The concept of fieldbus-independent I/O systems has proven to be reliable and offers maximum flexibility for the user. The extension of the fieldbus range for the Bus Terminal system now also enables the integration of AS interface components. All functions of the AS-i master are implemented in the new KL6201 Bus Terminal.

Modern wind power converters possess complex electronic control instrumentation that looks after the operation of the plant, including remote data monitoring, as well as the feed to the power grid. For its new D8 type wind power plant, the German company DeWind AG uses a new PC-based control concept from Beckhoff.

With the modular CX1000 Industrial PC, Beckhoff presents the corner stone of a new control generation. With all common PC and fieldbus interfaces, the Industrial PC for top-hat rail mounting offers a wide variety of industrial application options. With TwinCAT CE in combination with Windows CE.NET and Windows XP Embedded, the CX1000 becomes a powerful PLC and NC controller.
The "changing world", globalization and internationalization are often used as buzz words for expressing that existing limits and structures are being changed, broken or removed.

What effects does this process have on the automation industry? What opportunities and risks does the globalization of the markets bring? How does one react to the new underlying conditions and how does one position oneself for the future? All these are questions that international automation companies have to face. The transformation of the world also means a transformation of the markets: Worldwide, users require automation technology to locally provide products, technical know-how, technical service and spare parts. For the manufacturers of automation systems this is a challenge, but at the same time an opportunity to open up new markets and to demonstrate worldwide presence.

In the 1980s, Beckhoff's main activity was the implementation of innovative ideas for control solutions in development projects for German machine building customers. In the early 1990s, a tight-knit distribution network within Germany and subsequently – in Europe was established. At the end of the 1990s, Beckhoff conquered the international market. The fast and – compared with the competition – over-proportional growth of the company made this development appear to be inevitable. Internationalization applies both to users and to suppliers of automation systems: a presence on the worldwide market is imperative. The early recognition of future opportunities offered by PC control and innovative automation components based on international standards not only turned out to bring significant benefits for the users, but also established the competitive advantage of Beckhoff on national and international markets.

Past milestones of the international outlook was the establishment of Beckhoff subsidiaries in the USA, Switzerland, Austria, Finland and China as well as the formation of carefully selected, powerful distribution partnerships on all five continents. Beckhoff is now successfully represented in over 30 countries and, as one of the few suppliers of PC-based control technology on an international level, provides a reliable local service in the areas of customer care and advice, sales, support and training. Through direct and intense communication with the Beckhoff company headquarters in Germany and effective exchange of information and training, the Beckhoff subsidiaries and distributors are well equipped to be reliable and competent local partners for our customers. PC Control is thus successfully establishing itself worldwide in all types of industries, e.g. the automotive industry in Brazil (p. 40), in the semiconductor industry in the Netherlands (p. 42), in handling systems in Switzerland (p. 60) or flexible manufacturing systems in Finland (p. 64).
Over the last 5 years, Beckhoff rapidly established an international distribution network. This will continue to be the aim over the next few years. The plan is to be present in about 50 industrialized countries around the world. The export ratio of currently approximately 35% is intended to grow to 50% over the next few years, with simultaneous growth in the domestic market. The intention is to reach these goals through expansion, innovative new products such as the new modular CX1000 Industrial PC (p. 6), and based on a partnership with our customers.

One of the aims of the PC Control company magazine, of which this is the 3rd issue, is to inform about the latest foreign developments from Beckhoff and about worldwide automation technology applications. I hope you will enjoy this issue of the PC Control magazine.

Kai Ristau
Export Manager
6 | title
CX1000: Modular Industrial PC for mid-range control engineering

15 | Beckhoff expands the fieldbus range:
New AS-i master for Bus Terminal System

27 | application notes
External temperature measurement via fieldbus

10 | products
CP6000 Control Panel: Built-in-display offers almost unlimited control options

12 | TwinCAT CAM Design Tool:
Motion design in software PLC/SNC

18 | Motion control blocks according to PLCopen standard

22 | 8-channel Bus Terminals provide higher packing density

23 | High precision drive synchronization with CANopen

30 | applications
Hayes-Lemmerz has the most advanced wheel production facility in the world

34 | A new controller concept for wind power converters from DeWind
Beckhoff North America goes direct

Innovative engine production at DaimlerChrysler

Beckhoff control system monitors new ASML wafer production units

Flexible building automation with the Beckhoff automation kit

PC technology supports new approach for knife grinding from Knecht

TwinCAT as a basis for Manufacturing Management Systems

Producing flexibly and in mixed mode: DaimlerChrysler uses FMS from Fastems

Beckhoff technology for Finnish automation customers

A series of seminars on PC Control in Thailand and Singapore

Versatile testing methods are given a flexible implementation

Austrian branch becomes Beckhoff Automation GmbH

Austrians rely on Beckhoff technologies

Guédel uses Beckhoff technology for transfer and handling systems

Guédel: Innovative solution with Windows NT Embedded

Strategies for the future: Ronald Heinze interviews Hans Beckhoff

Growth through innovative automation know-how

Trade show dates 2002

Contact
As one of the highlights of the Hanover exhibition 2002, Beckhoff are presenting the foundation stone for a new generation of controllers: the CX1000, a modular, top-hat rail mounting, small-format Industrial PC. The features of the device are nothing short of astonishing. In combination with embedded operating systems such as Windows CE.NET and Windows XP Embedded working together with the Beckhoff PLC/NC software TwinCAT CE, the range of its industrial applications can only be guessed at.

CX1000 – the multi-talented top-hat rail performer

The price/performance ratio of the CX1000 places it at the “golden mean” of the Beckhoff controller spectrum. The general design approach is appropriate for the band above the Bus Terminal Controllers (BCs) with integrated PLC functionality up to the powerful Industrial PCs, providing seamless scaling of the control technology. This applies in particular to applications, and indeed sectors, in which PC control technology may well have been desirable, but where in the past entry costs prohibited implementation with an Industrial PC.
This will now change, because one of the fundamental features of the CX1000 is its modular construction. The “X” in the name stands for a modular system from which only those components that are necessary for the particular application need to be selected. The time has now passed when a top hat rail-mounted PC brought every conceivable PC interface with it, whether they were wanted or not. The base unit, therefore, consisting of the computer core and the power supply module, is only given one Ethernet interface and one serial interface. This is frequently quite sufficient for applications in which the PC is needed as a processing unit, but which do not require a screen display. The Ethernet interface provides network capability, while anything that communicates via the RS 232 standard, such as modems, scanners or text displays, can be connected via the serial interface.

"Honey, I shrunk the IPC"

One of the rules that governed development of the new device can be seen even in the base unit: high computing power in the smallest possible space. The CPU module measures no more than 100 x 38 x 91 mm. In addition to the Ethernet and RS 232 interfaces that have already been mentioned, it contains the following: a Pentium MMX-compatible CPU clocked at 266 MHz, 16 Mbyte internal Flash memory for operating system and applications (can be expanded to 64 Mbyte), 32 Mbyte RAM (can be expanded to 128 Mbyte), a Compact Flash Type II slot for commercially available Compact Flash cards, presently available in sizes from 4 Mbyte up to 1 Gbyte. A 1 Gbyte hard disk of the IBM MicroDrive type, representing an economical alternative to the non-rotating storage media, also fits into this slot.

Five LEDs provide indications of power, 10/100 Mbit network speed, activity and access to the Compact Flash memory. The 24 V power supply provides voltage for the CX1000 modular system, and, at 100 x 39 x 91 mm, it is not much larger. It has 8 kbyte of non-volatile memory (NOVRAM) and an illuminated diagnostic LCD display with two lines of text, each of 16 characters. This display can also be accessed by user programs.

The Industrial PC “marries” the Bus Terminal

A special feature of the power supply unit is that Beckhoff Bus Terminals may optionally be connected directly to it. Their process image is made available to the CPU unit via a Dual Port RAM (DPRAM) interface, and this opens up the full variety of signals from electronic terminal blocks to the CX1000. Nor is there any obstacle to using the Terminal Bus Extension: it can connect up to 255 Bus Terminals, distributed over a wide area, to a CX1000 controller.

And as if that was not enough, the IP 67 extension modules from the Beckhoff Fieldbus Box family can, if desired, also be used alone or in parallel with the Bus Terminals. Data is transferred optically along the optical fibers of the Beckhoff IP Link system.

But the fundamental rule applies again here: I/O connections are only provided when they are wanted, because there are also simple versions of the CX1000 power supply units with only a 24 V DC inlet. If required, it is also possible here for I/O signals to be connected through the fieldbus connections offered by the CX1000.

The dimensions of the CX1000 system have been designed to harmonize with Beckhoff Bus Terminals: the height of the CX modules is exactly the 100 mm dimension of the terminal, which simplifies physical placement and the arrangement of the top hat rails in the control cabinet. The small dimensions and the recessed connecting areas of the CX1000 system allow it to be mounted in a standard terminal box with 120 mm height.

All standard PC interfaces are integrated

The modularity and flexibility of the system has also been carried through to the PC interfaces. If, for instance, a screen is to be connected, then the module with a DVI and two USB interfaces is required. A screen, or a Beckhoff Control Panel with a DVI input, can be connected through the DVI interface at a distance, depending on the resolution, of 5–7 m. The supported resolutions are 640x480, 800x600 and 1024x768 pixels. The devices that can be connected via the USB are familiar: mouse, keyboard, printer, scanner or another USB hub. This makes the
CX1000 into a device that can also be programmed at an office desk, particularly because its DVI interface can be used to operate an ordinary CRT monitor with the aid of a small, passive, adapter plug.

The configuration can optionally be extended by two additional RS 232 interfaces, or by an audio module: this offers a “Line In” signal input and a pre-amplified “Line Out” output that can drive headphones, as well as a microphone input. Ordinary, commercially available loudspeakers can also been driven from the Line Out connection. The multimedia capabilities of the CX1000 can be extended by the optional video-module. This has an S-VHS signal input (e.g. from a camera) and offers both an S-VHS signal output and a composite signal output (e.g. for a television).

An interface module for the insertion of modems and radio LAN cards in Compact Flash format is still under development. In the meantime, however, it is possible to work with the normal RJ45 interface, because radio LAN connections are already marketed for this. If the system interfaces and extension facilities described here are not enough, the entire world of PC104 modules is nevertheless open: an adapter housing allows the CX1000 to drive commercially available PC104 cards. With a spectrum that ranges from RS 485 cards through specialized digital and analog I/O cards up to frame grabbers, these offer everything required to make the user’s heart race.

Fieldbus interface as master or slave

Fieldbus connectivity is of course a “must” for industrial control. Appropriate modules are available as master or slave versions. Unlike the system interfaces, these can be added later in the field, so that the control system can be extended at any time. The ability of the CX1000 to act as a master in a variety of fieldbusses transforms it into a full Industrial PC controller capable of operating relatively complex or extensive machines and equipment. It is possible for a number of fieldbusses, whether of the same type or different, to be operated in parallel at the CX1000. A Profibus module and a CANopen module, for instance, could be connected simultaneously. This automatically creates a gateway functionality between differing fieldbus systems.

Windows CE.NET and TwinCAT CE as pacemakers

The CX1000 system can be supplied, if desired, with the Microsoft operating system Windows CE.NET (also known as Windows CE 4.0 or as Tallisker) pre-installed, and with TwinCAT CE PLC, the software PLC that can now lay claim to more than 10,000 licensed installations around the world on “larger” Industrial PC systems.

Beckhoff’s decision in favor of Windows CE.NET as the operating system for the CX1000 is based on the consistent application of Microsoft operating systems in the embedded controller sector. Because Windows CE.NET offers, by design, real-time capability with a resolution of 1 ms, TwinCAT can be ported without any special extensions to the operating system. Its low resources requirement of only about 8 MB Flash still leaves 8 Mbyte of the CX1000’s Flash memory free for TwinCAT. Internet Explorer 5.5 and a web, telnet and ftp server are included in the basic configuration. The Remote Desktop protocol allows a CX1000 device to function as a console for a Windows NT/2000/XP computer, either in the “Remote Desktop” mode or as a “Remote Terminal Client”. This is helpful whenever the CX1000 is used in a subsidiary role working under a central Windows-based controller. There are two basic ways in which a user interface can be programmed for the CX1000: one is to use programming interfaces (API) of Windows CE.NET via Embedded Visual C++ or Embedded Visual Basic, the other is to use a SCADA package. In the latter case,
Beckhoff offer an OPC Server for CE that uses a standardized approach to create the interface between TwinCAT CE and the SCADA package.

**PLC and Motion Control**

TwinCAT CE PLC makes the CX1000 into a powerful PLC with a runtime system that can handle up to four PLC tasks. All IEC 61131-3 languages are available: IL, FBD, LD, SFC and ST. Programming is carried out using precisely the same TwinCAT Tools as are used for the "large" Industrial PCs. The control programs are transferred over Ethernet. The application programmer can develop and test his sequential program with TwinCAT entirely on a PC, and can then download it to the CX1000 hardware without any change, or can simply plug it in as a Compact Flash card.

The CX1000 can, however, do more than just function as a PLC. If required, the user can also control electrical axes with TwinCAT CE NC, and so handle applications that require both features: PLC and Motion Control. Once again, programming and commissioning are carried out using the same TwinCAT programming tools (System Manager, Scope, Cam plate Editor) as are used on the normal Industrial PCs. The number of controllable axes depends on the overall configuration. It would, for instance, be quite possible to operate between three and five axes with a control cycle time of 2 ms in parallel with a PLC program. TwinCAT’s extended functions in the field of motion control, such as electronic gearings, flying saws and cam plates, are also available.

Thanks to the possibility of extending the internal RAM to 128 Mbyte, the CX1000 can also run the Microsoft Windows XP Embedded operating system. This does require a Compact Flash card or an IBM MicroDrive to be fitted as a substitute for a hard disk. While the increased equipment specification does push the cost upwards, it does bring the well-known advantages of a scalable Windows system: the latest desktop technologies, with Internet Explorer 6.0, full WIN32 API, XML Parser 4.0, IPv6 support, etc.. One of the most important reasons, however, for using XP Embedded is that existing WIN32 applications can continue to be used, and can run on a CX1000 with Windows XP Embedded without any modification.

**One programming environment for every controller level**

The list of software features makes it clear that the scalability of Beckhoff’s controller technology mentioned earlier is not provided by making the user’s life difficult. Whether we are dealing with a BC, CX or PC controller, whether it is small, medium or large scale controller technology, the TwinCAT programming environment is the same for every platform. In the CX1000, Beckhoff is offering a powerful controller with a software PLC and software NC running under Windows CE.NET or Windows XP Embedded. The modular architecture, the small dimensions, the versatile I/O connection facilities and the continuity of the TwinCAT programming tools add up to an extremely attractive device.

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Beckhoff estimate market release 3rd Quarter 2002.
Beckhoff have expanded their comprehensive CP7000 Control Panel family by a flat variant designed to be built into control desks, control cabinet doors and operating panels. The CP6000 series has been developed for application in rough industrial environments. Its front is splashproof according to protection class IP 65. The high-quality 10, 12 or 15 inch TFT displays offer uniform illumination with long service life. The Control Panel can be fitted with a touch pad or with a touch screen and can be used for display, monitoring or visualization tasks in production process. For the connection to the PC, the user has a choice: the inexpensive DVI/USB standard (CP68xx) is suitable for distances of up to 5 m. The CP-Link connection (CP60xx) is ideal for distances up to 100 m.

The built-in variant, like the CP7000 Control Panels for mounting arm installation, offers a wide variety of options, resulting in a very versatile and powerful operating unit. The optional extension modules are like building blocks. Not only the membrane keypad can be customized, but also the connection of handwheels, potentiometers, push buttons, switches, optical indicators or other components. This is achieved via the USB/CP-Link interface without additional wiring. Each variant thus becomes an optimized system.

Compact Industrial PC with integrated operating unit
The CP6300 and CP6500 add-on PCs can be used in conjunction with all types of built-in Control Panel to create Industrial PCs with screens. The large number of available Control Panels means that there are more than 50 versions of the built-in Industrial PC. On the CP6300 version a flat PC housing is installed behind the Control Panel. The PC can be equipped with Celeron or Pentium III up to 850 MHz on an all-in-one plug-in card motherboard with passive backplane according to the PISA standard. Two free slots are available. In addition to the floppy drive, a CD-ROM or CD-RW drive can be installed.

The CP6500 add-on PC variant is equipped with a 7-slot standard ATX motherboard and an Intel Celeron 700 MHz or Pentium III 850 MHz processor. All slots are designed for plug-in cards with a length of up to 190 mm.
Beckhoff Fieldbus Box: The Watertight Solution

IP-Link – the economic extension of the Fieldbus Box system

Nothing is more universal: The Beckhoff IP 67 modules consequently continue the fieldbus idea.
➔ Rugged – remote I/Os directly in the machine, without an enclosure
➔ Watertight – ideal for wet, dirty, and dusty industrial environments
➔ Small – extremely small, needs almost no space in the machine
➔ Open – all important fieldbus protocols are supported
➔ Modular – free mix of signals with extensions
➔ Fast wired – with pre-molded cord sets
➔ Flexible – also field wireable connectors available
➔ Very reasonable – low system costs due to fine granularity

For further information and international sales contacts see: www.beckhoff.com

The IP link system for resistant communication via „trouble-free“ optical fibre:
➔ Stackable – 120 Extension Box Modules (up to 960 I/Os) on one Coupler Box, any combination possible
➔ Versatile – digital I/O, ±10 V, 0...20 mA, thermocouple, PT100, counter, PWM, RS 232, RS 485, TTY, SSI, incremental encoder interface
➔ Connection types – plug-in connectors Ø 8 snap-in, M8 and M12 screw-in
➔ Fast – 2 Mbit/s transmission rate, (120 E-modules below 1 ms)
➔ Safe – integrated IP-Link diagnostic options allow precise fault locating

BECKHOFF New Automation Technology
The design of these flexible movements should be supported by comprehensive information about the dynamic parameters. The graphics options of today’s PCs are able to support the motion designer in such a way that he can concentrate on his tasks. Apart from the spatial conditions of the mechanisms, the dynamic aspects also play a significant role. The motion designer requires graphical output not only of the position, the velocity and the acceleration, but also of the jerk function and of the dynamic moment in a cam plate editor. Since normally more than one mechanism is involved, the simultaneous display of all cams plates including their derivatives in different colours in the same chart is very helpful.

The TwinCAT Motion Design Tool enables an increase not only of the machine performance. Interactive optimization also reduces the engineering effort to a minimum. PC-based control technology enables conventional mechanical cam plates to be substituted by software modules. Special components or the mechanical mainshafts for drive control applications are replaced by standardized hardware and software. The Industrial PC can coordinate and synchronize a nearly unlimited number of drives, via the leading axis. The design of this cam plate functionality, via freely scalable tables, is very complex, even with software-based controls. Graphical design tools such as Beckhoff’s TwinCAT Cam Design Tool for automation software makes the design process easier.

Increased performance and reduced engineering costs

**Motion design in software PLC/NC**

The term cam plate is usually used in the context of the implementation of complex movements when used to define mechanics. The term therefore also lends itself for electronic control units that realize such movements. Cams plates are used wherever particularly demanding movements are required. They are usually the part of a machine that determines its overall performance. They are often used in packaging, textile and paper processing machines, but also in feed units, cutting machines or other processing machines.

The design of cams plates is a complex procedure, giving the motion designer plenty of space for creativity. At the same time, it is constrained by hard physical boundary conditions.

The design of these flexible movements should be supported by comprehensive information about the dynamic parameters. The graphics options of today’s PCs are able to support the motion designer in such a way that he can concentrate on his tasks. Apart from the spatial conditions of the mechanisms, the dynamic aspects also play a significant role. The motion designer requires graphical output not only of the position, the velocity and the acceleration, but also of the jerk function and of the dynamic moment in a cam plate editor. Since normally more than one mechanism is involved, the simultaneous display of all cams plates including their derivatives in different colours in the same chart is very helpful.
Software replaces mechanical cam plate

The advantages of the electronic cam plate are simple mechanical structure (direct drive) and high flexibility. The conversion to a different format (product size) is done at the push of a button. Furthermore, events can be responded to during operation and the motion adjusted accordingly (flying saw).

The TwinCAT software PLC/NC has already been offering the option to realize complex movements available in tabular form within the NC. The PLC can control these multi-axis movements via the Motion Control components that are standardized within the PLCopen framework and implemented in TwinCAT as a library. Cubical Spline Interpolation is now also available as an option. Among other factors, it requires fewer interpolation points, whose number can be optimized through non-equidistant master positions.

TwinCAT Cam Design Tool

The Cam Design Tool now offers a user interface within TwinCAT for the comfortable design of these movements and for the check of existing ones. This check represents purely mathematical check (spline interpolation) of the set values (position, velocity, acceleration and jerk). The actual values can be checked with the TwinCAT ScopeView software oscilloscope.

Beckhoff’s expert for motion design

Dr. rer. nat. Wilfried L. Plaß studied physics at the University of Bielefeld and subsequently did a PhD in mathematics at the Freie Universität Berlin. He has since worked for a machine manufacturer, where he developed programs for the processing of non-circular workpieces (cam shafts, polygons or harmonic drives) on CNC circular grinding machines, he now works with cam plates and splines. Among other things, he developed a module, integrated into a CAD system, for designing cam plates, including a kinetostatic system for designing complete mechanisms more comfortably.

Since January 2001, he has been contributing his know-how to Beckhoff’s fundamental research department, where he is a driving force behind the company’s motion design efforts.
The full integration of the cam plate editor into the TwinCAT System Manager, (configuration center), offers a user interface for all configuration tasks and enables saving of the cam plate data in the configuration file. As a result, tables are automatically generated and transferred into the NC when the system is restarted. The transfer of the tables via ADS, the TwinCAT communications router, can also be initiated from the user interface. This will update the data in the NC.

In the cam plate editor, not only all motion laws (functions) of the proven VDI guideline 2143 are available, but also some additional functions, particularly cubic splines (natural, tangential and periodical).

Interactive optimization

During the design of a cam plate, initially points are placed within the chart to create a motion. The addition of further information, e.g. boundary conditions or motion laws, will transform it into a motion diagram, which is defined section by section. Points and thus sections can also be inserted or deleted afterwards. The values of the points can be entered or the type of the motion law changed in the table of motion sections.

The position values in the chart can interactively be moved horizontally or vertically. Other options include:

- for a section with constant velocity; the start or end point can be moved along the straight line, or the velocity adjusted through vertical movement;
- for "rest" type motion sections (velocity and acceleration at the point are zero) in reverse (velocity is zero); the acceleration can be directly manipulated in the chart;
- for a common point of two motion sections with a 5th (7th) order polynomial motion law; both the velocity and the acceleration (and the jerk) can be changed interactively.

Apart from the current motion diagram, the other diagrams belonging to a common master can also be displayed in the background, together with their derivatives. This enables the coordination of the slave movements.

The "floating sliding point" command is available for accurate synchronization. It can be used to attach the start or end point of the adjacent section to the current section in such a way that velocity and acceleration are automatically adjusted. Through horizontal relocation, the point can be moved flexibly within the diagram section. This enables synchronization with any given motion to be started and to be stopped again.

Using these interactive options, together with the simultaneous graphical check of the dynamic values via a chart, the motion designer can design optimum cam plates. Because fine-tuning is all-important! But the chances for a significant increase in machine performance are improved not only by the graphical check, but also through direct monitoring at the machine, with an improved version being loaded into the NC at the push of a button.

The motion designer thus has a tool available, with which he can solve demanding mechatronics motion tasks through skillful utilization and creative implementation, while respecting the motion-related interrelationships.

The Cam Design Tool is a graphic design tool for electronic cam plates that is integrated into the TwinCAT System Manager. Cam plates create the tabular position context between a master axis and one or several slave axes. The motion of the master axis determines the slave axis dynamics.

Characteristics of the Design tool:

- Interactive design according to VDI 2143 guideline
- Cam plates are defined as portions of motion sections (e.g. polynomial functions, harmonic functions, ...)
- Graphic and tabular display of the dynamic slave values (velocity, acceleration, jerk, dynamic moment)
- Interactive mouse-based editing of a curve with automatic calculation of the other curves (derivatives)
- Comfortable editing options (sector zooming, moving, overview, ...)
- Simultaneous display of all slaves associated with a master (including derivatives)
- Reading of existing tabular cam plates with subsequent calculation of the derivatives
- Tabular export of the cam plates to files or direct download into the real-time TwinCAT environment
- Saving of the cam plate data in the system manager configuration file, so that tabular data generated automatically during system start-up are loaded into the real-time environment
- Export and import of the internal data of a slave or a master with all its slaves in a temporary file to enable exchange between different project files
The concept of fieldbus-independent I/O systems has proven to be reliable and offers the user maximum flexibility in the choice of an appropriate data transmission medium. The extension of the fieldbus range for the Beckhoff Bus Terminal system now also enables the integration of AS interface components. All functions of the AS-i master are also implemented in the new KL6201 Bus Terminal.

Beckhoff expands the fieldbus range

New AS-i master for Bus Terminal System

With the new KL6201 AS-i master Bus Terminal, Beckhoff introduces a further fieldbus alternative for its versatile I/O system. The range of fieldbus systems connecting to AS interface is thus expanded to 13: Profibus DP/FMS, Interbus, CANopen, DeviceNet, ControlNet, Modbus, SERCOS interface, RS 232/RS 485, Ethernet TCP/IP, USB and the Beckhoff Lightbus.

In contrast to the existing fieldbus connections that are designed as Bus Couplers, the AS-i master version is integrated as a Bus Terminal, since nearly every AS-i system has an additional higher-level fieldbus. This means that only a single system, containing an AS-i interface and higher-level fieldbus circuit, is required.

All functions of the “classic” AS-i master are also implemented in the new KL6201 Bus Terminal. For example, the identification or address allocation of the up to 62 AS-i slave devices that can be connected either occurs automatically via hardware identifier through the AS-i master, or after parameterization through the higher-level control.

The KL6201 AS-i master Bus Terminal ideally combines the proven advantages of the Bus Terminal system and the widely used advantages of the AS interface systems, internationally standardized via IEC 62026-2:
The aim of the development of the AS interface, which started in 1990, was not a universal fieldbus for all areas of automation, but an economically sensible cabling system for the lower field level. The AS interface (AS-i) was developed for networking binary sensors and actuators, and for integrating them into the higher control level, offering simple and efficient installation with low connection costs. It is internationally standardized through EN 50295 and IEC 62026-2. The certification mark for the individual AS-i components from the AS International Association user organization guarantees full compatibility and comes with documented security. Checked and certified products receive the AS interface shadow logo and an associated test number. Components from 170 manufacturers worldwide can thus easily be mounted side by side.

Programming, configuration and data access of the new Beckhoff KL6201 AS-i master Bus Terminal is via the "normal" control process image. Excellent IEC 61131-3 components make access for novice users much easier. The handling via the TwinCAT programming environment is particularly comfortable due to the rapid integration via the System Manager.

The advantages of the DP-V1 services can be utilized in the Profibus environment. This leads to a relief of the cyclic data exchange in the Profibus and improves the integration into any open system. The new KL6201 AS-i master Bus Terminal thus becomes a significant component of a flexible automation solution from Beckhoff.
Fieldbus-neutral coupling

The new Beckhoff AS-i master Bus Terminal, a quasi-AS-i gateway, now provides a technically and economically convincing solution for coupling the lower level of industrial communication (sensor/actuator level) with any common fieldbus system (DeviceNet, Ethernet, Interbus, Profibus and others). Like the complete Beckhoff Bus Terminal I/O system, this coupling is independent of the fieldbus. The cost advantage offered by the combination of Bus Coupler and KL6201 AS-i master

Bus Terminal as a gateway to all common fieldbus systems is further improved by the option to use several KL6201 terminals with a single Bus Coupler. The fact that the gateway transfers the AS-i slave signals to the Bus Terminal I/O bus and vice versa makes the AS-i coupling fieldbus-neutral. Coupling of the AS-i slaves is thus ideally solved via Bus Terminals, because the use of the advantageous and robustly designed AS-i components has proved sensible particularly in harsh industrial environments (protection class IP 67).

AS-i-cable has proved useful for this purpose. Because the AS-i slaves are easy to install, only little prior knowledge is required, which reduces downtime in case of a fault. In order to avoid the error-proneness and associated delays during installation known from other systems, potential sources of faults were eliminated in the AS interface. One example for the implementation of measures to reduce the error rate is the reverse voltage protection through the profiled cable. Furthermore, individual messages are repeatedly checked for possible transmission faults. Any faults are rectified automatically. In addition to communication errors, the AS interface can detect peripheral errors such as short circuit, overload or missing auxiliary supply. Such faults are reported to the master and can subsequently be located precisely.

The AS interface system represents more an intelligent cabling system than a genuine fieldbus. It cannot and is not intended to replace more complex networks. The AS interface is a single-master slave system with cyclic polling. An AS-i network contains only one master and up to 64 slaves. Based on AS-i version 2.1, the master deals with signal polling, the transfer of parameter settings, network monitoring and parameterization and diagnostic functions. While the AS-i system has been expanded, a slave from the first generation will still work without problem in conjunction with the latest master. In the original AS-i specification, only 31 binary sensors could be used. In the meantime, the specification was amended, making networking of up to 62 subscribers (31 A-slaves plus 31 B-slaves) possible. Each slave has up to 4 inputs and 3 outputs, i.e. one AS-i line can have up to 248 inputs and up to 186 outputs. The AS interface also enables the transfer of analog values without problem. The data type (binary or analog) of the connected AS-i slaves is automatically recognized by the master without configuration software.

As the control module of the line, the AS-i master polls the connected slaves at precisely defined intervals. Each slave device recognizes the data bits sent by the master and returns its own data. In intelligent slaves, an AS-i chip is integrated in the sensor or actuator.

www.as-interface.com
Before IEC 61131-3 had set a standard for the programming of programmable logic controllers (PLCs), each supplier did their own thing, resulting in a large number of different programming languages. With IEC 61131-3 having been established worldwide, this problem has now been rectified: every PLC programmer knows how a TON timer function block works - and it works the same for all manufacturers who support the standard! However, the actual portability is not the main issue; the important point is the common language. Anyone who has mastered IEC 61131-3 will quickly find their way round programs from different manufacturers.

During recent years, IEC 61131-3 has significantly influenced and simplified PLC programming. The motion control standard developed by PLCopen is intended to have a similar effect for motion control applications. The first projects using the new blocks have now been realized.

Motion control blocks

Up to now, the situation for motion control systems was quite different. Motion control had always been a very proprietary matter of the individual motion control suppliers. Not only the hardware, but the software too was very different. End users who had to support several motion control systems were faced with significant costs for development and maintenance. In order to correct this disadvantage, PLCopen, the IEC 61131-3 user organization, brought into being a working group that has defined a standard for the programming of motion control systems over recent years. The appropriate task force has representatives not only from drive technology manufacturers, but also from manufacturers of programming systems and end users. Their common aim: the creation of a library of PLC blocks for the operation of axes from within an IEC 61131-3 program, so that PLC and NC functionality are available from a single programming location. This application programmer-oriented block set should be equally easy to handle and maintain and, moreover be hardware and manufacturer-independent. In terms of the specifications, this means: all blocks have identical software, regardless of what hardware behind them. The hardware can be a
products

An electronic gearbox ensures the synchronicity of the two drives. To optimize the processes, feeding and discharge of the parts has to be coordinated with the press - upward movement of the ram causes the feeders to be put in motion. An Industrial PC running the TwinCAT control software controls each press including hydraulic controllers and the associated feeders.

In this application, all motion control-specific actions are controlled via the motion control blocks according to the PLCopen specification: Even direction-independent enabling of the individual axes is carried out with the block MC_Power. Once enabled, the axes are moved via MC_MoveAbsolute, during their motion they are extended to the new target position according to the ram position, and stopped via MC_Stop in case of a fault. The electronic gearbox is realized via the blocks MC_GearIn and MC_GearOut according to the standard. Several blocks that are not contained in the standard but are based on it, supplement the implementation, for example a block written by Beckhoff especially for override modifications. The application could have been written using the proprietary blocks already available at Beckhoff prior to the PLCopen specification. However, for the first time the motion control blocks provided a standardized simple programming method. This meant that a lot of time could be saved even at the system programming stage.

The introduction of the motion control blocks at Müller Weingarten represents a resolute continuation of the standardization efforts of the press manufacturer. After the application of IEC 61131-3 approximately three years ago, the application of the motion control blocks according to the PLCopen standard was the next logical step.

Cam plates according to IEC 61131-3

A further application was realized at Molex in Singapore. Molex is the second largest manufacturer worldwide of plug-in connectors for the electronics industry. The technical requirements can be very precise and can only be met using in-house machine construction capabilities. First, positive experience with IEC 61131-3 using several prototype machines and the associated motion control blocks was gathered.

Overview of the motion control blocks according to the PLCopen standard.

Function Block Categories

<table>
<thead>
<tr>
<th>Administrative</th>
<th>Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Axes</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- MC_Power</td>
</tr>
<tr>
<td></td>
<td>- MC_Reset</td>
</tr>
<tr>
<td></td>
<td>- MC_Home</td>
</tr>
<tr>
<td></td>
<td>- MC_Stop</td>
</tr>
<tr>
<td>Single Axes</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- MC_Power</td>
</tr>
<tr>
<td></td>
<td>- MC_Reset</td>
</tr>
<tr>
<td>Multiple Axes</td>
<td>-</td>
</tr>
<tr>
<td>Multiple Axes</td>
<td>- MC_CamTableSelect</td>
</tr>
<tr>
<td></td>
<td>- MC_GearIn</td>
</tr>
<tr>
<td></td>
<td>- MC_GearOut</td>
</tr>
<tr>
<td>Non-Interpolated</td>
<td></td>
</tr>
<tr>
<td>Interpolated</td>
<td></td>
</tr>
</tbody>
</table>

First specification October 2001

Simultaneously with the publication of the first PLCopen document in October 2001, Beckhoff implemented the blocks in the shape of a motion control library for the TwinCAT automation software. The first applications of these blocks have been completed successfully. Two examples of applications with very different functions are described below.

The motion control blocks were first used at Müller Weingarten, an internationally operating supplier of metal forming equipment and systems. Their core business is the design, specification and equipping of press tools for the manufacture of body parts by the automobile industry and its suppliers. The specific application that was realized was the automation of a feed and discharge system for a press line. The process in detail: the feeder transports raw parts under the press, where they are formed. A corresponding discharge feeder transports the formed parts out of the press and perhaps to further downstream presses. The feeder motion is controlled by two drives to the left and the right of the press. A light-weight carbon bar is situated between the drives, supporting the mounting fixture for the
Specifically, it is a machine for inserting pins into a connection strip with a variable number of pins. The pins have to be individually inserted into the appropriate openings at a distance of 0.5 mm and with a speed of 1000 pins per minute. A rotating axis continuously delivers pins for the connectors from a conveyor belt. Feeding and insertion are dealt with by a sophisticated mechanical system. The receiving raw connector is pushed under the inserting unit and moved on step by step according to the pin distance. Once the connector is fully equipped, it is discharged. Feeding, moving on and discharging of the connectors are done via two parallel mounted feed axes that move the connector within a trough using finger-like devices. One axis moves the connector in front of the inserting unit, while at the same time the second axis moves back in order to prepare moving of the next connector.

The coordination of the feed axes and the inserting axis is realized via two cam plates. The tables are processed in the PLC and consist of prefabricated parts for the acceleration phase and a number of short path sections for moving the raw connector under the inserting unit. The length of the path sections corresponds to the pin distance. The number of path sections corresponds to the number of pins in the connector. The table is completed with the return phase. Apart from the administrative motion control block MC_Power, the continuous travel MC_MoveVelocity for the movement of the inserting axis and several MC_MoveAbsolutes for the initial positioning or the feed axes, this application also uses the table coupling blocks MC_CAMSelect, MC_CAMin and MC_CAMout. A table is selected and parameterized via MC_CAMSelect. MC_CAMin is used for coupling master and slave, MC_CAMout for uncoupling. The relatively demanding task could be completed within two weeks with the aid of IEC 61131 and the easy to use standardized motion control blocks.

80 percent dealt with

The standard described in version 1.0 covers approximately 80% of motion control tasks. A useful future activity of the Motion Control task force would be the definition of blocks for interpolating movements with several axes. Standardized blocks would also be desirable for special tasks such as the flying saw or for special industries such as the packaging industry. Since the first version of the standard was received very well, further blocks can no doubt be expected in due course.

As for PLC programming according to IEC 61131-3, for motion control blocks, the aim is not necessarily the portability of the programs, but an understanding of the operating principle and circuitry of the blocks. In the same way as the function block works identically in all PLC systems, the function of the motion control blocks is also defined unambiguously. Even if small differences are allowed, this does not change the basic notion of the blocks. Both for the manufacturers of PLCs and motion control systems and for the users, the standardized motion control blocks have a number of advantages: The manufacturers can expect worldwide acceptance of their products. The end user benefits from less hardware and manufacturer-dependency and is provided with an easily reusable code, leading in particular to a reduction in maintenance costs.

Standardized motion control blocks used for the control of presses in combination with the TwinCAT software PLC/NC: The hydraulic tryout multi-curve presses from Müller Weingarten in use at Volkswagen (Germany). At the VW plant in Wolfsburg, a total of six presses simulate the real production environment before the tools enter series production.
The Built-in industrial PCs with components of the highest performance class

The right Industrial PC for every controller
The Built-in Industrial PC C3600 series is designed for installation into the front of a control cabinet:

➔ Highest performance PCs with Intel Pentium III/4 processor
➔ 12 or 15 inch TFT display, optional touch screen
➔ Easy access to PC components, accessible from the back of the housing
➔ Open standards conform to ATX
➔ Components carefully tested to ensure appropriateness for industrial applications

C3600 series variants:
➔ C3620: 12 inch TFT display, optionally with touch screen
➔ C3640: 15 inch TFT display, optionally with touch screen
➔ C36xx-1xxx: customer-specified versions

For further information and international sales contacts see: www.beckhoff.com

BECKHOFF New Automation Technology

Beckhoff Industrial PC series C3600: the Panel PC with standard ATX components and touch screen
Connect several buttons, contactors or sensors via one Bus Terminal

Following the trend of space savings and extended functionality in automation, Beckhoff have now developed digital input and output terminals with eight channels for special applications. Subsequently, the same number of buttons, contactors or sensors with a common ground wire can thus be connected to one Bus Terminal. This allows a huge amount of space to be saved inside a control cabinet without loss of function – the expense of wiring is reduced, the packing density is increased, and costs are saved.

In many applications, whether inside a control cabinet or in distributed terminal boxes, multi-wire connection can be omitted for buttons, operating units or contactor strips. A common reference potential is necessary, such as the ground wire for the inputs, or 24 V for the outputs. Beckhoff have developed the digital 8-channel KL1408 input terminal and the KL2408 output terminal for these applications. In the same way as the two-channel and four-channel versions, the digital input and output terminals acquire binary signals from the process and transport them, with electrical isolation, to the higher-level automation device, or vice versa. The great advantage is that the total of eight channels are handled in a housing 12 mm wide, thus taking the same space as a 2-channel version. 8 LEDs indicate the signal state of each channel. The single wire connection technology makes it possible to connect multiple channel sensors in a very small space and with little wiring. The power contacts, with 0 V reference ground, are therefore connected through to the KL1408 input terminals. In the KL2408 output terminal, which handles load currents and provides them with overload and short circuit protection, the outputs are fed by a 24 V power contact.

The two types of terminal can be operated with the full range of Bus Couplers from Beckhoff’s extensive range for all common fieldbus systems. As a result, it is possible to handle up to 512 channels without changing the maximum structure size of 64 terminals per coupler. The number of channels rises to 2040 for each Bus Coupler if the terminal bus extension is used, permitting up to 255 Bus Terminals. The packing density in the control cabinet or terminal box can therefore be significantly increased.
For many users and suppliers CAN is the first choice for drive communication – due to its reliability, efficiency and flexibility paired with low hardware costs. CANopen provides a synchronization mechanism, which uses the cyclic transmission of a SYNC message. However, the medium access method of CAN cannot guarantee absolute deterministic data delivery. Therefore specifically designed drive fieldbus systems had to be used for applications which require high precision drive synchronization such as printing machines, machine tools, packaging machines or robots.

High precision drive synchronization with CANopen

The deterministic behavior of the CANopen SYNC telegram is limited to one frame length and may jitter with 130 µs at 1 Mbit/s. This paper introduces a synchronization method that uses the standard CANopen SYNC but achieves distributed simultaneous drive control which jitters less than 2 µs. A phase locked loop mechanism that tolerates the jitter of a single SYNC frame is superimposed and provides the timing information for the position or velocity control data. The bus system capacity is discussed for various applications and it is shown that CAN and CANopen is suitable even for demanding real-time requirements.

Digital intelligent drives offer maximum precision and speeds while minimizing equipment costs. For some applications the performance and accuracy of the digital drive interface itself is not crucial, as the drive internal capabilities allow one to send a command without hard timing requirements while the high speed control loops are closed locally in real time fashion. In most cases though a high accuracy digital interface is required to make full use of the advantages that the digital drive offers – especially when several axes work in a synchronized manner. Examples are automatic supply machinery that transports and positions materials and products, grinding, drilling and polishing applications, handling devices that extract and palletize, etc. In all these cases several drives are involved and have to be mutually co-ordinated in their varying dependencies by NC or continuous path control systems.

System description

Servo drive applications can be classified in two categories:

- In most cases a central positioning or NC controller is used for set point generation, interpolation, path co-ordination and drive synchronization. The control unit typically provides or connects the user interface, and is able to control the motion path depending on external conditions like complex sensor information, varying geometries or user input. Proper drive synchronization is crucial.
- For very simple tasks local control may be sufficient. A locally executed drive control program that repeats the motion path is adequate especially when no interaction with other drives or external conditions is required.

The Beckhoff TwinCAT Software System acts as central drive controller. It turns any compatible PC into a real-time controller with a multi-PLC system, NC axis control, programming environment and operating station. TwinCAT NC offers 3D interpolation, an integrated PLC with an NC interface and can communicate via all major fieldbus systems. The CANopen master functionality is provided by the FC5101 PCI card, which is available with two CANopen channels (FC5202) as
Control cascade with digital drive system

products

well. The CANopen implementation was specifically designed for high performance applications while supporting the full range of CANopen features. Lenze’s intelligent drives are designed both for central drive control and for local drive control. The drives integrate the CAN bus with the standardized communication profile CANopen DS301. The drive can make full use of CANs multi-master capabilities by, for example, enhancing the input range with external CANopen I/O modules like the ones offered by Beckhoff. As each drive carries its own CPU, the computing performance and I/O capacity hence increases in networked drives with every additional controller.

Another supported CAN bus function is the synchronization of control algorithms in a drive group. Chronologically equidistant angular information is needed to avoid irregularities that might arise using control algorithms that function asynchronously. Such angular information is needed to ensure angularly synchronized running of individually driven axes and for spatially coordinated movement/s (continuous path control system/s) via bus system/s. Unlike drives with analog (±10V) interface, digital drives not only close the torque and speed control loops locally, but are able to perform fine interpolation and position control with very short cycle times. TwinCATs interpolator and NC calculates position command values (set points) cyclically for each machine axis at identical, short intervals. With its own position control, each axis follows the cyclical position command values supplied by the interpolator, with a high dynamic response and high precision.

Thus control is exercised where the information relevant to this level of the control system is captured without any delays caused by the communication system. The fast control cycles in the drive are used to damp out interference. The position set points, transmitted at slower cycle times, are fine interpolated by the fast controller/s in the drives for that purpose.

Please note that this distribution of the control cascade is not CAN specific, but typical for digital drives. Dedicated drive control systems like SERCOS favor the same approach.

Synchronization Method

Best drive accuracy is achieved when the drives are precisely synchronized with the superimposed continuous path control system. This permits controller processing of the set points exactly simultaneously. A phase error of about 2 degrees due to the internal position control phase offset is caused, for example, by a deviation of a mere 100 µs in synchronization precision at a speed of 3,000 RPM.

Only standard features of the CANopen specification DS301 are used for the drive synchronization method. DS301 includes the definition of a mode for synchronous cyclic data transmission. Periodically the SYNC telegram is transmitted by the SYNC producer. On reception of the SYNC, the consuming device actuates based on the contents of the synchronous process data object (PDO) received before the SYNC. The reception of a SYNC also prompts a device to sample its feedback data and transmit a synchronous PDO with an actual value as soon as possible afterwards.

This mechanism works fine but has some limitations: As the SYNC message cannot interrupt a CAN frame currently being transmitted on the bus, the SYNC delivery may jitter by several hundred microseconds — at least the time it takes to transmit a CAN frame with maximum length, but maybe even by another higher priority frame like a network management telegram. Furthermore, the quality of the SYNC mechanism very much depends on the software implementation. In many cases only the CANopen communication is synchronized, but not the application running on another CPU.

The high precision distributed synchronization control (dsc) used for the drive synchronization makes use of the CANopen SYNC mechanism with an enhanced application synchronization method. It permits exact synchronization of the chronological basis of the individual controllers. The synchronization telegram must be transmitted cyclically with several milliseconds (1-13) and in the median with quartz precision. This is achieved by the CANopen PCI card FC5101, which also precisely synchronizes the NC task with the CANopen cycle. It is as well possible to synchronize several CANopen channels on one or several cards. As described above, the single telegram fluctuation, however, may be several hundred us. The drive application uses a phased locked loop (PLL) mechanism to synchronize with the CANopen telegrams and thus synchronizes with the overall accuracy of the SYNC cycle. A single jitter has no influence. No further means of parallel transmission of a synchronization tact are needed and this functionality can therefore be achieved with standard CAN hardware.

The assumption that accurate cyclic behavior cannot be realized with the CAN bus is proven wrong by the results illustrated below. The synchronization tact was dictated to two intelligent drives of the 9300 series by the superimposed NC control system. The diagram shows the beginnings of the control algorithms of both controllers, whereby the first channel serves as trigger point. Statistical recording of 50 incoming signals shows the quality of synchronization, the jitter range being below 2 µs.
Angularly synchronous individual drives (used instead of vertical shaft)

The CAN bus is pre-destined for use as a transmission medium in angularly synchronous individual drives because of its multi-cast capabilities. A virtual master sends the set point with one process data object cyclically and a further SYNC message for system synchronization. All drives thus receive the same information at the same time. In angularly synchronous individual applications, average distances of up to 100 m bus extension must be allowed as a rule. As this is related to the data transmission speed, a baud rate of 500 kbaud is realistic in this particular case. At this rate, the data transmission time is about 400 µs for both objects. Given a cycle time of 1 ms, the bus system is thus about 40% used. Adequate reserve therefore remains for transmitting control and status information and/or other service data objects (SDO). The number of axes connected is only limited by the bus physics and thus by the CAN transceivers.

6-axis handling robot as example

In general the electronic components of handling robots are close together so that the data can be transmitted with 1 Mbaud. A CAN object has a max. of 8 data bytes. Two controllers with 32-bit cyclic position set point can hence be controlled per object. Three cyclic process data objects for the position set points plus one SYNC object are therefore needed for a 6-axis handling robot. The control information can be summarized in a single broadcast object for all the drives and transmitted event-controlled. The information is thus irrelevant where bus load calculation is concerned. Status information for each controller are e.g. exchanged in total every 24 ms alternately. Bus loading for a cycle time of 1 ms can then be calculated as follows:

<table>
<thead>
<tr>
<th>Bus length</th>
<th>Baud rate</th>
<th>No. of axes</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 m</td>
<td>1000 kbit/s</td>
<td>16</td>
</tr>
<tr>
<td>100 m</td>
<td>500 kbit/s</td>
<td>8</td>
</tr>
<tr>
<td>250 m</td>
<td>250 kbit/s</td>
<td>4</td>
</tr>
<tr>
<td>500 m</td>
<td>125 kbit/s</td>
<td>2</td>
</tr>
</tbody>
</table>

The number of axes can be further enhanced by not sending each actual position in each cycle, but spreading the feedback in a way that there is only one actual position value sent in each cycle. As the position control loop is closed locally, this is sufficient.

Effects of data transmission on drive characteristics

It is necessary to examine the drive characteristics of a single controller to obtain valid data on this. For this purpose, the contouring error of a series 9300 servo position controller with high-resolution feedback system (sine/cosine encoder) was measured over a speed range of 0 to 4,000 RPM in idle. Measurements results show deviations of less than 2 angular minutes over the entire speed range. Two controllers were then set up using the synchronization mechanism described above to obtain data on the influence of data transmission on drive characteristics. The angular deviation of the two rotating motor shafts relative to one another were then measured. The measurements show that here again precision of less than 2 angular minutes is achieved over the entire setting range. The phase offset is thus always of similar dimensions to the contouring errors of the individual controllers. The bus (CAN with CANopen) used for the Beckhoff TwinCAT / Lenze communication with distributed synchronization control (dsc) has no negative influence on the system and is optimally suited for multi-axis-coordinated movement sequences.
Dynamic and static drive characteristics measurements under load conditions and conditions of higher data flow due to further asynchronous bus participants led to the same results.

Field experience

TwinCAT NC can perform significantly faster control cycles than the CAN bandwidth allows to communicate. Field experience though shows, that in combination with intelligent digital drives and high precision synchronization, CAN easily meets most application demands. For handling systems, for example, a cycle time of 4 ms is adequate in more than 90% of the applications. The deviations in synchronicity of less than 2 angular minutes (1/10800th of a shaft revolution) can usually be disregarded by comparison with mechanical imprecision (torsion in the mechanical shafts, gearing tooth face change, etc.).

Applications that have been successfully solved with the CANopen digital drive interface include:

- 3-axis precision cutting machine
- 9-axis special handling device
- Handling robot for extracting injected plastics parts
- Engraving steel blocks in the steel industry
- Printing machinery without shafts
- Blister packaging machinery for the pharmaceutical industry
- Bookbinding machinery
- Wire pulling machinery
- Foil covering plants
- etc.

Why CAN and CANopen?

What are the advantages of CAN and CANopen compared with dedicated drive control systems like SERCOS? Low costs and versatility. As CAN adds only little cost to a drive hardware, Lenze and many other drives come with a CAN interface by default while other fieldbus interface cards are optional. And CANopen is not only supported by drives and I/Os, but by all kinds of devices. In most cases the available bandwidth allows one to combine drives, controllers and other devices on the same CAN network — and if the bandwidth is not sufficient, a second CAN network is available at little cost with the Beckhoff two channel CANopen card.

CAN and CANopen is suitable for many drive engineering applications due to its multi-master and multi-cast capabilities. It is therefore used by Lenze as the system bus for integrating systems and expanding them and supported by Beckhoff’s TwinCAT NC and PLC system.

This bus is pre-destined to exchange data within intelligent subsystems that are networked via standard fieldbus systems to superimposed control computers. Development of the distributed synchronization control (dsc) shows that CANopen is suitable even for demanding real-time uses. The cost advantages, including networking without extra cost as CANopen is default while other bus systems are optional, combined with the robustness and the versatile use of this system will lead to further increasing acceptance.

Martin Rostan, Product Manager Fieldbus Systems, Beckhoff
Josef Langfermann, Application Manager, Lenze Corporation, Lawrenceville, GA
We might be tempted to think that measuring temperatures with PT100 or thermocouple sensors is old hat. But with the aid of exciting electronics – integrated into I/O systems – there still is room for innovation. In addition to precise measurement, the electronics makes the signals easier to handle and contributes to avoiding errors, while the fieldbus provides system continuity from the process bits all the way to the upper command level.

I/O systems for PT100 and thermocouple sensors

External temperature measurement via fieldbus

There are a number of procedures for measuring temperature electrically. Resistance thermometers and thermocouples are the sensors most frequently applied. It is also possible to measure temperature by analyzing the reverse current of diodes or transistors. In the context of automation technology, temperature measurements are most often made using thermocouples or resistance thermometers. Thermocouples are robust and economical, have narrow measurement tolerances and, depending on the material, can measure over a range between –200 and +1,800 °C. The structure of the thermocouple is composed simply of a pair of different wires welded together at the end. The thermal voltage is developed at this junction, and depends on the temperature and on the difference between the two materials. The combination of materials is selected according to the relevant temperature range. Nickel-chromium/nickel wires, for instance, are suitable for the range from 0 up to 1,000 °C.

Resistance thermometers demonstrate an approximately linear change in resistance with temperature. The metals most often used are platinum (e.g. PT100) and nickel (e.g. Ni100). They have a high temperature coefficient and acceptable linearity. They are particularly useful for precise temperature measurement over a wide temperature range, extending theoretically from –200 °C up to 850 °C. The associated insulation means that the majority of sensors are only suitable for a smaller range. PTC and NTC sensors are also resistance thermometers, but have significantly larger temperature coefficients. They are, however, extremely non-linear, and are used for economical measurement over small temperature ranges.

All common temperature sensors are supported

The Beckhoff I/O systems, made to protection class IP 20 and IP 67, provide a comprehensive range of products for temperature sensors. In both the Bus
Terminal system and the modules from the Fieldbus Box series, the signals are transported over any appropriate fieldbus to the controller. All sensors commonly available on the market for the various measurement processes are supported. The fieldbus components allow the sensors to be directly connected. The electronics evaluates the sensor signal, linearizes it, checks it for plausibility and errors, and provides an understandable value with, for instance, a resolution of 0.1 °C, to the fieldbus. Other number formats may optionally be used to in order to simplify handling in particular PLC systems.

Thermocouples in particular place tough demands on the evaluating electronics. The cold junction, or reference junction, must also be measured and included in the linearization. In some circumstances, the internal reference junction is not directly attached to the evaluating electronics. The transition from the thermal wires to copper may take place some meters away. This transition can lead to undesired thermal voltages which cause errors in the measurement. To avoid these errors, the temperature is measured at the transition of the external reference junction. Both the Bus Terminals and the Fieldbus Box Modules support both kinds of reference junction measurement.

**Internal reference junction measurement**

Internal measurement involves bringing the thermal wire to evaluation electronics and measuring the temperature at the mechanical contact location, i.e. the reference junction. Two pairs of thermocouples can be directly connected with the KL3312 analog Bus Terminal. Measurement of the temperature of the reference junction takes place in the Bus Terminal itself. The IP3312-Bxxx Fieldbus Box devices with integrated fieldbus interface, or the IE3312 Extension Box version are more suitable for use in tough industrial environments. Their special feature is a unique M12 connector, into which the measurement of the reference junction has been integrated. If internal measurement is to yield proper results, it is necessary that the thermal wire is brought to the electronics homogeneously, i.e. without any differences in the material. The difficulty of particularly long equalizing wires can be a disadvantage here. Laying the stiff nickel-chromium/nickel wires and measuring the temperature at the mechanical contact location, i.e. the reference junction measurement.

**External reference junction measurement**

This disadvantage is eliminated by the “external measurement” version. Instead of long, awkward equalizing wires, flexible copper wire, for instance, can be used here. A location is required at which the temperature of the reference junction can be measured. The user can take standard cables from this cold junction to the KL3312 Bus Terminal. The advantages of this go beyond the economy and flexibility of these solutions: special constructions such as high rigidity assemblies are possible, as is used in trailing cables, while prefabricated wiring harnesses can reduce the installation effort. There is a further positive side-effect: the solution obviates one frequent source of error, namely the inversion of the thermal wires, perhaps in the course of a repair.

This version is made possible through external measurement of the temperature at the cold junction. This temperature can, for instance, be measured with a PT100 thermal resistance sensor through the KL3202 Bus Terminal. The analog PT100 Bus Terminal measures the reference value of the cold junction, and passes it to the thermocouple’s measurement system via the KL3312 input terminal. This task is carried out by the higher-level PLC. It reads the value of the PT100 measurement and writes it to the relevant thermocouple terminals. It is possible for several thermocouples to be connected via one reference location if the measurement of the temperature of the cold junction is carried out at a common thermal unit. The costs involved in measuring the temperature of the cold junction therefore only arise once.

The special feature of the Fieldbus Box solution is the M12 connector described above. It can either be used at the module itself, or at a distance of some meters. This moves the transition from thermal wires to copper and the associated temperature compensation to a point closer to the process, so that the equalizing wire can be correspondingly shortened. Conventional 4-core pre-assembled sensor cable can be used to make the extension. There is an additional advantage: The user can locate the evaluation electronics optimally, without being restricted by the location of the thermocouple.

**Any fieldbus can be used**

The temperature measurement, whether using the Bus Terminal system or using Fieldbus Box Modules, is independent of the fieldbus. The FM3300 fieldbus...
module, with which up to 32 thermocouples can be directly linked to Profibus, is an exception to this rule. The electronics and the measurement of the cold junction temperature, moreover, are located in an IP 65 industrial plug connector. Other electronic features of the FM3300 series are an integrated Profibus interface, the ability of the thermocouple inputs to withstand up to 230 V AC, and complete potting of the electronics. This economical and compact solution is particularly suitable for monitoring large heating elements or extensive thermal processes.

The Beckhoff components support all familiar thermocouples over their entire temperature range. It is also possible to select any kind of resistance thermometer, such as PT100, 200, 500, 1000, Ni100 or Ni1000, as well as other special sensors from the building automation sector. The full range of linearization curves are stored in the electronics. This means there are no restrictions on applying the devices in control systems, process computers or controllers. The intelligent system detects both short circuits and broken conductors in the measurement circuit. An error LED indicates a sensor fault in either measurement system.

Both the more economical 2-conductor and the more accurate 3-conductor technique can be used with the resistance sensors. The 4-wire technique, in contrast, does not bring any significant advantage to standard applications, because the electronics cannot obtain greater measurement precision through use of the fourth conductor. All the components are electrically isolated, so that there are no errors arising from equalization currents. Mains hum, which can generate interference in the range of mV, is also eliminated by an appropriate choice of measurement interval and the use of digital filters.

**Components for temperature measurement**

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Bus Terminals (IP 20)</th>
<th>Fieldbus Box (IP 67)</th>
<th>Fieldbus Module (IP 65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance sensor</td>
<td>KL3202, 2-channel</td>
<td>IP3202-Bxxx, 4-channel</td>
<td>FM3312, 12-channel</td>
</tr>
<tr>
<td>(PT100, PT200, PT500, PT1000, Ni100)</td>
<td>KL3204, 4-channel</td>
<td>IE3202, 4-channel</td>
<td></td>
</tr>
<tr>
<td>Thermocouple</td>
<td>KL3312, 2-channel</td>
<td>IP3312-Bxxx, 4-channel</td>
<td>FM3332, 32-channel</td>
</tr>
<tr>
<td>(Type J, K, L, B, E, N, R, S, T, U)</td>
<td>IE3312, 4-channel</td>
<td>(Type J, K)</td>
<td></td>
</tr>
</tbody>
</table>

**Temperature measurement with thermocouple (Fieldbus Box Module).**

**TwinCAT connects to the PC**

The process signals pass over the fieldbus to the TwinCAT automation software from Beckhoff, or to another control system. This means that all the parameters can be set through software over the fieldbus. As a consequence, precise selection of the hardware does not need to be made when planning the installation. It also means that the state can be modified during commissioning in order to adapt to the given conditions.

The project planning, parameterization and commissioning of the pre-set modules is carried out with remarkable simplicity using the KS2000 configuration software. During commissioning, the data is downloaded to the fieldbus stations via RS232, Ethernet or over a fieldbus. During this phase, a monitoring system allows the input and output images at the Bus Terminals to be observed and manipulated in a dialog window.

A special feature of the KS2000 windows software is the facility for carrying out extremely precise measurements over a small temperature range, such as the measurement of room temperature using thermocouples. A thermocouple, nevertheless, has a temperature range from –200 up to +1,800 °C. For this reason, the Bus Terminal or the fieldbus box is calibrated through KS2000, and a reference temperature is set. The original output of the KL3312 could, for instance, be 26.9 °C, whereas in fact 27.4 °C is measured. The KL3312 is then calibrated for the "correct" value. By calibrating in this way for a value from the actual application, a particularly high precision is reached in the relevant area, as a result of which all the system errors, such as those from the sensor, cables or other influences, are significantly reduced.
Over the last 2 years, the most advanced wheel production facility in the world was built at the site of the former Lemmerz factories in Königswinter, Germany. For automation purposes, Beckhoff technology is used exclusively: PC-based TwinCAT PLC and positioning controllers, Industrial PC as well as Beckhoff Lightbus for I/O communication.

It’s a long way from sheet metal to the finished wheel. Initially, the wheel disk and wheel rim are produced in separate production processes and subsequently welded together in an assembly line. The wheel disk is produced from coil stock in a deep-drawing process using a progressive press (shaping and punching). The associated wheel rim is produced in the wheel rim line. Here too, the basic product is a sheet metal coil. The coil is unwound and cut to length, and subsequently pre-bent (round bending) and welded into a circular blank. This circular blank is then profiled via roll stands and is shaped into the typical wheel rim profile. In the assembly line the disk is pressed into the wheel rim, welded, checked and subsequently dip-primed. A new wheel is ready every 6 seconds. What may sound relatively easy here in reality involves the integration of a variety of process technologies and their interlinking into an approximately 200 m long production line.

The welding process

The complex control process starts with welding of the circular blank in the wheel rim line. This procedure is technologically very demanding and consists of the following steps:

1. The two ends of the round-bent sheet are brought together via a hydraulic axis until they are in contact.
2. Once they are in contact, they are heated by applying a controlled current. The round-bent pieces are then welded together, with the material being upset during the welding process. During this process, in addition to the current and the pressure, the position of the hydraulic axes involved is also monitored.
The next production step is the profiling of the wheel rim blank in three successive roll stands. This process is more demanding than it may appear at first glance. The blank is transported step-wise into the roll stands. The upper and lower rolls close in a controlled way to generate the profile. At the start of each manufacturing stage, the peripheral speed of the two rolls is adjusted to the mean radius of the wheel rim blank. Once a frictional connection between the two rolls has been established via the wheel rim material, the process control is changed to moment control. Here too, high computing capacity and deterministic machining at short cycles is required. Due to its nearly inexhaustible reserve capacity, a TwinCAT PC control is able to meet these two requirements extremely well.

The last operation, i.e. final assembly of wheel disk and wheel rim, is just as complex. A robot positions the wheel disk in front of a camera system, which detects the rotational position. The wheel disk is then placed into a wheel rim positioned on two walking beams. A gripper for clamping the wheel is positioned on each side of the walking beam. Once the gripper engages, a frictional connection is established between the two beams via the fixed wheel. During transport, the beams are synchronized with high precision in order to avoid mechanical damage. The beams are synchronized electronically via TwinCAT through linear master-slave coupling.

The wheel disk is pressed in via a press, creating a firm connection. The height of the burner heads in the subsequent welding stations is adjusted depending on the height of the wheel disk patch. Four weld seams are simultaneously produced. For this purpose, 4 burner heads are symmetrically arranged at each station. Each burner can be individually fine-tuned, i.e. one axis for vertical and radial positioning, one for lifting or for positioning of the wheel under the burner heads, and one rotational axis for rotating the wheel during the welding process are available. Measurement and quality control of the finished wheel are carried out with a specially developed camera and image processing system.

Therefore, several processes correlate with each other, i.e. the pressure and the position control for upsetting the sheet metal and the control of the welding current.

Until now, the welding process used a proprietary control and a PC-based system for generating, managing and downloading the welding programs and for generating the set values. The wheel rim line manufacturer, Fontijne, combines both processes via a Beckhoff TwinCAT control system, thus demonstrating its performance and flexibility, particularly for the realization of technological control processes.
of several thousand bytes. The performance capability of a TwinCAT control system could scarcely be documented more impressively.

**Flexible visualization via Visual Basic**

The visualization of the assembly machine, which was created in-house at Hayes-Lemmerz, is carried out on an additional Industrial PC that is networked with the TwinCAT control system via Ethernet. In house visualization was done because a large number of off-the-shelf products are ideally suited for process engineering applications, but are sub-optimal for machine construction. Visualization via Visual Basic is very flexible and cost-efficient, since there are no license costs, and it is optimally adjustable. System care and maintenance can be carried out in-house without problem.

For example, the DXF files of the construction drawings are used and amended with appropriate status indicators. This is not only practical, but it also leads to a very appealing and clear appearance.

**Free networking**

The networking and communications options are also very effective. Since TwinCAT is a PC-based software solution for PLC and Motion Control, networking is supplied as a matter of course via the PC platform. For internal device communication, e.g. between TwinCAT PLC and visualization, standard interfaces such as ActiveX or OPC are used. This makes access to data within the network for interfacing with MDE or BDE or for remote maintenance very easy. Since the same language is spoken here and in other standard EDP applications, the in-house expertise of the appropriate departments can be utilized.

**Convincing overall factory automation concept**

According to Michael Glos, Director Electronic Design at Hayes-Lemmerz, the TwinCAT PLC and positioning controller is the optimum solution for wheel production. Due to the tremendously large process images and the extremely exacting demands in terms of computing capacity for PLC and positioning, only a PC-based solution such as TwinCAT offers the opportunity to automate such a machine with a single CPU system and to avoid inadequate (yet costly in programming terms) communication between several PLC CPUs. The conclusive and straightforward integration of the complete Motion Control within the TwinCAT system is ideal. Apart from the simple handling, Michael Glos is also very enthusiastic about the central data management of a drive solution with central intelligence and integration into the PLC programming system: “Normally, I would require different specialists for the PLC, the drive technology and the technological controls. Thanks to the integrated system platform of the TwinCAT control, only one programmer is required for the complete project design and programming of the system”.

At the reeling machine, the coil for the wheel rim is unwound and cut to length, and subsequently pre-bent (round bending) and welded into a circular blank.

Profiling of the wheel rims.
At the assembly machine, the wheel disk is inserted into the wheel rim.

The central drive intelligence is also advantageous in terms of costs. For a distributed solution, each drive controller would required approximately 500 euros worth of integrated technology cards. Additionally, a further bus system would have been required for the synchronization. The Lightbus, however, is powerful enough to be able to transmit the real time data (set values and current position values of the drives) cyclically and deterministically from and to the central position controller of the TwinCAT PTP positioning system, synchronized with the central position controller. Further hardware costs are thus avoided. At the same time, handling is simplified because the minimum possible number of systems is used. After two years experience with Beckhoff TwinCAT, Michael Glos sums up his experience as follows: “In hindsight, I would take the same decision again any time.”

The automation components are connected with each other via a Lightbus system.

Automation technology at a glance

The following components are used for the automation of the complete wheel assembly line:

**Industrial PC:**
- 16 C6140 control cabinet PCs (Pentium III, 850 MHz)
- 8 CP7021 Control Panels, 2 CP7022 Control Panels, 2 CP7032 Control Panels

**Fieldbus:**
- 20 Lightbus FC2001/2 PC fieldbus cards
- 120 Lightbus BK2000 Bus Couplers
- 5,000 digital Bus Terminals, 1,000 analog Bus Terminals

**Software:**
- TwinCAT PLC cycle time: 9 ms
- TwinCAT NC cycle time: 3 ms with max. 57 servo axes in a single TC control system

**Visualization:**
- Visual Basic, interfacing via TwinCAT OPC
It used to be that the growing number of wind power towers was restricted to coastal regions or to Germany’s plateaus. The demand for renewable sources of energy, such as wind power, is becoming more and more important throughout Europe. Within a few years, 50% of Europe’s entire electrical power should be generated from renewable sources. In the year 2000, the number of wind power converters in operation had already reached 9,369, representing a total power of around 6 GW. This meant that 2.5% of German electricity was obtained from wind power. The first wind farms out at sea are already being designed. To ensure future growth, the wind power industry must respond to energy planners demands for larger converters to be installed in diversified locations. The fact that Germany politically is one of the leading promoters of wind power technology does not hurt the growth of the industry. The manufacturers’ job is to develop their wind power converters into versions that are fully competitive with conventional methods of power generation while the political environment favors them. The new DeWind Type D8 wind power converters, utilize a new controller design based on Beckhoff Industrial PCs, TwinCAT automation software, and Bus Terminal technologies.

Modern wind power converters possess complex electronic control instrumentation that looks after the operation of the plant, including remote data monitoring, as well as the feed to the power grid. The new DeWind Type D8 wind power converters, utilize a new controller concept based on Beckhoff Industrial PCs, TwinCAT automation software, and Bus Terminal technologies.

The wind is blowing in a new direction with TwinCAT

It used to be that the growing number of wind power towers was restricted to coastal regions or to Germany’s plateaus. The demand for renewable sources of energy, such as wind power, is becoming more and more important throughout Europe. Within a few years, 50% of Europe’s entire electrical power should be generated from renewable sources. In the year 2000, the number of wind power converters in operation had already reached 9,369, representing a total power of around 6 GW. This meant that 2.5% of German electricity was obtained from wind power. The first wind farms out at sea are already being designed. To ensure future growth, the wind power industry must respond to energy planners demands for larger converters to be installed in diversified locations. The fact that Germany politically is one of the leading promoters of wind power technology does not hurt the growth of the industry. The manufacturers’ job is to develop their wind power converters into versions that are fully competitive with conventional methods of power generation while the political environment favors them. The new 2 MW converter from DeWind AG, Germany, also known as “the D8”, is a first step in that direction. The PC-based control technology from Beckhoff makes its own contribution to this.

Wind energy converter delivers up to two megawatts

The DeWind D8, generating a rated power of 2 MW from its 80 m diameter rotor follows the DeWind D6 series, generating 1.25 MW. The D8 features a high power yield, quiet operation, good grid compatibility, long service life and attractive design. DeWind AG plans to produce about 30 units of this flagship product in this year. It is forecasted that 100 wind power converters will be built annually, from 2003 onwards. A first project is currently being implemented at Siestedt, Germany.
With this addition to their range of products, DeWind is serving new markets and their specific profiles. The next steps in the development process have already been taken. The DeWind D8, with its 2 megawatts of rated power, has a rotor diameter of 80 meters, and is offered in tower versions with hub heights at 80 or 95 meters. The D8 is pitch-controlled, and is operated with variable rotation speeds.

The new generation of DeWind converters are characterized by highest yields and reliable operation. The blades, drive train, gearings, generator and frequency converter are closely matched to one another.

Key figures:
- Rated power 2,000 kW
- Rotor diameter 80 m
- Swept area 5,017 m²
- Variable speed
- Power limitation by means of pitching (PSP)
- Double-feed induction generator
- Cut-in wind speed 3 m/s
- Nominal wind speed 13.5 m/s
- Hub height 80 or 95 m
- Structure-borne noise insulation through vibration elements in the drive train

It is not just the external dimensions of the D8 that are setting new standards in wind power technology; the controller solution is also opening up new possibilities. The tasks of a wind power converter controller are both very complex and extremely varied. Four servomotors and hydraulically operated brakes take care of the azimuth control, i.e. the adjustment for the wind direction. The D8 is also fitted with a fast pitch regulation system, in which the rotor blades are rapidly but gently adjusted to the available wind or to the power requirements of the power supply company if operating at full capacity. A very important point in the control of wind power converters is grid monitoring and control of the power feed via a frequency converter. In parallel with these tasks, the environmental conditions, temperatures and pressures in the hydraulic system, rotation speeds and vibrations are all monitored.
The potential for development of proprietary controllers has been exhausted
Controller solutions have, until now, consisted of a large number of microcontrollers and proprietary bus systems. Robert Müller, Electrical Construction Manager at DeWind AG stated: “The development capacity of the controllers for wind power converters generally found on the market has come to the end of the line. Their performance is limited, and their resources are exhausted. The difficulties of interfacing the various functional units such as the controller, the remote data transmission systems and in-house production and planning systems in their present state can not effectively be overcome”. This means that the control systems used today can only with great difficulty fulfill their tasks in relation to controlling the converter, managing the network and remote diagnostics – the significance of which will continue to grow in the future. In addition to this it must be borne in mind that conventional controllers have only limited resources, and can therefore only offer restricted monitoring and diagnostic functions. They are not able to grow to meet future demands. “This is, however, unacceptable in the light of the increasing demands placed on wind power converters and manufacturers”, continued Robert Müller. “Customers expect significantly better analysis and diagnostic facilities. Power grid operators, furthermore, specify flexible network management with fast reaction times, in particular for wind farms”. The first goal of the technological development work was to improve the efficiency of the converters, reduce the loading and increase the convenience of operation for the sake of greater profits and reduced costs.
DeWind is following a radical, new controller philosophy, with regard to the D8. Information that might originate in control of the frequency converter and of the power converter – generated in each case by closed systems with incompatible functions and approaches to communication – would have to be read via entirely separate communication paths, and a great deal of effort would have to be expended to bring them into a proper relationship if, for instance, they were need-

applications

ed for diagnostic purposes. The use of open, standardized software and hardware should obviate problems originating with lack of compatibility.

D8 – controlled by TwinCAT
A Beckhoff Industrial PC running the TwinCAT automation software performs all control tasks of the D8. Around 200 I/Os distributed over the nacelle and the base of the tower are passed through the Bus Terminal system to the PC controller. The real-time requirements of the system for general control and regulation lie in the range of a deterministic cycle time of 10 ms; for power feeding and monitoring task, the time is around 1 ms. This is possible with the C6220 Control Cabinet PC. This is entirely assembled without moving parts. The mass storage system consists of a Flash drive, and because of the low power consumption in the processor and power supply unit there is no need for a fan. The usual PC interfaces such as graphic card, RS 232, USB and Ethernet are mounted directly on the processor card.
The mains network monitoring and the link to the frequency converter located in the base of the tower are implemented via CANopen through the 2-channel FC5102 PC Fieldbus Card. The master card contains a NOVRAM to save the work-
The Lightbus is used to transfer the signals within the nacelle with no risk of electromagnetic interference. The Bus Terminals are here connected through optical fibers and the FC2001 Lightbus Card to the Industrial PC located in the base of the tower. An additional Bus Terminal station in the nacelle is connected via an Ethernet optical fiber cable to the controller. This again demonstrates the flexibility of the software PLC/NC TwinCAT, supporting any common fieldbus system (even simultaneously!).

**Programming standards ease project planning**
Dewind wind power experts used the powerful TwinCAT development environment meeting IEC 61131-3 for the PLC programming. This meant that all the control and regulation tasks could be implemented in an open programming interface. The application software was therefore truly Dewind's own in-house development. The open platform offered by the Industrial PC also simplifies the continuously growing need for compatible interfaces to the outside world. Application adjustments, due to unexpected developments or discoveries, are very easy because the hardware and software components allow for limitless changes to the controller making.

Wind power installations in wind farms can communicate with one another and be configured without difficulty. Additional measuring instrumentation can be integrated at any time, and does not have to be operated in parallel. TwinCAT can easily handle the exchange of information using existing features. The manufacturers, operators and owners of wind power converters need increasing amounts of information. This information can be economically transferred across the Internet. Therefore, with Beckhoff “New Automation Technology” detailed information from every single I/O point can be obtained, and if necessary parameterized. Commissioning and servicing of the equipment also becomes easier. The program code can easily be debugged, even online. Important characteristic figures relating to the wind power converter are recorded according to the cascade method, and can be called up at any time. This allows important conclusions to be drawn relative to the early detection of damage, and in the long run this can result in higher plant availability. The operators of wind power converters must perform additional tasks for the power supply companies, who presently specify flexible network management with fast reaction times. Whereas formerly these converters needed to be taken off the grid when they were experiencing problems, they are presently expected to support the grid. This calls for the implementation of highly complex algorithms, and these can be handled in real-time using TwinCAT’s high computing power.

**Competitive wind power**
With the D8 control system, Dewind AG can offer customized service packages for their customers. That include converter monitoring, with a free choice of analysis and display variations. The system guarantees a much higher reliability in feeding the mains grid to the power supply companies, while at the same time its high capacity satisfies customers’ growing demands for clean energy from wind power at every location. With the D8, Dewind AG have succeeded in using an open system platform to adapt the control technology to the requirements of the future. While maintaining compatibility with proven international standards, it allows both the hardware and software to be freely scaled. Beckhoff provides the tools to meet these demands.
Netherlands: The progress in lithography technology to produce better chips
Page 42

Brazil: Ethernet on the factory floor
Page 40

Beckhoff North America goes direct
Take control of fieldbus networks, Page 39

Germany: Flexible building automation with the Beckhoff automation kit, Page 46
PC technology supports new approach for knife grinding, Page 50
Versatile testing methods are given a flexible implementation, Page 52

Singapore: A series of seminars on PC Control in Thailand and Singapore
Page 68

Finland: Manufacturing systems from Fastems promise better results, Page 64
DaimlerChrysler uses FMS from Fastems, Page 65

Switzerland: Güdel uses Beckhoff technology for transfer and handling systems – PC as control platform, Page 60

Austria: Austrian branch becomes Beckhoff Automation GmbH
Austrians rely on Beckhoff technologies, Page 54

Germany:

Netherlands:

Brazil:

Beckhoff North America goes direct
Take control of fieldbus networks, Page 39

Germany: Flexible building automation with the Beckhoff automation kit, Page 46
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Beckhoff are expanding their North American direct sales and support force; simultaneously terminating the commercial relationship with distributor Interlink BT. Beckhoff now directly and exclusively provide all products and services, configuration support and application engineering and will honor warranty to all existing product users. Beckhoff further penetrate the market with own extended offices, offering local Sales and Application Engineering complementing their product line of Industrial PC, industrial network I/O systems, drives and automation software through an exclusive and “one stop” source.

In February 2002, Beckhoff organized a series of seminars across the USA on the topic of fieldbus applications. In a two-week tour through five states in Canada and the USA, customers at various industrial centers were shown the latest developments and substantial technology for the most important industrial networks, Profibus and DeviceNet. Beckhoff experts also reported on the current state of development of Ethernet as an industrial I/O network and of SERCOS as a drives bus. Live demonstrations of configuration, operation and fault-finding in all the networks on control systems from various manufacturers rounded off the theoretical part with some hands-on experience. Participants took a programmable Ethernet Bus Terminal controller with a few I/O terminals away with them as a demonstration kit. Beckhoff received special compliments: the opportunity to try out practical applications and theoretical possibilities convinced the participants of the quality and completeness of the seminar covering these complex technologies.

Beckhoff North America goes direct

Beckhoff’s growth strategy is focused on meeting customers demands for improved support response, fast, professional customer interaction, in-depth product and technology know-how, consulting, and direct contact to real people helping in case of questions:

- Providing application services and manufacturer know-how for OEMs, System Integrators and End Users,
- Offering extended services, a 12 hour hotline (1800TwinCAT), with access to product specialists, application engineers, and training.
- Expanding to 7 local offices in Minneapolis, MN, Chicago, IL, Toronto, ON, CA, Columbus, OH, Raleigh, NC, Birmingham, AL, and Yuma, AZ, offering automation know-how, sales and application support,
- Offering continuous standard warranty to existing users of the products,
- Offering efficient and productive direct customer relationships and attractive direct pricing.

The direct approach of Beckhoff to the customer is based on the strong international orientation of Beckhoff in the automation industry, being actively involved in a global rollout of PC based technology for many customers. With this customer base, unified, efficient, global pricing and direct customer relationships are of the essence — and are seen as key advantages especially by North American automation customers. Beckhoff preserves all the benefits of open PC based architecture and adds true single source responsibility with a tightly integrated control solution that can reduce integration work by 30-40%.

Customers enjoy a “one source” relationship — Beckhoff manufacture and supply worldwide a broad range of products such as Industrial PC, industrial I/O, fieldbus scanner cards, drives, automation software for real-time PLC and motion control applications. As information and specifications come from one source, product performance specifications can be warranted, and customers can make decisions about applicability faster.

Take control of fieldbus networks

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Each seminar in Minneapolis MN, Toronto CA, Charlotte NC, Austin TX, and Los Angeles CA brought together up to 30 interested participants who were either about to introduce this technology or who wanted to become informed about the latest trends. The lectures were presented by engineers from Beckhoff USA and Europe; they included, among others, Martin Rostan, Chairman of the CANopen interest group CiA (CAN in Automation) and Vice-President of the IAONA Technical Steering Committee. Experiences and trends in more recent developments in the Ethernet field could therefore be presented, while information direct from the CAN sector was discussed. Altogether a successful start to 2002!
In the first half of 2001 DaimlerChrysler Brazil began operation of a new production line for CDI engines – an innovative project, in which a whole series of new approaches were integrated into a familiar manufacturing process. Almost all of these innovations had previously been integrated into various processes at DaimlerChrysler Brazil and tested. The new challenge was to bring them all together within one project.

**Ethernet on the factory floor**

The DaimlerChrysler factory in São Bernardo do Campo, São Paulo, is the central production location for buses and trucks. 9,500 employees currently work there in three shifts. In addition to the traditional production of commercial vehicles, the company has now extended its production to include saloon cars through investment at another site.

The new production system in São Bernardo do Campo has combined a number of different approaches, such as carousel assembly in which the two fitters assemble the engine from the beginning to the end of the process, the constant-speed assembly line, "Poka-Yoke-Kits" – a kind of tray precisely offering those parts required at a particular station – and the "supermarket", a central stores close to the assembly line, where all the kits and parts required to supply the line are made available or are pre-assembled.

**New assembly line for CDI engines**

"We are assembling a new engine here, using new technologies that we have been developing for 10 years. The engine was originally built for automobiles, and then was adapted in Germany for use in transport vehicles and light trucks. The project began in 1997. It involved an assembly line that contained a range of innovations: in-line quality tests (dynamic tests and leakage tests) and a trolley for transporting the engines that allows 360 degree access to the engine parts", explained André Wulfhorst, team leader in the engine production planning department.

The new and very compact assembly line has no more than 10 assembly stations, and when it is fully operational it will be able to produce 160 engines per day in two shifts. The target for the early months of 2002 is around 80 engines per day. In order to communicate the confirmed production sequence information from the mainframe computer to the production area, the employees in the São Bernardo do Campo factory developed the EPM (Engine Production Management) system.

Scada software passes the parameter data to the machines on the assembly line, including the total of 27 nutrunners. Different parameters must be transferred for the different types of engine.
Conexel – Beckhoff’s partner in Brazil

Conexel is a Brazilian company with head offices in São Bernardo do Campo, in the federal region of São Paulo. Conexel’s products are designed to co-operate with sensors/actuators and control devices. This is why Conexel is often referred to as the “interface partner”. The product range primarily consists of electrical and electronic items. Electrical products include terminals, PCB contacts, crimping, cutting and insulation removal tools, marking systems for cables and plugs and a large number of accessories.

The electronic products include relays and opto-couplers, insulators and signal conditioners, power supply units, interfaces for direct connection of PLC IOs, building automation modules based on LONWorks, industrial automation products using PC-based control technology, over voltage protection equipment, monitoring modules, time relays and passive component arrays (resistor arrays, diode arrays etc.).

Most of these electrical and electronic products are developed and manufactured at the company’s 12,000 m² production works. The site is situated in the largest industrial region of São Paulo, in the immediate neighborhood of international companies such as Volkswagen, Mercedes-Benz, Ford, General Motors and others.

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BC9000 Bus Terminal Controllers solve communication problems

Automation components from Beckhoff solved the communication problems between the individual nutrunners and the Scada software. Because the nutrunners are not themselves capable of communication, they can neither receive parameters from the PC via the Scada software nor send it.

A decision was made to use the Beckhoff BC9000 Bus Terminal Controller that can communicate over an Ethernet network with Bus Terminals. There were a number of reasons why DaimlerChrysler Brazil took this decision: compact hardware that could be separately attached to each nutrunner was required. The hardware needed to be capable of handling a variety of signal types – digital inputs and outputs, and an RS232 channel. The solution also needed to offer the best possible cost/performance ratio.

A team of engineers from DaimlerChrysler Brazil, Debis-Humaitá and Conexel, Beckhoff’s exclusive representatives in Brazil, developed the application for this assembly line together. Because there are four different types of nutrunner, the team developed different modifications of the application software. This software can run on the BC9000 Bus Terminal Controllers with Ethernet interfaces. The BC9000 allows information to be exchanged between all the other assembly lines at DaimlerChrysler Brazil, because it is connected via an Ethernet switch to the company network.

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The progress in lithography technology to produce better chips worldwide

Beckhoff control system monitors new ASML wafer production units
The rapid innovation in the electronics industry generates many new products and services which play a major role in all aspects of society. This holds both for the information and telecommunications industry, as well as for many aspects of everyday life, such as transport, mobile phones, television etc. Technological developments in the semiconductor industry are just as quick. As one of the leading manufacturers of semiconductor production machines, ASML developed a production line for 300 mm wafers, the TWINSCAN range. The innovative PC-based control solution for monitoring and diagnosis of the complete system was realized with Beckhoff components.

The application of digital electronics is rapidly expanding throughout the entire world. At the heart of these applications is the integrated circuit (IC or chip). The rapid progress in electronics is a direct result from revolutionary improvements in the products of the IC industry. Since the beginning of the IC production, an enormous progress has been made in the performance and cost per function of these devices. The performance of chips roughly improves by a factor of eight every five years and the production costs decrease by about a factor of 20, during the same period. ICs are complex structures of patterns that are printed on silicon, a semiconducting material. A thin disk made of silicon, a wafer, is used for this. The most commonly used wafer today, typically has a size of 200 mm in diameter but the size of an IC is typically less than one square centimeter, so hundreds of ICs can be printed on one wafer.

With TWINSCAN at the limits of optical lithography

The IC industry is able to innovate so rapidly because of the reduction in dimensions of the electrical components, such as transistors. This enables the increase in the performance such as the speed of microprocessors and the reduction of cost per bit for DRAMs. To build the integrated circuit, about 20 to 30 layers of patterns have to be superimposed to obtain a three dimensional structure. With the introduction of TWINSCAN, ASML has launched a new era in lithography productivity. Thanks to revolutionary dual stages, balance mass compensation and advances in metrology technology, the promise of profitable 300 mm wafer processing is now a reality.

Two of everything: TwinCAT for TWINSCAN

With MBDS (Machine Based Diagnostic System), the new TWINSCAN series is equipped with a flexible monitoring and diagnostic system. MBDS monitors all safety and emergency systems and logs any alarms. At the same time, the current state of production is visualized on two display elements. An integrated assistant facilitates the setting of the diagnostic functions.
Among other requirements, the new control solution was expected to offer reliable monitoring of the safety circuits. The MTBF values (mean time between failure) of the system should be higher than the monitoring components. Furthermore, the system should enable flexible and easily expandable interfacing with the diagnostic sensors.

Following comprehensive evaluation, ASML selected the control system from Beckhoff. In cooperation with Industrial Automation Link, the exclusive Beckhoff partner in Holland, an automation concept consisting of Industrial PC, fieldbus communication via DeviceNet and software PLC was selected.

A further requirement for the hardware was small physical size. For this reason, the C6110 Industrial PC as the smallest device of the C6100 Control Cabinet PC range was selected. Two Control Panels with 10 inch TFT display for operation and visualization are connected to the system. The fully software-based control is realized via TwinCAT PLC. TwinCAT OPC deals with the interfacing to the Genesis 32 visualization software from Iconics. The I/Os for the monitoring and diagnostic functions of the TWINSCAN range are connected to a total of eight Bus Terminal stations. DeviceNet is used as a fieldbus. It is increasingly establishing itself as the standard for the semiconductor industry.

Control and visualization on a single PC

The use of a PC-based solution with standardized IT interfaces simplifies the integration of remote maintenance and remote access for data security. A further advantage is that control and visualization run on a single system, so that no further hardware is required.

The Control Panel can be configured to face right or left so that adjacent systems can be paired across a single operator aisle for ease of access. TWINSCAN’s modular design provides numerous benefits: move-in time is greatly reduced, bringing productivity online faster than ever; access to functional parts is improved to maximize uptime; and, future developments can be more readily incorporated. Maintenance is facilitated and uptime is increased. Efficient human interaction with the equipment is equally important. Intuitive software screens and online help text keep the operator fully informed of system status and events.

System integration expertise has enabled ASML to take the leadership position in the design and manufacture of imaging systems.
ASML is one of the world’s leading providers of advanced technology systems for the semiconductor industry. The company offers an integrated portfolio of lithography, track and thermal systems mainly for manufacturing complex integrated circuits.

Headquartered in Veldhoven, the Netherlands, ASML is traded on Euronext Amsterdam and Nasdaq under the symbol ASML. In 2001 the company reported net sales of over EUR 1.84 billion and employs approximately 7,000 people in 50 locations throughout the world.

www.asml.com
The PC-based control system from Beckhoff is also increasingly used for intelligent building automation. In a variety of projects, the company Herrmann GmbH is using Industrial PCs, Bus Terminals and the TwinCAT automation software.

Flexible building automation with the Beckhoff automation kit

For a number of years, the company, based in Plüderhausen, Germany, has been carrying out building automation and building management refurbishment work at the Allianz head office in Stuttgart. The refurbishment concept proposed by Herrmann envisaged to integrate the existing building automation system, which was based on older AEG technology, into the new system without interrupting the operation. A demanding task, considering that around 20,000 connected data points had to be processed. Beckhoff products are used in the refurbished areas; in parallel, some of the AEG technology remains in the Allianz building. The Beckhoff Bus Terminals used in the refurbished areas were initially networked via Profibus. Meanwhile, Ethernet is used for the continuously progressing refurbishment.

Case study: refurbishment of the building management system at the Allianz building in Stuttgart using high-tech automation tools

The Allianz project combines different technology worlds: Apart from the AEG world, solutions from Siemens and Beckhoff are interlinked via the building management system. The greatest challenge was the large number of binary data points, which all had to be integrated into the new Hercon building management system from Herrmann. More than 20,000 data points were distributed across three buildings. The client specified that the existing building management network should be used. The initial aim of this refurbishment phase was the replacement of the building management system computer, with continued utilization of the existing substations. Technically, the existing network was a telephone wire network. For the refurbishment of the substations and for the data collection from existing equipment, Herrmann suggested to use Beckhoff Bus Terminals with Profibus interface. Via Profibus, data could be transmitted through this network with the lowest transmission rate of 187.5 kbit/s.

The first application of the Bus Terminals was data collection at a lift installation. Once this application had been commissioned successfully, local intelligence was used for the subsequent application. The intelligent BC3100 Bus Terminal Controller was used, which contains a mini-PLC for small PLC applications. The aim was the realization of a fail-safe solution. Associated with this solution was the “discovery” of the Beckhoff automation kit by the company Herrmann. “In this way we examined the wide variety of the Bus Terminals, the Industrial PCs, the TwinCAT software PLC, and the openness of the system including OPC, and we investigated how we could integrate these options into our solution strategy”, said Gerhard Haag, project engineer at Herrmann.

Depending on the signal form, i.e. single or two-channel, the appropriate solution could be implemented with the Beckhoff terminal blocks like in a construction kit. This was one of the most important arguments for the use of Beckhoff products. The modularity and the associated cost advantages enables customers to move from existing, out of date technology to a new, modern technology with little expense. The refurbishment of the building management system is completed, but the Allianz project is still continuing. The older building management system substations are gradually being replaced with Bus Terminals. This work is likely to continue for several years. The original strategy had been to keep the existing equipment and to supplement it with Beckhoff products. The arrival of the intelligent Bus Terminal Controllers provided the opportunity to realize decentralized intelligent individual solutions. “The solution concepts now on offer could not be realized previously. The number of ideas has literally exploded”, comments Michael Falkenstein, instrumentation and control specialist at Herrmann. The BC9000 stations are now used with Ethernet interface, and an Ethernet network for building automation has been implemented. Distributed intelligence enables the creation of redundant control solutions, for example for the control of the refrigeration technology that is essential for a data center.

The individual projects realized at Allianz up to now deal with the refrigeration system, heating and ventilation equipment, data collection, intelligent camera control, lighting control and the logging of energy use. From the Beckhoff automation kit, the elements Bus Coupler, Bus Terminal Controller, Bus Terminals and the TwinCAT software PLC are being used.
In the center of Frankfurt, the company Herrmann undertook the building automation and building management work for the Eurotheum skyscraper, with 30 floors and a total height of 110 meters—one of the architectural highlights of the financial center on the river Main. A hotel is located in the upper part of the building, while the lower part is occupied by the European Central Bank (ECB). One requirement was the option of a new utilization concept for the premises. Flexibility was a high priority. In concrete terms this means that the room configurations and the room sizes can be rearranged within a predefined period.

Originally, the rooms were to be arranged in a "biaxial grid", the so-called biaxial solution. However, the ECB required a single axis solution. Single axis solution means that every window arrangement can be used flexibly. Because of its international staff structure, ECB specified that it should be possible to create three individual offices and a conference room for a particular team within 24 hours.

Apart from flexible wall layout, this also requires particular flexibility in terms of building automation. While the infrastructure of the end points for HVAC control as well as the blinds, sensors and actuators and the control elements for the lighting remains unchanged, the building user must be able to vary the interaction of these data points that are linked to the building management system. This is achieved through parameterization of the building management system.

According to the original utilization concept, all data points are connected via Interbus modules. These distributed data points are connected using Interbus technology and coupled with an interface card installed in an Industrial PC. Beckhoff computers are used as IPC stations. They are capable of integrating up to four Interbus interface cards. All data points within one office floor can thus be connected to a single computer. Bus terminals were also used for connecting additional data points that were subsequently required due to the change in utilization.

Oliver Schaube, project manager at Herrmann, describes the building automation concept of the Eurotheum building as follows: "The solution is a perfect example of the use of open systems. The building systems were connected with the industrial PCs via open I/O connection and bus technology. We are using a total of 40 Beckhoff C6130 Industrial PCs with 128 MB of RAM each, all running Windows NT4.0. Based on OPC, different makes were integrated into the building management system." The Industrial PCs with TwinCAT software PLC are all networked via Ethernet and linked to the central building management system.

With the switch from analog control engineering to digital technology, the significance of data communication in building automation increased, and the requirements became stricter.

TwinCAT deals with floor control at ECB
Mr. Herrmann, how do you process projects, how did you come across Beckhoff products?

Herrmann: From our point of view, the necessity to provide services means service from start to finish. In case of faults, we must be able to respond quickly. In my opinion, hindrances such as third-party software, for which no license is available and which requires service staff from the software manufacturer, should be eliminated from building automation. The same applies for the complete infrastructure. The complete supply chain is therefore very important to us.

Since we have been dealing with projects without relying on specific brands for some time now, and based on the premise that building management will be based on our software, we look for open solutions, with which we can realize our projects. This is how we came across Beckhoff.

What strategy did you use previously?

Herrmann: We realized projects based on various product concepts, for example with Landis&Staefa, Simatic S7 or Phoenix Contact. We now have had very positive experience with Beckhoff. For automation applications, we program Beckhoff products based on TwinCAT with structured text according to IEC 61131-3, i.e. we create reusable, open program blocks, particularly for building automation.

The Beckhoff products opened up a very interesting, open perspective. Starting with the question how we could realize economically and technically attractive and reliable solutions based on our service concept and given the required hardware coupling, Beckhoff offered a very flexible platform, almost like a system construction kit. This enables us to work out structured solutions, without our services being affected by dependencies.

What is your experience so far with Beckhoff products?

Herrmann: The answer is two-fold. For the Eurotheum project in Frankfurt we are using approximately 40 Industrial PCs from Beckhoff, each containing Interbus coupling modules. In this case, the data is logged via the Interbus and transferred to the Industrial PC stations. The IPCs are connected with our hercon building management system via TwinCAT and OPC. For the Allianz project, in addition to the IPCs we also used Beckhoff Bus Terminals in the refurbished areas for connecting the data points. We found the products to be very reliable, very open and modular, from connection method to software coupling.

What concrete measures do you support in case of faults, what is your approach?

Herrmann: We recently had a malfunction that demonstrated the significance that automation now has, and what the important issues are. A device failed over the weekend. During the troubleshooting we realized how helpful it can be to have the option of manual control directly at the device, in addition to central building management. The intelligent Bus Terminal Controllers from Beckhoff enable such solution details.

Why did you decide to go for Beckhoff Bus Terminals?

Herrmann: With an HVAC plant you never know exactly how many I/O points are required. The more flexibly one can plan, the more precisely the cost frame can be defined, particularly with analog I/O connections. Every card that is not required reduces the cost frame. The Beckhoff Bus Terminals enable very detailed planning and also very fine amendments. Further advantages arise from the open connection method. Our software specialists got used to the TwinCAT software PLC very quickly. The process created no problems whatsoever.
Beckhoff Drive Technology: The drive system for highly dynamic positioning tasks

Compact Digital Servo Drive and Synchronous Servomotors

Together with the Servomotors from the AM2000 series and the AL2000 Linear Motors, the AX2000 compact Servo Drives offer the ideal digital drive system for single or multiple axis positioning tasks:

➔ Digital Compact Servo Drives AX2000
  ➔ servo drives offering four different current loadings (3 A, 6 A, 10 A, 20 A)
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  ➔ brushless and high dynamic performance, with low moment of inertia
  ➔ a wide range of motors can be selected, from 0.1–40 Nm

➔ Linear Servomotors AL2000
  ➔ exceptional drive characteristics in terms of dynamics and synchronism
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For further information and international sales contacts see: www.beckhoff.com

BECKHOFF New Automation Technology
Replacing a conventional, fully automatic template-controlled system for blade grinding with a Compact PC saves expensive grinding templates, reduces set-up times, achieves better reproducibility and offers the option of remote maintenance.

Radical overhaul of the grinding machine series

PC technology supports new approach for knife grinding

It is a well known problem in the butcher trade: A correctly grinded knife increases the quality of the cutter products, while imperfect grinding not only has a negative influence on the emulsification or mixing of the raw meat materials, but also significantly reduces the service life of the knives. The company Knecht GmbH, based in Bergstreute, Germany, is serving this market niche of grinding and polishing cutter knives for nearly 45 years. The construction of machines for complicated grinding operations is also part of the company tradition.

In May 2001, developers from Knecht made a strong appearance at the IFFA in Frankfurt, one of the largest trade fairs for meat industry investment goods. The food industry was presented with the first CNC-controlled grinding and polishing machine, the B 600. The core of the new machine is formed by an Industrial PC from Beckhoff, the TwinCAT NC I automation software for CNC functionality and digital Bus Terminals with a Profibus Bus Coupler as distributed I/O station. A knife changer with magazine enables automatic processing of up to eight knives.

The end for templates – displays and keyboards take over

"Activate the control, select the knife type and press start," this is how Peter Heine summarizes the advantages for the user. Previously, the user had to rely on a fully automatic, template-controlled system for guiding the knives to generate linear or circular tracks. Today he simply selects one of the knife types stored in the PC. "The old system did produce good quality," reports the chief designer, "but set-up times and reproducibility had reached their performance limits."

Another disadvantage: The expensive grinding templates became obsolete when the knife was changed. "With the increasing variety of cutter knives, our customers wanted a more advanced system", the grinding expert recalls. The experts from Knecht responded accordingly. Over the last few years, intense efforts were made to adapt the machine concept to CNC.

With the Beckhoff system, the CNC concept of the new B 600 machine generation was launched. "Our main aim," said Peter Heine, "was the realization of an advanced, clearly user-oriented control concept." The main requirements can be summarized as follows: First of all, the machine set-up times had to be reduced. Other aims were better reproducibility and thus improved quality. The system had to be user-friendly and easily comprehensible and produce the optimum blade shape and blade profile for each knife type with maximum precision. "What we had in mind," reports Heine, "was an open control system, which on the one hand was suitable for adaptation to new grinding tasks and on the other hand offered..."
the user simple operation." Beckhoff offered such a system. The developers from Knecht chose the CP7130 Control Panel with add-on PC and integrated keyboard extension as the operating station. Mounted on an adjustable supporting arm, the system offers optimum ergonomics for the operator in each machine installation situation. The advantage of this add-on PC solution is that the fully-fledged PC is mounted at the rear of the Control Panel, thus saving valuable space at the machine. TwinCAT NC I (NC interpolation) based on the Windows NT operating system is used as automation software in the production machines from Knecht. Via the axis interpolation CNC functionality, TwinCAT NC I controls the knife support through set value generation and position control. For communication purposes, the machine developers selected the Profibus, since the valve group integrated in the control system is equipped with a Profibus interface.

Complex control enables intuitive operation
The different knife shapes and sizes are stored on the hard disk of the PC. The intuitively simple operation means that the operator merely has to select the knife type on the TFT display of the Control Panel. Once the machine is started, the knife changer positions the first of eight knives from the magazine in the right position count of through appropriate additional cutting contours in the description of the geometry. This description is stored in XML files in a structured way. It is processed via a second XML file containing the stored processing steps and the actual condition of the knife. The curves for the respective machining and feeding steps are calculated and stored in tables. The NC calls up the specifications from the tables and moves along the paths with the knife. If a wear limit is violated, the computer does not activate the grinding process.

Remote maintenance via modem
For Peter Heine, a big advantage of this solution lies in the option of remote maintenance and fault diagnostics. "The program PC-Anywhere enables us to log into our customers' machines worldwide via modem," as Heine describes the advanced approach. The grinding experts can thus not only immediately detect machine or operator errors, but also maintain the software and install new updates. Peter Heine: "This has drastically reduced our service expenses and made most journeys to our customers superfluous."
Becker GmbH & Co. factories in Wuppertal and Apolda qualify more than 80,000 vacuum pumps and compressors each year following a successful test run. The parameter test and the functional testing are indispensable elements in the products’ quality assurance. Because the products are used in all parts of the world, they must support the power supply voltages at the site where they will be used. This can vary between 110 and 600 V, has frequencies of between 40 and 85 Hz, may supply a power of up to 90 kW, and may be available as three-phase power or as simple AC. This wide variety makes particular demands on the flexibility of the test system. The test system must meet very varied requirements, according to the device type – and must do this without long set-up times.

Testing the electrical and pneumatic parameters of pumps and compressors is done in a number of stages. Following final assembly, the devices are given numbers so that they may be uniquely identified. Each product type also has a factory number, by means of which the supply voltage parameters required for testing may be determined. In the subsequent phases, a barcode reader identifies the item by its factory number and device number. To begin with, the voltage parameters recorded in the device type are set. The device is then allowed to warm up for one hour, during which the electrical parameters are monitored, recorded and archived. This includes the measurement of effective power, current and voltage. After the warm-up phase, the pneumatic parameters of input and output pressure, input and output temperature and the volume rate of flow are measured. These parameters are determined and archived for at least three working conditions: full load, half load and idling. The ambient conditions, such as temperature and air pressure, under which each measurement was taken are also measured and appended to the set of test data. For the purposes of quality assurance and subsequent statistical analysis, the test results for each device are placed in a long term archive, and can be recalled at any time.

A total of six test units constitute the quality assurance system for the pumps and compressors. Each unit controls twelve test locations in parallel. The test benches are co-ordinated by a higher-level server. The Bus Terminal technology and bus-compatible components such as frequency converters and effective power instrumentation are consistently put to use at the I/O level. Each test system acquires about 70 digital and 100 analog signals through the Beckhoff Bus Terminals. The fieldbus devices communicate with the associated test location PC via Interbus. At the heart of a test bench is an Industrial PC for control of the test locations and six compact PCs of type CP7132 for visualization. The 15 inch Control Panel with Touch Screen and integrated add-on PC meet protection class IP 65. The test and inspection processes are controlled with the TwinCAT automation software. ObjectVIEW from Vogel Automatisierungstechnik, is used for visualization and parameterization of the test locations and test procedures. Also, ObjectVIEW is used for coupling to the higher-level server. TwinCAT OPC provides the link to the control software.

The tasks of the visualization software are divided into a number of modules. The first step is to provide the controller with the appropriate parameter data; thus, depending on which type of device has been read, the correct monitoring parameters and test procedures can be provided. The appropriate data is transferred to the frequency converter, so that it can provide the necessary supply voltage, and the test locations are synchronized. Another module is the one for operating and observing the test processes. Detailed information on the current state of the individual test processes can be examined. If any of the monitored parameters are exceeded, it is reported and archived. The implementation of automatically executed safety strategies when limit values are exceeded avoids destruction of or damage to any test items that may have faults. A central server is used to manage the data for the test benches. Its tasks include the acceptance and archiving.
Vogel Automatisierungstechnik GmbH

Vogel Automatisierungstechnik GmbH, as partners for the integration of automation and IT systems, implement customized technical applications and integrate them with company information systems. Vogel have brought pioneering innovations to the application of the LabVIEW graphical programming system from National Instruments through the extension of "Graphical Object Technology" with ObjectVIEW. This allows design, implementation and documentation to be carried out in the course of one working process, based on graphical data and event flow, object and Petri networks. ObjectVIEW is based on LabVIEW, a graphical programming tool in widespread use for instrumentation applications, but which until now has primarily been restricted to measurement tasks, and was not intended as a universal programming tool for distributed systems. With ObjectVIEW extending the functionality of LabVIEW it is possible to create applications of any size graphically. The software structure is based on intelligent distributed software nodes. Real objects such as sensors or intelligent bus components are assigned to software objects. This means that the application no longer consists of enormous blocks, but of a large number of small components that interact with one another. ObjectVIEW makes it possible to program complex test procedures as flow diagrams, and to execute them directly. The software is many times clearer and more transparent than implementations involving text-based programming tools such as C or Visual Basic. Changes to the test processes can be implemented rapidly without having to make far-reaching modifications to the software. This can bring a significant reduction in the effort required to develop and implement the software, and this finally results in a not inconsiderable cost advantage.

Vogel Automatisierungstechnik GmbH, Jena, Germany

Systematic organization of the control system

Picture proof: Klinisches Medienzentrum (Clinical Media Centre) FSU-Jena, Michael Szabó

Test location for Becker vacuum pumps in the Apolda works

of the test results, saving them to CD, and the management of all the necessary parameter data sets for the testing processes. The ObjectVIEW Server provides Internet client’s access to the test system data. This means that modifications can be made to the parameter data sets, individual test results can be researched, and a variety of statistical analyses made using a standard Internet browser.

Jens Vogel, General Manager of Vogel Automatisierungstechnik GmbH, summarized in conclusion: “The combination of TwinCAT as the PC-based controller, and ObjectVIEW as the visualization and archiving software offers both large cost benefits in contrast with proprietary controllers, as well as a powerful technology that can effectively be adapted to future developments.”
Austrian branch becomes Beckhoff Automation GmbH

The head office of Beckhoff Austria is in the town of Bürs, embedded in the sunny, alpine region of Vorarlberg. The success story of the branch, initially solely represented by graduate industrial engineer Armin Pehlivan, started from here. Armin Pehlivan recalls the beginnings, when the Beckhoff branch had a total of 2.5 customers. Over the past 5 years, the number of customers has increased to 200. This positive company development in the technology sector is not necessarily characteristic for Austrian conditions. Because in addition to the four large domestic controller manufacturers, international companies, e.g. from Germany, USA and Japan, are also competing in this relatively small market. Despite the competitive situation, Beckhoff managed to hold its ground through their innovative product range.

The continuous growth requires changes, not least in the European market. Having been in existence since June 1, 1997, Beckhoff’s Austrian branch will write its own company history as Beckhoff Automation GmbH as of May 1, 2002.

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“A first-class, state-of-the-art product forms the basis for a viable company”, says Armin Pehlivan, “but our company structure with shallow hierarchies and our quick-reacting and competent team are also significant factors of our success. Every customer, from small engineering consultancies to large companies, receives the same thorough service from us. This often includes active support for the company’s own development work. Our customers often have their own pioneering ideas and technological innovations, leading to very special and individual demands on our work and associated adaptation of the Beckhoff products. Many successful projects, starting from conception via compliance with the schedule and machine operation vindicate our company philosophy.”

This special form of customer care is further enhanced by our support service. For support manager Michael Jäger, relationships on a partnership basis and personal bonding with the customer are a high priority. “In order to jointly develop solutions for these complex requirements, we design directly at the site where the application is to be implemented. After the realization, we continue to provide personal customer support. Continuous availability via telephone as an elementary support instrument, particularly for customers using support-intensive products such as TwinCAT, is a matter of course.”

With their training programme, the Austrians take the proven Beckhoff route of minimizing the support effort and increasing efficiency at the customer’s. In addition to the training center at the company headquarters in Germany, a trip to the new training facility in the Austrian town of Bürs is now an attractive option for many customers from southern Germany and Switzerland. The training room is designed for groups of up to 10 persons.

The aim of providing area-wide and continuous customer care has already been implemented through the expansion of our sales and support department within Austria, and through setting up a Beckhoff agency with offices near Linz (Upper Austria). Since July 2000, Klaus Wurm is responsible for sales and customer care there. “The customers appreciate our ‘all from a single source’ service and the excellent price/performance ratio. The convincing know-how lies in the unique openness of our systems and the advantages of the PC-based control”, as branch manager Wurm comments on the market prospects of the planned expansion.

For its controllers for the concrete industry, Dorner Electronic GmbH relies on real-time capability with the TwinCAT automation software and the Bus Terminal system from Beckhoff. The customer can still choose which fieldbus system he wants to go for. The modular system offers high flexibility and reliability during operation.

the separator plant extracting the oil from the emulsion was equipped with the C6140 Industrial PC and with the TwinCAT automation software. The visualization for the operation of the plant could be integrated as a third-party component without problem. Interfacing with the field level was realized via Interbus. An H1 connection via Ethernet for communication with other plants with S5 control units was also established. At the same time, a connection to our plant management system is maintained, where all fault messages and operational data are transmitted, visualized and recorded. This coupling was successfully realized with the TwinCAT OPC Server via OPC client server connection to the plant management system via TCP/IP.
the short term, Beckhoff Austria is planning to enlarge this office and to expand it by a technical support component. A further branch is planned to open in Vienna in early summer. In the short term, we also plan to expand our effective team by a young engineer for service and technology. The main company aims are quality assurance within the area of personal customer care and further increases in performance. The medium-term turnover target of the Austrian Beckhoff subsidiary is 20 million euros.

The managing director of Beckhoff Automation GmbH explains: “For our customers, everything remains as before. The only changes will be small organizational ones, which will have no effect on what really matters. Optimum customer support is the task we want to be measured against, and this will remain the case.”

Berhard Schwarzer, Manager Control Technology: “During the last 12 years, Filzmoser has produced over 50 reinforcement plants using robots. Last year, the robot was re-programmed for the Beckhoff system. The fully automatic triangular girder welding plant was also converted to the Beckhoff system.

The technology of the partially automated reinforcement plant of a precast concrete component facility was fully automated with the latest technology, in order to increase its effectiveness. To this end, an interface between the old B&R control and the Beckhoff system was created via ARC-NET. This development enabled Filzmoser to operate the latest equipment together with existing machines.

Austrians rely on Beckhoff technologies
**FRAMAG Industrieanlagenbau GmbH, Frankenburg**

Dipl. Ing. Christian Aigner, Saw Technology Project Manager: “The main consideration for the decision to use a distributed periphery, the CE6140 Industrial PC and the operating panels from Beckhoff was the required availability of a remanent memory at PC level for our circular cold saws. We are now able to offer our customers an all-in-one system without having to install a second system for database interfacing.”

With their Beckhoff components, the circular cold saw plants for the steel industry from FRAMAG Industrieanlagenbau GmbH are equipped with industrial PC control with database connection, which is accessible for all authorized users at any time. The open communication of the system also enabled the adaptation to the LENZE drives.

**igm Robotersysteme AG, Wiener Neudorf**

Ing. Gerald Schmerlaib, Technical Manager: “For our new generation of robots we use DeviceNet Bus Couplers from Beckhoff in order to control the periphery devices. This is a very cost-effective solution, because the robots are equipped with DeviceNet inputs/outputs as standard, and Beckhoff offers the option to connect as many input and output modules as are required. For more complex applications we use intelligent, programmable Bus Terminal controllers.”

The welding robots from igm Robotersysteme AG are mainly used in heavy machine construction. The rough industrial environment with high interference emissions places high demands on the design and on the robust quality of the hardware. The trouble-free, powerful Beckhoff control cabinet PC is screwed directly onto the mounting plate of the control cabinets. Visualization and data acquisition are done outside the workstation via extremely soiling-resistant Control Panels. A panel with a PC as master computer is used for the visualization of all networked welding robots. Software developed in-house at igm is used for data acquisition. Since the system is made up of standard components, it also ensures the continuity of the spare parts supply.

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**Isotec Bewegungstechnik GmbH, Tull-Staatsdorf**

Andreas Bernreitner, Software Engineering: “In order to implement our diverse applications as quickly and efficiently as possible, together with Beckhoff we have found an integrated and flexible solution for our machine control systems, starting from simple PLC functions via NC-PTP functions to cam plates and CNC functionality.”

By using the Beckhoff components of control cabinet PC, Lightbus card and Lightbus coupler as well as the Beckhoff servomotors, Isotec Bewegungstechnik GmbH has implemented a unified concept for all types of machines. Visualization is done via a Beckhoff Control Panel. The system offers full PC functionality of the control system and thus big advantages for visualization, modern and Internet connection. The simple data exchange via standard Windows interfaces offers high system flexibility.

**Langzauner GmbH, Lambrechtien**

Erwin Witzmann, Managing Director: “The Beckhoff components are advanced and easy to operate via Windows interfaces. The system can also easily be connected to other networks for the transfer of data from others systems such as production planning. The option of remote maintenance in case of a fault is particularly beneficial.”

LANGZAUNER, a company from Upper Austria dealing with woodworking machines and plastics processing and machining has improved the operation and visualization of its new automatic cutting machine located in the plate-dividing center. Components of the positioning software from Beckhoff were used for programming, and the in-house PLC programs were integrated into the control system via an Industrial PC. The interface and graphics were also implemented as third-party components. The optimization of the cuts or the division of the plates can thus be displayed graphically. The Lightbus is used at the field level.
Austrians rely on Beckhoff technologies

Roman Skamletz, Director Electrical Engineering: "The ingenious thing about the TwinCAT software from Beckhoff is the cost-saving through the avoidance of technical expenditure for hardware. The use of standard components enables our customers to set up a cost-effective spare parts depot. And we can deal with customer requirements much more individually. Initially, we had reservations about the time required for implementing the software design. However, during the testing phase everything turned out to work without problems, and this has been the case ever since."

Robotech Logistiksysteme GmbH specializes in system design for highly dynamic material flow systems. Projects for customers across the world are realized from the design stage to the commissioning of warehouse and transport systems. Regional differences in the standards for hardware and programming language led to Robotech’s decision to convert to the internationally recognized IEC 61131-3 standard. Robotech has fully converted to the TwinCAT control from Beckhoff under Windows NT and to fieldbus components. TwinCAT works remarkably well in conjunction with Robotech’s own software for the warehouse control system. The standard components make Robotech GmbH hardware-independent worldwide.

MAG Anlagenproduktion GmbH, Deutschlandsberg

Robert Urch, strategic buyer: "With the introduction of the Beckhoff components, we were able to minimize our failure rate via a safe and stable process, which now continues to run even in case of failure of the industrial PC."

The PLC scheme for a central PC control was designed from scratch by MAG, and was developed from a basic structure into a complete solution using Ethernet, fieldbus and intelligent Beckhoff Bus Terminals. The intelligent, memory-capable Bus Terminal Controllers were programmed in such a way that they can control the system automatically. The control cabinet PC with Touch Panel visualises the state of the different modules, which can be queried at any time, and is used for controlling, setting and monitoring the manufacturing process.

SAA Engineering GmbH, Vienna

Dr. Christian Hanser, Managing Director: "The open policy of the Beckhoff fieldbus system and of the interfaces makes us independent for the future. A comparably powerful software PLC and NC is difficult to find in the market, especially with such a good price/performance ratio. Our technical demands on the Beckhoff team, e.g. in the area of path control, are very high. We very much appreciate the dynamic service and the excellent support."

SAA Engineering GmbH is one of the leading suppliers of complete solutions for concrete precasting plants in Europe. The range of services includes management and control systems for industrial plant engineering. The latest solution is a path control for gantry robots, developed on the TwinCAT platform. The picture shows a handling robot that places formwork components for the production of wall elements for domestic buildings onto a pallet. The individual design of the precast parts means that all robot movements have to be recalculated online for each new part. Together with a graphical travel range editor, a powerful collision algorithm monitors the preset system limits and the obstructions that have to be avoided. The control solution consists of TwinCAT running on a C6140 control cabinet PC with connected Control Panel. The four servo axes and the digital inputs and outputs of the complete plant are controlled via Lightbus.
TEST-FUCHS GmbH, Groß-Siegharts

Volker Fuchs, Owner: "For high-performance automation, our quality requirements for continuous PC operation are very high. Our devices are tested for 72 hours. The Industrial PC from Beckhoff offers higher reliability and more flexibility in conjunction with standard components."

The concrete production plants from SCHLÜSSELBAUER Maschinenbau GmbH enable a large number of standard products as well as very individual products to be produced. The tremendous control effort is managed with a C6140 Industrial PC and TwinCAT NC PTP. The system consists of four runtime systems for the production machine, the pallet handling, the production crane robot and the Muffenkran robot. The production manager with database connection, programmed in Delphi, receives and transmits information from and to the four runtime systems via TwinCAT ADS communication. The complete systems with Beckhoff control are commissioned worldwide by SCHLÜSSELBAUER GmbH.

STIWA Fertigungstechnik GmbH, Attnang-Puchheim

Harald Strauß, Director Development Systems: "We have invested a lot of time and intense efforts in completely new concepts, resulting in fast communication and access to all axis set and actual values via the Beckhoff components. To achieve this, a direct development partnership with the Beckhoff developers is imperative. We utilize the system to its limits and sometimes beyond."

A typical control cabinet design at STIWA Fertigungstechnik with five Beckhoff industrial PCs, TwinCAT software PLC and fieldbus components. Almost unlimited memory for constantly increasing the computing capacity and free programming are STIWA’s system requirements. With TwinCAT, STIWA uses a pure PC-based software solution and reaches PLC real-time capability in the millisecond range. Several control PCs communicate with each other simultaneously via TCP/IP. The Beckhoff Lightbus deals with the fast measuring and control processes (bus cycle 1 ms).

TEST-FUCHS GmbH has developed its own measuring software that controls their testing devices for space and aeronautical engineering applications. The prerequisite for individual, customized programming is flexible hardware. TEST-FUCHS therefore uses rack-type industrial PCs for installation in the control cabinet from Beckhoff.

Hydraulic floor trolleys for menu-controlled checking of hydraulic systems in helicopters.
The exacting demands of transfer and handling systems are realized via a modular mechanical system and a powerful PC controller. The technology applied can be summarized as follows: The basic mechanical modules are sheet loader, loading and unloading devices, inter-press shuttle devices, 2- and 3-dimensional transfer devices as well as suction bar transfer devices. The movements of a large number of servo axes, synchronized with the press via two master encoders, is realized through the SERCOS interface drive bus via a motion law (5th degree polynomial). Nearly jerk-free motion of the handling equipment and transfer devices is ensured at any time. An electronic shaft connects all axes, so that they are synchronized with the respective press angle and the variables “velocity” and “position”. The interfacing of the I/O layer is done via Profinet DP through the Beckhoff Bus Terminals.

Güdel uses Beckhoff technology for transfer and handling systems

PC as control platform

Latest control and servo technology, combined into a mechatronic system using an innovative mechanical concept, allows extremely flexible, optimally designed solutions for the automation of movement sequence. Güdel proves how software PLC/NCs can achieve maximum productivity of a production process with the transfer and handling systems for presses, large-scale presses and press application.

A satisfactory result for the end customer requires customer understanding of a new technology. This understanding can only be achieved through close co-operation between machine manufacturer and control developer. In the current example, the team made up of representatives from the companies Güdel (Langenthal/Switzerland), TAS (Recherswil/Switzerland) and Beckhoff, already experienced in such demanding tasks, proved once again successful.

Lower costs, yet more security

In too many cases, the control experts have to struggle with the evaluation of a variety of hardware components (visualization PC, PLC, NC/CNC modules etc.), have to balance operating systems and programming languages and worry about hardware and software interface problems. Compared with traditional control technology via PLC, PC-based control with software PLC reduces the complexity of the controller by at least 40 percent and the cost by at least 60 percent. An additional benefit are increased reliability and availability because far fewer individual components are used. Due to the predominant use of standard modules, the exchangeability of faulty modules is improved significantly. Due to the reduced engineering effort, more time is available for what really matters - process optimization. The “time to market” is clearly improved.

Axis coupling with tables

In many applications it is necessary to synchronize two or more axes. This also applies to the Güdel example. A hardware solution failed to deliver the desired result, but the software version was able to fully satisfy the demands of the customer. Axes can be software-coupled via Twincat NC PTP. A master axis is ac-
tively controlled, and one or more coupled slave axes are synchronously positioned via TwinCAT. The simplest type of coupling is linear coupling with a fixed transmission ratio (electronic gearbox). More complex applications, such as the example described, require more complex coupling of master and slave, which cannot be described by a simple mathematical formula. Such a relationship can be described by means of a table that specifies an associated slave position for every master position. TwinCAT now offers the option of coupling a slave axis with a master axis (electronic cam plate) via a (cam plate) table. The table contains a certain number of prescribed reference points, and the NC interpolates position and velocity between them. Multi-table coupling also links a slave axis with a master axis, but different tables are used for different position regions.

**Worldwide application**

The question of the acceptance and the reliability of software PLC systems has been answered positively some time ago - at least at Beckhoff and others. The reason why various industries are still reluctant to use the technology is that it is difficult to say goodbye to familiar and accustomed technologies. There is no significant technical argument that would prohibit the use of software PLC for complex applications. Moreover, the successful application examples worldwide signal a clear approval by customers from an economic viewpoint.

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**Key transfer figures at Güdel**

<table>
<thead>
<tr>
<th><strong>NC part</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of SERCOS axes</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Master axis encoder via SERCOS</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No. of TwinCAT axes</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Table couplings</td>
<td>10, of which 2 multi-tables</td>
<td></td>
</tr>
<tr>
<td>Coupling types</td>
<td>linear, tables, 2 real and 2 virtual master axes</td>
<td></td>
</tr>
<tr>
<td>Table entries per table</td>
<td>3600 rows</td>
<td></td>
</tr>
<tr>
<td>Motion law</td>
<td>5th degree polynomial, calculated in the PLC</td>
<td></td>
</tr>
<tr>
<td>NC cycle</td>
<td>2 ms</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>PLC part</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions</td>
<td>approx. 45,000</td>
<td></td>
</tr>
<tr>
<td>Cycle time</td>
<td>10 ms</td>
<td></td>
</tr>
<tr>
<td>Real-time load</td>
<td>approx. 40 %</td>
<td></td>
</tr>
<tr>
<td>Axis data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td>7.5 m/s</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>15 m/s²</td>
<td></td>
</tr>
</tbody>
</table>

The control architecture of the electric transfer consists of industrial PC, Profibus Bus Terminals for I/O interfacing and the drive technology with SERCOS interface.
Windows NT Embedded supports an open, purely software-based automation solution. Via the platform generator, the original NT operating system can be reduced to a size that corresponds to the application. Like in the example of the “roboLoop” handling system from Güdel, this enables “manless” remote control via a wireless LAN.

The “roboLoop” developed by Güdel AG can handle large loads with maximum precision. In order to meet these demands, the control system and the TwinCAT automation software from Beckhoff were chosen, together with the Windows NT Embedded operating system from Microsoft. The main concern was to provide an open, intelligent control system with real-time kernel, which was easy to integrate into new and existing systems. Such a solution significantly reduces the development times.

Güdel: “Manless” automation

Innovative solution with Windows NT Embedded
The “roboLoop” transport trolleys run on tracks on the ceiling or on the floor and move from one machine or production center to the next.

Basic communication principle of the “roboLoop” system.

TwinCAT – the scalar platform for various applications
Güdel chose TwinCAT, since this software solution met the demanding requirements. On the mobile transport trolleys, NT-Embedded only requires an 85 MB Flash disc in the Industrial PC (instead of a hard disk), so that rough environments, vibrations and high ambient temperatures cannot cause any damage. Furthermore, TwinCAT offers a single automation solution for every possible application - from normal PC to embedded systems. The advantages and benefits for the application described are as follows:

- Via the platform generator, the original NT operating system can be reduced to a size that corresponds to the application.
- This option reduces the required storage capacity by half, in this case to 20 MB.
- The remote control makes “manless” operation possible that requires no monitor, keyboard or mouse.
- This remote control can be realized via TCP/IP protocol and wireless LAN.

The “roboLoop” system
The handling systems from Güdel are used in the automotive, vehicle components, textile and other industries. “roboLoop” automates the material transport from one machine or production center to the next in such a way that workpieces and tools arrive at the right place and at the right time for machining, assembling, checking or packaging. “roboLoop” is the first handling system that can move parts into any position not sequentially, but order-controlled.

A typical “roboLoop” system is populated with 10 to 15 trolleys on one processing line. Each trolley has an aerial for communicating with the cell computer via the wireless LAN (Windows NT Server 4.0). The cell computer communicates with the company’s production planning system (PPS) as well as with all processing machines within the production chain. The PPS “knows” all production processes and their sequence. It issues the appropriate travel commands to the cell computer responsible for the management of the PPS jobs and distributes them to the appropriate positions (machines) via the wireless LAN.
With more than 260 flexible manufacturing systems supplied in Europe and North America since 1982, Fastems is the worldwide leader in FMS technology. These extremely flexible systems enable both standard and customized solutions in the shape of individual machine cells or factory-wide systems. As an integrator of open systems, the FMS from Fastems is compatible with the machine tools of more than 40 different manufacturers.

Control power within the FM system
MMS (Manufacturing Management System) is a control system for flexible manufacturing systems that enables production to start directly after commissioning. This is made possible by the fact that no predefined data structures or other preparation are required in the basic configuration of the system. In the long term, the MMS can be used as an advanced manufacturing executive system (MES), dealing with a variety of production planning operations as well as resource management within the FM system.

In order to continue to be successful against the competition, Fastems continuously works on the further development of its control systems. The cooperation of Fastems with the company headquarters in Tampere (Finland) and with Beckhoff started five years ago. "Early 1998 we were looking for options to use the software PLC/NC from Beckhoff in our MMS control units," reports Matti Nurminen, Director Research and Development. "We looked at numerous alternatives and found that TwinCAT is particularly flexible and communicates very well with the outside world. The software appeared to be reliable. Its use in practice has proven that this assessment had been correct," continued Nurminen.

"Beckhoff was able to produce first-class references and to supply the best solution for our requirements."
explains Jari Tikkala, Director Automation Design. "In June 1998 we decided to use Beckhoff as our supplier. In early 1999, the first prototypes of the MMS control system were already being tested". Soon afterwards, the first systems with TwinCAT were presented at the EMO in Paris in 1999. The first delivery to customers went out not much later in the same year.

The cooperation between Beckhoff and Fastems continues today. At the end of 1999, fieldbus modules from Beckhoff were used for the first time. To date, Fastems has supplied more than 100 systems with TwinCAT and Bus Terminals with Profibus interface. Visualization is realized with Visual Basic and integrated in the control via TwinCAT ADS. Since the flexible manufacturing systems from Fastems are always tailor-made solutions, the modular design and the wide range of I/Os and Bus Terminals are ideally suited for this application.

Even a mass-producer such as DaimlerChrysler regularly produces individual pieces or small series. Prototypes, components for powerful engines in small quantities or spare parts have to be produced: High quality for smallest quantities requires modern, flexible manufacturing equipment that the qualified staff must be able to rely on. At its Simau site in Germany, DaimlerChrysler has just commissioned a new flexible manufacturing system from Fastems with control technology from Beckhoff as well as processing centers from Heckert.

"The new system leads to a tremendous reduction in production throughput times. "

Wolfgang Hanger, production manager for cubical parts at DaimlerChrysler in Simau, considers the decision to install a new production plant to be vindicated even after only a few months of operation. The aim to produce more productively and efficiently has been achieved. That the quality is right is taken for granted. The additional capacities had become necessary predominantly due to a new housing for powerful V-engines. The new manufacturing island consists of two CWK 630 D processing centers from Heckert, one CWK 630/5 and the flexible manufacturing system FMS from Fastems. Currentl., DaimlerChrysler uses the system for producing crank cases. The raw parts delivered from Untertürkheim are mechanically processed in four production steps and completed via intermediate manual manufacturing stages. However, the system is designed for a much wider product range. In principle, the plant can also deal with complete gearboxes or cylinder heads. Wolfgang Hanger explains his requirements: "The flexibility of the system is a result of the machines themselves and their machine environment as well as the tool magazines." With the combination of machines and FMS, even a product mix with a lot size of 1 is no problem.
An important element contributing to the flexibility of the plant is the flexible manufacturing system from Fastems that links the three machines. Originally, two alternatives were discussed: The simple solution would have consisted of stand-alone machines. With such a system, the staff would have had to deal with transporting the parts to be machined from machine to machine. However, we decided in favor of a linked system. The crucial factor was no doubt the gain in flexibility. Moreover, it was reassuring to know that Fastems, in combination with machine tool manufacturers, has plenty of experience in the realization of FMS in a wide range of variants. According to Hanger, further selection criteria were the compact design and the resulting simple installation. A storage shelf with 28 spaces for machine pallets is located between the processing centers and the assembly stations, at which manual tasks are carried out between the individual manufacturing steps. On this side, a tiltable and a linearly driven fitting station are provided. That process safety was a high priority almost goes without saying at DaimlerChrysler. The easily accessible fitting stations that can simply be loaded from above contribute to making the process safe. The complete control software, Manufacturing Management System (MMS) with integrated TwinCAT system, runs on a PC. It controls not only the process planning but also manages NC programs and tools including the preset data. The machining data required for the next job are transferred part-related to the machine control as a background process. Depending on the size of the clamping equipment, several different parts can be processed on one pallet. The MMS control deals with tasks according to the FIFO principle (first in, first out). Urgent jobs can be given priority as required. An already specified job sequence can thus be changed subsequently.

The plant has been officially in operation since October 2001. The first good parts could be produced only a few weeks after the installation of the machines and of the FMS – another argument for such a flexible manufacturing system. In the meantime, the system has been equipped with a 5-axis processing center, an innovation from Heckert. The integration of the processing center into the plant and its connection with the MMS took only just under four days. In retrospect, Hanger praises the speedy integration with largely continuous production: “It all worked out very well.” Of course the system should be used to capacity. Wolfgang Hanger: “Once the run-in phase of the 5-axis machine is complete and the staff has been trained in parallel, we will run the plant in 3-shift operation.” The Fastems aim - 8760 productive hours per year - has thus come a step closer.

Beckhoff technology for Finnish automation customers

Established in 2000, Beckhoff’s Finnish subsidiary started out with one employee. In two years, the number of the Beckhoff Automation Oy employees in Finland has quadrupled, the company has achieved a solid position on the Finnish market, and its business is growing.

The Finns are often in the lead when it comes to adopting the latest technological solutions. A good example of this is the fact that the per capita density of mobile phones and Internet connections in Finland is among the highest in the world. Finland also has many high-tech companies that can benefit from the top-notch technical solutions found in Beckhoff products.

Beckhoff Finland has customers in different industrial segments: Some of its clients specialize in materials handling and NC machines, and some are from the paper and process industry, and the electronics, plastics and energy industries. More and more often, sales of Fieldbus I/O systems evolve to the delivery of total PC-based systems customized to meet the customer’s needs.
Beckhoff in Finland held its second Automation in Motion seminar for its customers in late January. This year the very popular event brought in more than 70 participants.

The purpose of the Automation in Motion seminar is to bring customers information about new Beckhoff products and to provide a forum for industry professionals. Held in the historic Vanajanlinna castle, the day-long seminar hosted guests from the process, sawmill, electronics and plastics industries as well as representatives from production automation and machine engineering companies. Additionally, participants from Finnish colleges and universities were also present.

Beckhoff in Finland's Managing Director Mikko Uuskoski opened the seminar with an overview of the company’s operations in Finland. The Beckhoff products were introduced by Technical Support Manager Antti Airto and Key Account Manager Matti Korhonen.

Over the course of the day, some Finnish Beckhoff customers reported on projects they have implemented using Beckhoff products, and the future of automation was touched upon in a presentation by Kari Koskinen, Professor of Information and Computer Systems in Automation at the Helsinki University of Technology.
TDS Technology (S) Pte Ltd. have been exclusive distributors for Beckhoff in Singapore since the beginning of last year. TDS Technology have relationships with independent system partners in the neighboring countries of Malaysia, Thailand and the Philippines. In order to increase local industry’s awareness of Beckhoff products and systems solutions, TDS organized two seminars in Thailand and Singapore on the topic of PC Control in December of 2001. Kai Ristau, export manager from the firm’s German headquarters, was amongst the guest speakers.

The first seminar took place in the presence of 150 engineers and managers from 80 companies in Bangkok, Thailand. Organized by IBCON Co Ltd. in Bangkok, the Beckhoff components and concrete system solutions for automation were presented. In a further series of lectures in Singapore, 80 participants from 44 companies were invited to an introduction of Beckhoff’s PC Control technology.

Many participants in both seminars had positive comments to make about the products from the Industrial PC range, I/O systems and the TwinCAT automation software. Against a background of rising need for high-performance machines, there is a high potential demand for Beckhoff’s New Automation Technology.
Beckhoff PC Fieldbus Cards for fast control and real-time tasks

PC Fieldbus Cards with PCI interface provide compact fieldbus intelligence

The Beckhoff PC Fieldbus Cards have been particularly developed for fast controllers and for real-time tasks such as drive position control, and can therefore be used in a wide range of applications:

➔ fast data exchange through short cycle times (e.g. Lightbus: to 100 µs) powerful parameter and diagnostics interfaces
➔ freely configurable bus management for every device
➔ process data communication is either free running, synchronized or equidistant
➔ the intelligent Fieldbus Cards power is most easily seen when combined with the TwinCAT software PLC and NC

Use with optionally one or two fieldbus channels:
➔ Lightbus: FC2001, FC2002
➔ Profibus DP: DP-V1, DP-V2, MC: FC3101, FC3102
➔ CANopen: FC5101, FC5102
➔ DeviceNet: FC5201, FC5202
➔ SERCOS interface: FC7501, FC7502

Software:
TwinCAT I/O: Configuration tool, driver for Windows NT/2000/XP
TwinCAT OPC: OPC server for access to cards from OPC applications

For further information and international sales contacts see: www.beckhoff.com
Ronald Heinze interviews Hans Beckhoff about trends, visions and developments.

Beckhoff implements open automation systems based on PC-compatible control technology. "First and foremost, we see ourselves as a system provider for the automation industry. We produce all the necessary components," as Hans Beckhoff, Managing Director of Beckhoff Industrie Elektronik emphasizes. "We have developed our technology primarily for the machine construction industry," Beckhoff continues, "but the products are increasingly used in other areas too. Examples of successful applications are building automation, plant engineering or wind power converters.

Unabated growth
There is no question about Beckhoff being the industry leader, a model for many small to medium sized automation companies. Even during the difficult last year, the industry electronics section within the Elektro Beckhoff GmbH was able to achieve further growth in sales of just under 16 % to 77 million euros. The total result of the company for last year was 96 million euros. However, Hans Beckhoff admits that this growth mainly occurred during the first six months - with a growth rate of 30 % during this period. The second six months suffered from the slowdown in the machine construction industry, "although since October the number of orders has been growing again." For the current year, the 48 year old Beckhoff expects a mirror-image development, i.e. weaker first half, good second half. The entrepreneur does not consider the long-term growth targets of the company to be affected by the current lull. Because he is convinced that, with PC automation and fieldbus technology, his business is based on markets with above-
ever, the automation experts from Beckhoff are at a loss to understand why Siemens needs three different control variants, i.e. Simatic, Simotion and Sinumerik, to cover user requirements. “Today, functionality is offered in the shape of software on universal hardware”, says Beckhoff. There is therefore no technological reason for the tri-partition suggested by Siemens. Beckhoff prefers a unified control approach. “With TwinCAT, the IPC philosophy and the fieldbus technology we offer an integrated and unified automation world without discontinuities, from mini PLC to high end CNC.” The area of production machines, which Siemens wants to cover with Simotion, has been supplied very well with Beckhoff solutions for a long time. The same applies to the PLC and CNC worlds. “Combined with Beckhoff technology, the software CNC is experiencing an upturn”, confirms the managing partner and points out a large number of “pure” CNC projects that were successfully handled by the Verl-based company - not least in series machine construction. As an example he mentions milling centers for woodworking machines, but also classic metal machining applications. Technologically, this is no surprise, because functional modules are already part of TwinCAT in this area; for example, there is a module for interpolating path technology. Considering the market as a whole, these successes are rather remarkable: The traditional CNC suppliers obviously do not yet see a reason for replacing their CNC hardware concepts with PC-based solutions. Here too, the CNC market appears to be less keen on innovation than the PLC sector. The question of distributed control units is currently being discussed intensely within the market. Beckhoff’s view is that “different control architectures may be appropriate for different machines.” Transfer lines, for example, require more distributed automation. Overall, Beckhoff considers the concept of hierarchic modular automation to be a sensible one. Fully decentralized control intelligence will not be the main focus. A hierarchic control architecture allows for central or distributed intelligence, depending on requirements. The automation specialist considers the separation of hardware and software to be more important. The software increasingly provides the functionality and also deals with communication interfacing. An OPC server for TwinCAT has been in existence for a long time. Beckhoff also considers OPC DX to be a sensible development: “Once this technology has a certain market relevance, we will support it with our products.” The Microsoft technologies are used as a basis for the automation software. For a number of years, the SME from eastern Westphalia has been co-operating intensely with the software giant Microsoft. Hans Beckhoff is convinced, not least for this reason, that “Windows XP, Windows XP Embedded and CE offer the industry a well balanced operating system world.” According to the automation specialist, Dot-Net offers “an additional layer of abstraction. This is very welcome, since it is now possible to write programs that are independent of the processor and the operating system.” Since .Net will eventually enter the automation market, “the dependency on Microsoft will no doubt..."
Automation in the near and distant future

The technological development of automation is driven by micro-electronics: The electronics industry is rapidly developing Tera-Hertz processors that are faster still by a factor of 100. "Automation engineers will then ask themselves the question whether there is life below 1 ms," says Beckhoff, the automation visionary: "I think the answer is yes. In my opinion, the gain in processing speed could be utilized particularly well for the cost-saving application of fast measuring technology in automation. Faster and faster fieldbusses can deal with fast measuring signals. Here, Beckhoff sees interesting opportunities for the future through the combination of classic automation technology and scientific solution approaches.

Control engineering will also benefit, particularly in the area of drive technology, with opportunities for new applications opening up - keyword mechatronics. "Previously, the mechanically forced movements in the machines were faster than the electrical control technology, this balance is currently changing in favor of the electronics." Movement sequences are thus becoming faster and faster and less expensive. According to Beckhoff, this leads to a paradigm shift in machine construction.

The entrepreneur continues: "Engineering has a lot of automation potential, which Beckhoff will explore." The development of engineering tools will progress rapidly, in order to make the complex automation technology more manageable. Today, humans still take on many tasks that could be done by compilers: "This human translation work could be transferred to tools that are refined step by step. This will be the trend over the next two to five years. Further down the line, in Beckhoff's opinion there are many opportunities for "personal automation". Hans Beckhoff's daughter (9 years) and son (16 years) dream of their own R2D2 robot (from the Star Wars series). "The questions is who will tackle these tasks in the future - Sony or the machine construction industry."

World-wide presence on all continents

Nine branches located all across Germany represent Beckhoff. A presence in the international market is ensured through subsidiary firms in Switzerland, Austria, Finland, China and in the USA. With worldwide co-operation partners, Beckhoff is represented in over 30 countries. Additional agencies are planned for the Czech Republic, Poland, Turkey, Korea and New Zealand. Notwithstanding the economic downturn, sales in the USA have also increased. Hans Beckhoff: "Our US subsidiary is shaping up very well. Also, there are first signs that the US economy is recovering." This would match the long-term economic development, which tends to show two years of recession after five to seven years of boom. "This rhythm was only interrupted by the IT boom, which had extended the last upturn phase to nine or ten years," as the entrepreneur explains. The new agency in Canada is also supported from the USA.
Beckhoff increases turnover in the year 2001 by more than 16%

Growth through innovative automation know-how

With a turnover of 77 million euros, Beckhoff Industrie Elektronik, Germany, achieved a plus of around 16% compared with the previous year, which brought a turnover of 66.5 million euros. New Industrial PC variants, expansion of the I/O product line and successful re-launch of the TwinCAT 2.8 automation software were important guarantors of success during a difficult year for the entire automation industry.

With the “New Automation Technology”, Beckhoff increased its turnover during 2001 by 16% to 77 million euros (2000: 66.5 million euros).

A milestone for resolute growth was the construction of an additional production hall with a 2500 m² floor area and the establishment of a service and logistics center with a 1200 m² floor area. These new facilities have increased the available area at the headquarters in Verl to over 10,000 m². This had a direct effect on the production of Industrial PCs, which last year increased by more than 50% to nearly 10,000 units.

Pushing ahead with globalization

A further cornerstone of expansion is the significant increase in orders received, particularly abroad. The foreign subsidiaries and the partner companies across the world made a substantial contribution to the excellent export results. Beckhoff established its own agency in China as well as partner companies in India and South-East Asia. Also, Beckhoff strengthened the existing Beckhoff USA head office, located in Minneapolis, with seven branches, covering all time zones in North America. Operations in Eastern Europe were also expanded through partner companies in Hungary and Slovenia, giving Beckhoff representation in over 30 countries. Beckhoff further increases customer awareness of the “New Automation Technology” by completing several projects in the newly entered industries of building automation and measuring instrumentation.
Trade show dates
2002

For additional information of our worldwide subsidiaries and partner companies trade show schedule please check www.beckhoff.com
www.pc-control.net

Online or offline: interested readers can choose to consult the "New Automation Technology Magazine" in hard copy, or through the convenience of the Internet.

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