoff mean by "Scientific Automation?"

Josef Papenfort: Scientific Automation is the integration of findings from engineering science into automation software. With PC Control, Beckhoff has a very powerful control platform that offers ample space for this integration, above all with a view to the future, with even more powerful processors.

Even now, PC Control is based on the most advanced processor technology: currently quad-core technology and, in the near future, octa-core architectures. By means of the continual increase in power, the control is no longer utilized by PLC applications alone. This means that the control has sufficient resources which exceed those required by traditional applications such as PLC, NC and CNC. Additional functions for the single CPU solution can be measurement technology, Condition Monitoring, robotics or the integration of vision systems. We have already presented the first of such solutions. With increasing system performance, further functions such as expert systems or neural networks will follow.

What advantages does the integration of measurement technology and robotics into PC Control offer?

Michael Jost: Traditionally, special functions for measurement technology, image processing and robotics are implemented in separate CPUs. The functionality is either distributed in the field or handled in the PC via plug-in cards. Only the concentrated data are transferred to the central control system. Traditionally, pre-processing takes place in the 'black boxes' and cannot be changed as a rule. If the special functions are implemented on a platform in software, there is no friction loss and the programmer can develop all the functions on a platform in a familiar environment.

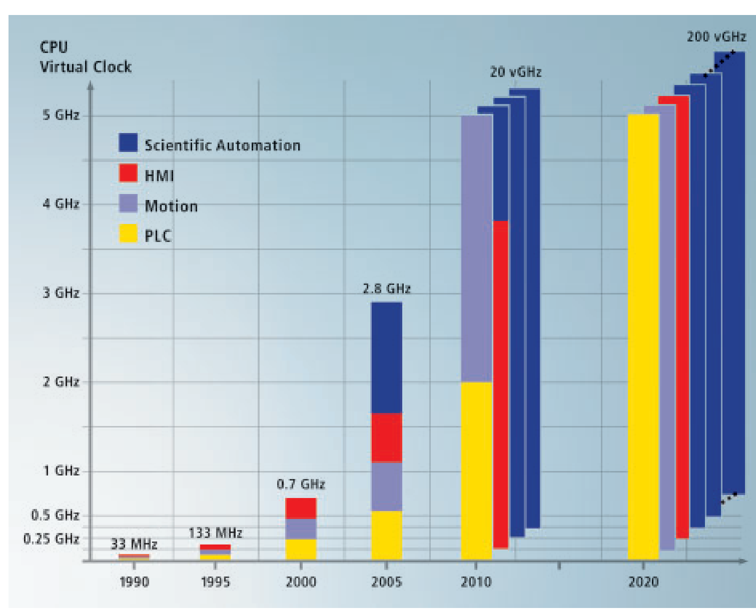
Measurement technology

How is PC-based measurement technology integrated in the overall Beckhoff automation concept?

Josef Papenfort: Measurement technology is a key component of an automation system. Only integration in a CPU enables all functions of a measuring system to be utilized optimally. Measured data can already be transported to the central PLC via a high-performance fieldbus. A number of PLC libraries with different filters and controllers are already available for this purpose and are utilized extensively by customers. EtherCAT facilitates high-precision measurements in order to obtain measured values in the PLC quickly and with precise time stamps.

Beckhoff defines extremely fast control technology based on PC Control, EtherCAT and fast I/O with XFC (eXtreme Fast Control technology). What do these new options mean for Scientific Automation?

Michael Jost: Ultimately, XFC (fast communication and the acquisition of measured data) is the basis for highly accurate, precise measurement technology. This wide range of communication options and controller computing power are only made possible by this technology, which in turn enables the integration of advanced measuring functions.



PC-based control offers ample power reserves for Scientific Automation. The 'Virtual GHz' unit serves to compare single-core and multi-core processors simply. A quad-core CPU with 2.5 GHz would therefore have 10 vGHz with four processor cores.

Dr. Josef Papenfort is TwinCAT Product Manager at Beckhoff.

Michael Jost is EtherCAT Product Manager at Beckhoff.

High-end-measurement technology through XFC
- Standard I/O replaces expensive special local controllers.
- Standard I/O replaces expensive measurement technology interfaces.
- Measurement technology in an integrated control system, no separate system required
- Condition Monitoring with standard control system

What functions do Beckhoff's I/O systems offer for Scientific Automation?

Michael Jost: The Bus and EtherCAT Terminal systems provide many terminal types and variants for standard measurement technology. Current/voltage, energy, temperature, pressure, frequency, position or even the new digital multimeter in Bus Terminal format. The EtherCAT Terminal system is primarily designed for high-end measurement technology. It combines the highest performance with the highest possible accuracy.

An example of high-precision analog technology is the EL3602 input terminal for voltages from -10 to +10 V. The voltage is digitized with a high resolution of 24 bit. The high precision of 0.01 % at 25 °C enables the execution of high-precision measuring tasks, at a machine or for test rig automation, for example. The seamless integration of measurement technology into the automation solution makes specialized modules unnecessary. These functions for high-precision measurement technology are also available in IP 67 format in the new EtherCAT Box modules for harsh environments.

What additional I/O solutions are to follow?

Michael Jost: We will expand our series of 24-bit terminals, for example. With these we will be offering the precision required by the quality departments of production areas. For if you intend to guarantee a certain class of quality, the precision of your measurement technology must be at least a class higher. This applies both to measuring physical quantities via strain gauge, temperature or vibration sensors and the dimensional measuring of material thickness or spaces for example, as well as to measuring electrical quantities, for example of voltage values. Besides increasing measurement accuracy and speed for standard signals, it will be possible to measure other physical quantities with our terminals in the future. The calibration capability of the terminals for special areas of quality assurance will also grow in importance.

How much "Scientific Automation" is there in TwinCAT already with regard to measurement technology? What libraries and tools are available? What is planned?

Josef Papenfort: All the main standard filters and controllers are already implemented in the TwinCAT Controller Toolbox. These can fulfill many measuring tasks. On the data display side, TwinCAT Scope 2 has already implemented all the necessary functions. Processes can be recorded very accurately in terms of time with the Scope and conveniently stored as well. Additional, higher-class filter algorithms are to follow in the next phase. In the future, we will offer even better integration of tools such as LabView and Matlab/Simulink.

TwinCAT is closely based on the IEC 61131-3 standard, also known as the PLC programming standard. Does TwinCAT offer sufficient 'degrees of freedom' to incorporate Scientific Automation with high-end measurement technology?

Josef Papenfort: IEC 61131-3 merely defines a model, an architecture and the languages. It does not define any functions. This means that a fast Fourier transform algorithm can be included both in the IEC standard and in the programming language C. Accordingly, these two worlds, automation and measurement technology, do not contradict one another. The integration of a C++ algorithm for a particular filter will be simpler in the next TwinCAT version.

TwinCAT Scope 2

TwinCAT Scope 2 enables the full utilization of the graphics features of the newest PC generations. TwinCAT Scope 2 combines fast data logging with a fast graphic display tool. The logger can process both long records and very fast cycles, including those from oversampling terminals, and make them available to the viewer part of the Scope. A large number of curves can be illustrated and precisely defined in time terms in the viewer. Different interfaces enable Beckhoff customers to use parts of the Scope directly in their application.

Hanover Fair 2009: Condition Monitoring solution with EL3632 EtherCAT Terminal

Condition Monitoring

Condition Monitoring will also become an integral part of PC-based control with the new EL3632 EtherCAT Terminal. What advantages does this offer the user?

Michael Jost: Our solution permits the integration of Condition Monitoring functions into the machine at little extra cost. The EL3632 is the first step towards integrating Condition Monitoring functions into the Beckhoff controller. Condition Monitoring is becoming increasingly important in machine design and plant engineering as a means of avoiding downtime and prolonging maintenance intervals. Customer demand together with the new possibilities offered by EtherCAT prompted us to develop the terminal. The EL3632 enables the direct connection of different accelerometers which usually have an IEPE/ICP interface. The data are recorded and transferred to the PC where they are evaluated, that is, the warning and switch-off thresholds are set. The data can then be further processed in the PC either as a complete solution with TwinCAT libraries or through the assessment of the raw data via the user's own evaluation. The fact that the information is available on the central controller and can be evaluated there accordingly is the most important aspect.

How does this differ from solution concepts offering Condition Monitoring analysis up until now?

Michael Jost: Until now, special, proprietary systems were required for Condition Monitoring which could only be used for this function. By integrating Condition Monitoring into the EtherCAT Terminal system it becomes an integral part of PC-based control technology, providing high-class added value.

Josef Papenfort: With many of the approaches until now data are processed directly on-site. Only 'defective' or 'non defective' binary information is given or shown via LED display. Further processing of the measured values is impossible or only possible via very complex means. Correlating the recorded data with other signals such as temperatures or pressure is not possible. However, in many cases, this correlation is necessary for sophisticated applications. For this reason, in Beckhoff's solution, all the raw data are transferred by EtherCAT to the PC where they are processed by the software in the TwinCAT system. The Condition Monitoring solution is supported by corresponding TwinCAT libraries: for example, by a library with top-quality filters or fast Fourier transform. TwinCAT Scope 2 is also being expanded for Condition Monitoring.

Robotics

A TwinCAT robotics module was presented for the first time at Hanover Fair 2009. What were the reasons for developing this software?

Josef Papenfort: The main reason was to integrate independent robotic cells into the production process, that is, to cut down on external robot CPUs in order to improve integration and optimize costs. So in other words, it is intended to pursue the concept of Scientific Automation consistently. Our customers want robots to be integrated into the existing TwinCAT platform in order to cut down engineering costs. This means completely integrating configuration, programming and diagnostics into the TwinCAT system. The application and product are improving in qualitative terms because friction loss, which occurs when different CPUs for PLC, motion and robots interoperate, can be avoided.

What are the application areas for TwinCAT Kinematic Transformation? What are the highlights of this new solution?

Josef Papenfort: Kinematic Transformation for TwinCAT has primarily been developed for pick-and-place applications. We have succeeded in making a PLC, a Motion Control system and a robot run in synch on a PC-based CPU. The advantage is the integration of the robot kinematics into the existing program, in other words, complete control on the 'normal' control PC. The synchronization of the robotics with the existing Motion Control blocks in TwinCAT NC PTP and TwinCAT NC I is particularly interesting. Any of the NC PTP features such as cam plates, flying saw and NC I can be combined as desired. The simple programming is a great advantage as well. The target coordinates are programmed conveniently in the Cartesian coordinate system. Conversion to the corresponding motor positions (reverse transformation) is done by the kinematic module. In addition, the dynamic model for torque precontrol can be calculated.

Outlook

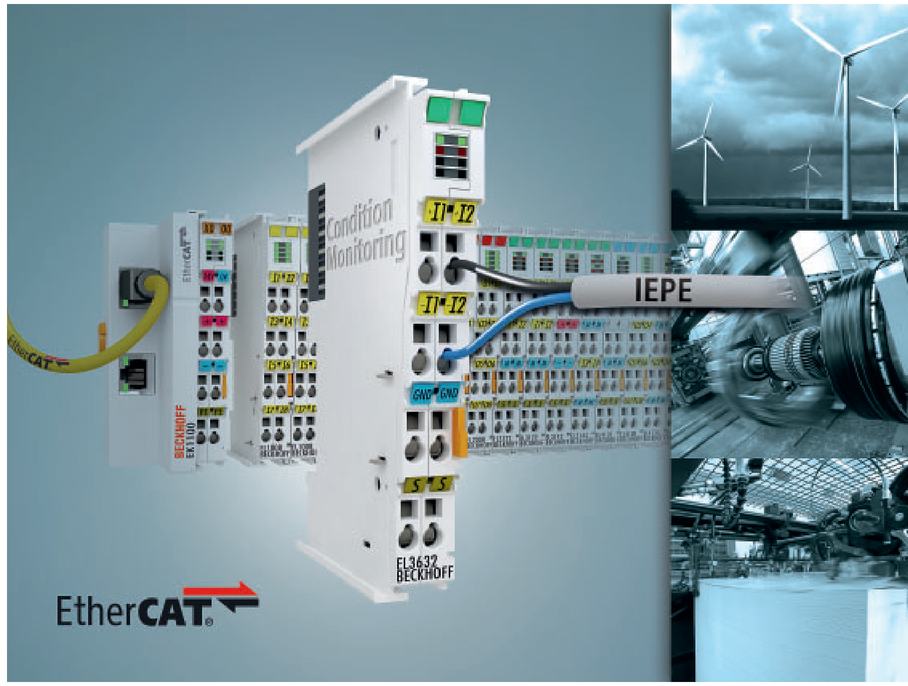
What are Beckhoff's next steps in the field of Scientific Automation?

Michael Jost: We will implement the new options offered by XFC technology in I/O hardware and extend the possible uses of our system in higher precision, speed or with new measuring signals.

Josef Papenfort: Our customers can still expect a great deal from Beckhoff in terms of Scientific Automation. Measurement technology and Condition Monitoring are areas we are continually expanding. A vision solution is also an indispensable component when using robots. This will be one of the next steps.

Scientific Automation: EL3632 EtherCAT Terminal records status data via IEPE accelerometers

Condition Monitoring functions can be integrated simply and cost-effectively into the EtherCAT I/O system from Beckhoff using the EL3632 EtherCAT Terminal. For the user, this means: no additional hardware, optimum integration into the control system and considerable cost reductions. The signals are analyzed on the PC using either TwinCAT automation software or user software. The EtherCAT real-time Ethernet system offers the ideal network for high-performance communication of all measured data back to the PC.



Condition Monitoring functions can be integrated simply and cost-effectively in the PC-based control system using the EL3632 EtherCAT Terminal.

Condition Monitoring: an integral part of PC-based control

Condition Monitoring systems for tracking the status of a machine or plant undoubtedly help reduce downtime and maintenance costs. To this end, the ever-changing physical variables such as vibration and temperature are measured on the machine. The EL3632 EtherCAT Terminal enables the direct connection of various accelerometers via an IEPE (Integrated Electronics Piezo-Electric) or ICP (Integrated Circuit Piezoelectric) interface. These sensors record vibrations in a machine, bearing or motor so that, by means of analysis, wear and damage can be detected before a breakdown occurs, avoiding unplanned downtime or prolonged maintenance intervals. A central, PC-based controller here is advantageous, particularly if large amounts of data from different devices need to be referred to for analysis or if damage frequencies need to be evaluated in relation to rotary speeds.

Condition Monitoring becomes an integrated part of the controller when using the EL3632. The data is recorded by the standard I/O system and made available to the superordinated PC controller. The measurement signals are evaluated on the PC using a TwinCAT library or user software; the warning and shutdown thresholds are set accordingly. Adjustable filters and supply currents for matching various sensors enable the user-specific adaptation of the Condition Monitoring terminal.

Through interfacing via EtherCAT and support of the distributed clocks function, the measurement results – and any detected defects – can be precisely allocated to an axis position. In this way, the user knows what is happening at each axis position on the machine. By matching positions to acceleration values, conclusions can be drawn about possible sources of error. On the software side, the EL3632 is supported by various TwinCAT libraries, e.g. with high-quality filters such as FFT (Fast Fourier Transformation), digital high-pass or low-pass filters, or envelope monitoring. TwinCAT Scope is also being expanded to include Condition Monitoring functions.

The EL3632 Condition Monitoring terminal is easy to integrate in the control system and is easy to retrofit. Its range of applications is extremely versatile, extending from mechanical engineering and process technology to status monitoring in wind turbines.

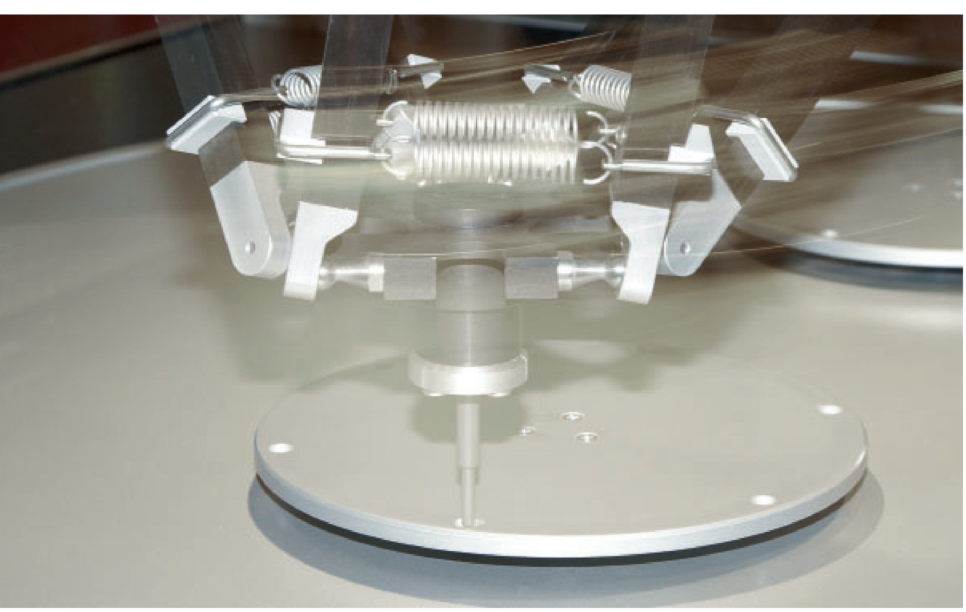
Traditional Condition Monitoring systems are expensive, constructed as separate hardware devices and need to be coupled elaborately with the automation system. Other solutions merely report the respective operating status without supplying detailed information to the controller. In EtherCAT, a capable communication system is available for the high-performance relaying of the recorded status data to the PC controller. The "Scientific Automation" concept is applied on the central PC: besides sequential control, Motion Control and HMI, TwinCAT also integrates additional functions such as Condition Monitoring on a software and hardware platform. In addition to the perfect integration of all components and the reduction of hardware costs, engineering efforts are also greatly simplified: configuration, programming and diagnostics take place on one system using TwinCAT.

www.beckhoff.com/EL3632

Robotics integration in TwinCAT enables optimum synchronization between robots and standard Motion Control

TwinCAT automation software now permits the integration of robots (delta kinematics, SCARA) as well as their interaction and synchronization with existing Motion Control functions. This results in seamless integration into the overall control system and being able to dispense with additional robot CPUs. The PC-based controller from Beckhoff unites PLC, Motion Control and robotics all on one hardware and software platform.

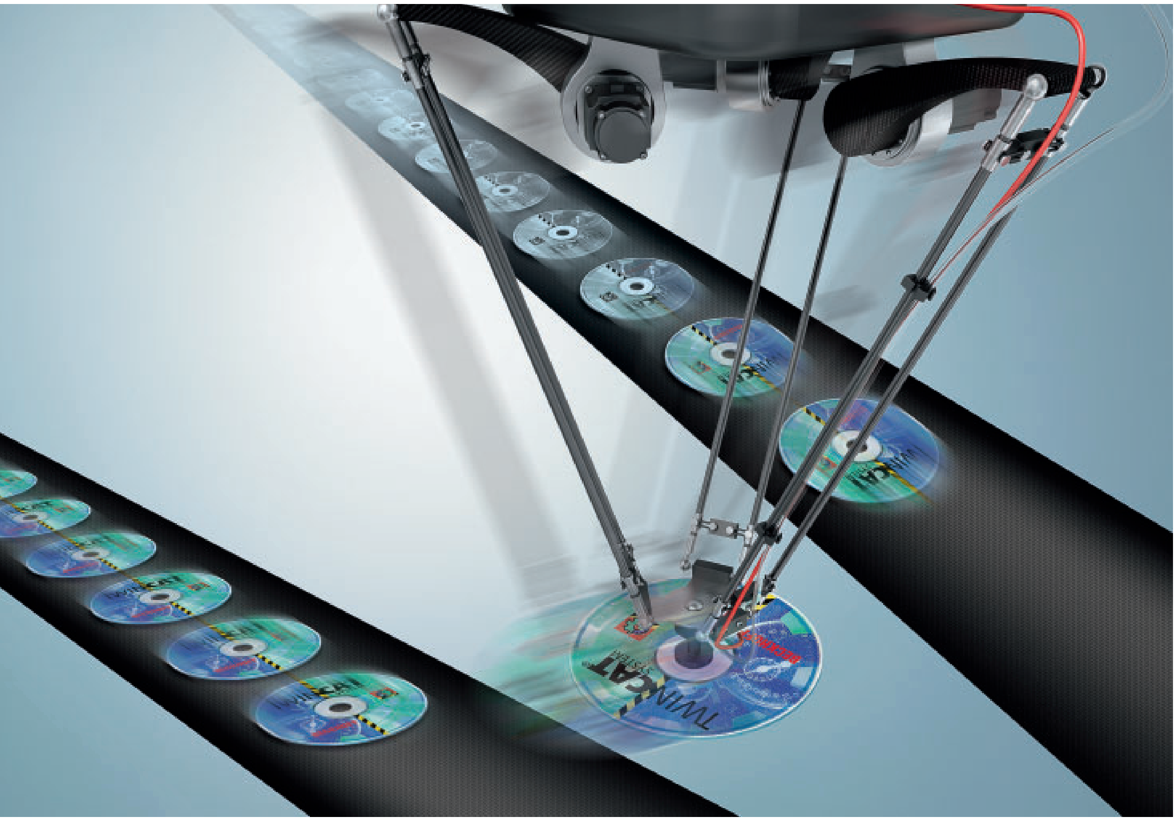
Robotics, Motion Control and PLC on one PC platform



New: robot integration in TwinCAT enables optimum synchronization between robots and standard Motion Control.

"TwinCAT Kinematic Transformation" software is the first step toward integrating robot control into the TwinCAT automation software suite. The PLC, Motion Control, HMI and robotic functions run on one powerful Industrial PC CPU. This provides the user with a whole series of advantages:

- eliminating the additional CPU required for robot control
- reduction in engineering costs: configuration, parameterization and diagnostics in one system
- TwinCAT, a well-known tool that adheres to global standards for configuration, programming and diagnostics
- no friction losses due to the interaction of various CPUs for PLC, motion and robotics
- Higher performance and accuracy due to direct interfaces; complex communication between CPUs is no longer required.



"TwinCAT Kinematic Transformation" for pick-and-place applications; robotic and Motion Control functions can be optimally synchronized using TwinCAT NC PTP or NC I.

TwinCAT Kinematic Transformation integrates itself transparently in the existing Motion Control world: robotic and Motion Control functions can be optimally synchronized 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" (synchronization of a slave axis with a moving master axis) can be combined as desired on a common hardware and software platform.

TwinCAT supports various parallel and serial kinematics, such as those used for pick-and-place tasks. Regarding programming, the software is based on TwinCAT NC I and G-Code (DIN 66025). The target coordinates are programmed conveniently in the Cartesian coordinate system. The Kinematic module takes care of conversion to the associated motor position (reverse transformation). In addition, the dynamic model for torque pre-control can be calculated.

The kinematic system can be selected conveniently in TwinCAT System Manager. The kinematic channel is used to parameterize the type (e.g. delta), bar lengths and offsets. Mass and mass inertia values can be specified for dynamic pre-control. The "flying saw" and "cam plate" functions enable robot synchronization with conveyor belts for picking or placing workpieces, for example. These applications are met frequently in the material handling and packaging industries.

www.beckhoff.com/kinematics