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PC-based control for process automation: New products for hazardous areas and integration of relevant interfaces

HART functionality integrated in TwinCAT software and I/O system

In the process industries, demands are increasing for groundbreaking and innovative automation solutions that reduce costs. The greatest potential for optimization is opened up by implementing a universal platform that covers both industrial automation and process automation. PC-based control from Beckhoff fits this bill by integrating process-specific protocols and interfaces, and by offering an extended range of products for hazardous areas. Full implementation of HART functionality, both in the I/O system and in the TwinCAT engineering environment, promotes simple project planning and reliable commissioning.

TwinCAT automation software clearly reduces development efforts in process technology because it facilitates the application of comprehensive HART functions directly from the engineering interface. In this way, the TwinCAT FDT (Field Device Tool) container enables implementation of any field device drivers (Device Type Manager, DTM). Thus, an entire HART configuration can be implemented efficiently using a single tool.

The Beckhoff CommDTM integrates the TwinCAT platform into existing process control systems. With its help, the DTM can be implemented in any FDT container. This applies to all field devices connected to the HART-capable EtherCAT Terminals. These devices can be configured and parameterized remotely in the known containers without requiring direct PLC access. As a result, system operation is simplified and reduced to the essentials. In addition, the Beckhoff OPC UA Server and Client enable secure global distribution of process data, as well as convenient system control and remote maintenance capabilities.

Explosion protection systematically integrated into product portfolio

The new, highly compact EtherCAT Terminals in the ELX series are also HART-capable. With intrinsically safe inputs/outputs, they enable the direct integration of field devices installed in hazardous areas, Zones 0, 1 or 2, into the automation system. The reduced wiring effort and associated space savings result in an integrated, cost-effective solution for process applications. Furthermore, the new CPX series of Control Panels and Panel PCs makes the high-quality design and advanced multi-touch display technology from Beckhoff available for locations subject to explosion hazards.

Further information:

www.beckhoff.com/process
Significant investments in the training of young professionals:
Beckhoff Automation employs 105 apprentices and 95 student trainees

Dynamic growth has created rapidly increasing demand for highly qualified staff at Beckhoff. The company currently employs 1,100 engineers in its product development, sales and support operations worldwide. To meet this rising need for skilled personnel, Beckhoff invests roughly 3.5 million euros each year into the education and training of young professionals.

Structured training of young people represents a long-standing tradition at Beckhoff and is a core part of the company’s business philosophy. On September 1, 2017, 32 young employees embarked on their professional careers at Beckhoff. The spectrum of training opportunities is broad, and ranges from specialized computer science for application development and systems integration to electronics specialists with a focus on automation, industrial engineering, or devices and systems, to industrial business managers, media designers and specialists in storage logistics. A practice-oriented degree course program has also proven beneficial for students and Beckhoff alike. On August 1, 2017, 27 students enrolled in bachelor’s degree programs in mechatronics/automation, industrial engineering, digital logistics and product service engineering. Currently, 94 students and 105 apprentices are employed at Beckhoff. The company plans to hire all of them upon the successful completion of their apprenticeships, or once they receive their degrees.
Digital sensors return a discrete value of 0 or 1 to a controller. The controller, usually connected to I/O systems over a fieldbus, reads out the bus system data in a set cycle, commonly clocked in the millisecond range. Important to note here is that the bus system needs a degree of determinism and the controller must run in synchronization with it, even if bus cycles are sometimes longer or shorter. With Beckhoff hardware and software, the synchronization between controller and bus system are assured, as are the deterministic features of the ultra-fast EtherCAT communication system. This means that PC-based control provides the ideal foundation on which to implement oversampling technology.

**Bus cycle subdivision with oversampling**

Oversampling involves polling signals at a configurable multiple of the bus cycle time (i.e. in micro cycles) and writing the results to a temporary buffer. The set of process data collected is then transferred during the next bus cycle.

Oversampling functionality can avoid situations like the following during signal polling: If, for example, a sensor is queried every 10 ms, only the data available at the precise time of the query is actually acquired. The controller is effectively blind from one query to the next, so details of any changes in the sensor’s state occurring between PLC queries are not recorded. For instance, a sensor’s state might switch from 0 to 1 and stay there for 9.9 ms. If it then reverts to 0, the sensor signal — from the perspective of the controller reading it out — will appear not to have changed at all over the 10 ms cycle.

Situations like this can be detected by using an EtherCAT oversampling input terminal such as the EL1262 to connect the sensor. This EtherCAT Terminal is able to subdivide the bus cycle into as many as 1,000 micro cycles. In the case of a 10 ms bus cycle, an oversampling factor of 1,000 translates into a sampling interval of 10 μs. In a 1 ms bus cycle, a sampling interval of just 1 μs can be achieved.
be achieved, which is the shortest that EtherCAT oversampling terminals can currently support. This technology is ideal for reading out SENT sensors.

**The pulse width encoding protocol: SENT**

Single Edge Nibble Transmission (SENT) is a simple, unidirectional, asynchronous protocol that encodes sensor data based on the time between falling edges in a digital signal. The pulse length describes the signal value transmitted. A single bit in the SENT protocol generally corresponds to 3 µs, which meets the minimum requirement in terms of sampling precision. The signal level is 5 V. The EL1262-0050 oversampling terminal meets both requirements in that it supports precise data acquisition down to 1 µs and is capable of processing the signal level directly. It can sample each bit of the SENT signal three times – more than enough to reliably read the data transmitted in a signal pulse.

The data sets acquired are then processed in a ready-made function block, which evaluates the pulse lengths recorded, calculates the checksums and then marks the value either as valid or invalid.

The SENT protocol is mainly used for communication between sensors and electronic control units in vehicle electronics. Due to the simplicity of the protocol, the microcontrollers in ECUs are capable of evaluating it. SENT protocol receivers are not available for use in constructing measurement and test benches, but the open Beckhoff control system offers an alternative: The EL9505 power supply terminal can serve as the required 5 V power source, and the EL1262-0050 variant of the EtherCAT digital input terminal can be used to capture the sensor signal. In this way, SENT sensors can be directly and easily connected to the open and modular control platform from Beckhoff. This means that test benches equipped with Beckhoff technology can be used to conduct quality inspections on, say, throttle valve or steering torque sensors and make any necessary adjustments before the sensors are fitted to a vehicle.

**Oversampling: Part of the XFC technology toolbox**

In the case of SENT, oversampling is ideal for evaluating the protocol on the controller side using IEC 61131 commands. It also makes it possible to react quickly to changes, additions or new protocols.

XFC technology offers the right tools, even for more complex protocol evaluations. The EtherCAT distributed clocks functionality, which allows an EL1262 oversampling terminal to synchronise its timebase with other EtherCAT hosts highly precisely, is one example. With the distributed clocks, not only can signals be captured in up to 1 µs, they are also time-stamped with an accuracy of up to 10 ns.

The time stamp/multi-time stamp technology thus allows additional, much more accurate timing information to be provided on each process datum, which can be valuable when more extensive signal evaluation or analysis is required.

XFC (eXtreme Fast Control) offers the automotive sector a control solution with exceptionally high performance. It is based on an optimized control and communication architecture that consists of an advanced Industrial PC, ultra-fast I/O terminals with enhanced real-time characteristics, the high-speed EtherCAT industrial Ethernet system and TwinCAT automation software. With XFC, I/O response times of less than 100 µs are possible.

Further information:
- www.beckhoff.com/EL1262-0050
- www.beckhoff.com/XFC
New connector series expands EtherCAT and EtherCAT P communication with additional power supply

One Cable Automation — flexible one cable solution combines communication and power

The One Cable Automation (OCA) philosophy from Beckhoff is based on the connection of individual field devices, decentralized terminal boxes, and even machine modules using only one cable. This cable technology combines ultra-fast communication via EtherCAT with the power supply required by the connected components. For the 24 V field level, this was implemented using the EtherCAT P technology expansion connected via special M8 connectors. To provide additional power supply capabilities via a one cable solution, Beckhoff developed the new ENP and ECP connector families. These combine EtherCAT or EtherCAT P communication with additional power conductors in one cable, and are easy to use, mechanically coded to prevent installation errors and offer a high protection rating of IP 67.
One Cable Automation has an exceptionally flexible design that is ideal for use in a broad range of applications. Different sections in a network can be connected selecting the suitable one cable solution for devices and components according to their individual power requirements. The unrestricted openness for mixed network topologies is a key benefit. This enables flexible transitions between:

- EtherCAT P communication with integrated power supply (one cable solution with M8 connector)
- a one cable solution using hybrid cables that combine an EtherCAT or EtherCAT P communication element with additional power conductors (one cable solution with the new ENP or ECP connectors)
- a conventional two-cable solution with separate power supply (EtherCAT via M8/RJ45 connector or EtherCAT/EtherCAT P via ENP/ECP connector)

The new ECP and ENP connector series implement the combination of communication and power elements in different performance classes that range from 3 A to 64 A, all in an extremely compact design. The system is a completely new product development and meets the full scope of OCA requirements regarding connected devices and modules, including drives, sensors/actuators, control cabinets and entire machine modules. Reducing the system to the essentials – namely the EtherCAT or EtherCAT P communication element and DC or AC power supply lines – creates a cost-effective connection concept. In addition,
the system is very easy to use due to the bayonet connections with mechanical and color coding. The ECP variant for EtherCAT P also provides another benefit: The power transmission integrated into EtherCAT P enables the elimination of the four wires normally required for 2 x 24 V. This allows the use of thinner, lower-cost cables and alternatively, the supply of other voltages.

**EtherCAT P as an OCA solution for 24 V I/O systems**

With EtherCAT P, Beckhoff has expanded the globally established EtherCAT technology to combine ultra-fast EtherCAT communication with a 24 V system and peripheral power supply (US or UP), all in a standard Ethernet cable. Beckhoff developed special M8 connectors for EtherCAT P with mechanical encoding that eliminates possible confusion with connectors used for standard EtherCAT slaves.

The design of a specific machine or plant installation is simplified using a TwinCAT software tool that helps specify all individual EtherCAT P consumers and cable lengths to configure the highest performance and most cost-effective EtherCAT P network. For that purpose, the new and highly compact EPP9022-0060 EtherCAT P Box module, with dimensions of only 30 x 86 x 26.5 mm, can be used to gather important data. This module measures the US and UP voltages along with the IS and IP currents in the system and passes on the information to the controller. Provided the system has the data from all consumers, it can also take the individual devices’ power consumption over time into account. For example, if two actuators never switch at the same time for logical reasons, this can be taken into account when configuring the maximum current. This introduces additional savings potential with regard to the required number of power supply feeds and power supply units.

**Connector series for EtherCAT and EtherCAT P**

If higher power or additional supplies are required in addition to the 24 V system and peripheral power supply via EtherCAT P, power can be supplied via corresponding hybrid cables together with the ECP and ENP connector series developed by Beckhoff for this purpose:

- **ECP (EtherCAT P + Power):** This connector series combines a compact, trapezoidal EtherCAT P element (using the same pin allocation as the EtherCAT P encoded M8 connector) with additional power pins. In this way, the 24 V supply integrated into EtherCAT P is complemented with an additional power supply line.

- **ENP (EtherCAT/Ethernet + Power):** These connectors combine a trapezoidal central communication element with additional power pins in the same way as ECP. The trapezoidal element has an inverse design to prevent incorrect connections and provides data transmission via EtherCAT, standard Ethernet or other Ethernet-based communication protocols.

Different connector sizes from B12 to B36 are available with a varying number of power pins (2 to 6 pins) so that they can be easily adapted to the requirements of different network types and the power consumption of connected consumers. The complete and full-length 360° shielding of the central trapezoidal element continues the typical high performance of EtherCAT. Furthermore, the
compact design also provides adequate space for the power pins, ensuring high current-carrying capacity and dielectric strength. The quick and easy-to-use bayonet connection, along with the broad flange spectrum in the diverse housing variants for rear panel, front panel and square installation, provide additional user benefits. Additionally, there are versions for field assembly that enable extreme time-savings during installation.

**Broad range of applications**
The ECP and ENP connector families, together with the EtherCAT P-encoded M8 connector type, cover all applications from 24 V DC on the I/O level to drive systems with 480 V AC and a maximum of 64 A. The high flexibility of the connection system is available in every application area. Depending on specific needs, EtherCAT, EtherCAT P or a mixture of both can be used. Typical engineering requirements for small and mid-sized systems are covered by EtherCAT P with up to 3 A for U_s and U_p in combination with M8 or ECP connectors. In contrast, the ENP connector series is the ideal solution for larger installations involving longer transmission distances. The same also applies for applications without EtherCAT P, such as an endpoint with a 24 V power supply unit or for the supply of 24 V consumers with very high power demands.

Expanding the One Cable Automation concept through the growing diversity of the EtherCAT P, ECP and ENP devices and components constantly expands the range of application options for users. Current examples are the two new infrastructure box modules EP9221-0057 (1 channel) and EP9224-0037 (4 channel) from Beckhoff. Via B17-ENP connectors, these power distributors provide two 24 V supplies and a protective conductor along with EtherCAT communication in the trapezoidal element. The power cable has a cross-section that is approximately five times larger than the EtherCAT P element and can bridge longer distances or conduct significantly higher currents (up to 20 A at ambient temperature).

The sophisticated design of the connector elements also facilitates time-saving, error-free installation in the field.

**Connectors from the ECP series (illustrated) and the ENP series are ideal for connecting stepper motors with controllers (B12), asynchronous motors with frequency converters and smaller control cabinets or decentralized terminal boxes (B17), along with complete control cabinets and robotics applications (B23/B36).**

Further information:
-[www.beckhoff.com/ECP-ENP](http://www.beckhoff.com/ECP-ENP)
-[www.beckhoff.com/EtherCATP](http://www.beckhoff.com/EtherCATP)
TwinCAT supports critical IoT data exchange formats

Standardized IoT communication simplifies implementation of Industrie 4.0 concepts

As information technology and automation technology continue to converge, cloud-based communication services are increasingly used in industrial control projects. As a result, PC-based control technology is gaining in importance as well. The TwinCAT automation software platform from Beckhoff supports relevant communication standards for this purpose, such as OPC UA, MQTT and AMQP, simplifying the implementation of cloud-based manufacturing concepts.

Pioneering automation solutions can be created today that extend the scope of conventional control systems through the implementation of big data, data mining as well as condition and power monitoring. Industrie 4.0 and Internet of Things (IoT) strategies, however, place new challenges on the communication among devices and services. In terms of the classic communication pyramid, a large-scale data exchange between sensors and higher-level layers is involved. Moreover, horizontal communication between devices continues to play an important role in all modern production facilities.

PC-based control integrates cloud services and message brokers

PC-based control provides key technologies for advanced communication scenarios and has become an integral part of many present day automation projects. The cloud is increasingly assuming the role of an IoT project enabler. Cloud service providers deliver their infrastructures and services in an abstracted manner for customers globally and thus minimize the complexities of system configuration.

Such cloud services can provide basic storage functions such as SQL or noSQL databases in addition to complex machine-learning algorithms that are hosted and executed on the cloud provider’s infrastructure. When communicating with services in a public cloud, a message broker is frequently used for data ingestion. From the perspective of the transport protocol, the message broker represents a secure and standardized end point for distributing messages to the cloud, and serves as a means to access and use other cloud services (Fig. 1). Popular examples of such broker services in public clouds include Microsoft Azure™ IoT Hub, Amazon Web Services IoT, IBM Watson IoT and Google IoT.

The IoT communication protocol: MQTT

The underlying transport protocol is the common denominator for all of these platforms. A protocol for data transport became established quite early on in the form of the Message Queuing Telemetry Transport (MQTT) protocol and was adopted by all major public cloud systems. Simplicity and low overhead make this protocol attractive even for applications where small embedded systems
have to exchange data over unstable communication lines – either with the cloud or among each other.

Unlike conventional client/server applications, as familiar for many years in the area of automation, MQTT is based on the publisher/subscriber principle. As a result, integration in existing IT infrastructures is simplified because of the purely outbound data connections. In addition, established security mechanisms such as TLS can be used to secure the transport channel and implement device authentication mechanisms.

Yet even if the transport channel over MQTT has been standardized, MQTT still volunteers nothing about the content of a message. That’s because the message content is initially declared as “purely binary” according to the specification, which always makes serialization and de-serialization of messages application- or vendor-specific. The normal use of JavaScript Object Notation (JSON) for coding message contents has been common practice now for a number of years with cloud systems, yet the contents of JSON messages can also be application-specific and differ from manufacturer-to-manufacturer and even from cloud provider-to-cloud provider.

From an application perspective, this makes further processing of the data extremely difficult. Fortunately, the OPC Foundation has addressed the advantages of cloud-based communication based on publisher/subscriber principles in its Unified Architecture (UA) communication protocol. A corresponding working group within the OPC Foundation is extending the OPC UA specification based on publisher/subscriber mechanisms. MQTT was chosen as a transport protocol since the transport channel in OPC UA is exchangeable and the need to develop a transport channel for publisher/subscriber mechanisms can be avoided as a result. In this way, a high level of compatibility is achieved with existing systems, which is further supported by the increasing adoption of MQTT within cloud systems.

Seamless integration of standard IoT protocols in TwinCAT

With new IoT products and concepts, the TwinCAT 3 engineering and control software provides the ideal technological foundation for Industrie 4.0 concepts and IoT communication. What’s more, new I/O components from Beckhoff, such as the EK9160 IoT Bus Coupler, enable seamless and easily configurable integration in public and private cloud applications.

For these purposes, the TwinCAT automation platform is enriched with the TwinCAT OPC UA and TwinCAT IoT supplementary products through the inclusion of standardized and secure communication paths (not only) for the cloud. The platform provides both MQTT publisher/subscriber and OPC UA functionalities such as classic client/server communication, historical access, alarms, and conditions, as well as various mechanisms for communication with and access to the control logic contents. Communication can be carried out in this way using popular cloud systems, such as Microsoft Azure™, Amazon Web Services, IBM Watson, Google IoT, as well as private cloud scenarios within the respective corporate or machine network. Beckhoff systems can be connected to the cloud in this way using OPC UA and via third-party systems. Through the continual cooperation of Beckhoff in the corresponding working groups of the OPC Foundation, the first OPC UA publisher/subscriber prototypes have been successfully implemented even before the specification extensions were finalized.

Further information:
www.beckhoff.com/TwinCAT-IoT
Interview with GF Machining solutions about TwinCAT as powerful CNC solution for wire EDM machines

Open CNC improves flexibility and integrates intellectual property protection

TwinCAT offers CNC functionality that is seamlessly integrated with standard control technology. In addition, it provides open integration of customer-specific solutions via TcCOM (TwinCAT Component Object Model) modules. Orio Sargenti, Head of Platform Engineering, Conformity and Norms at GF Machining Solutions SA, based in Losone, Switzerland, explains how the company benefits from the new generation of wire EDM (electrical discharge machining) machines in terms of flexibility, intellectual property protection and reduced engineering effort.
How did the collaboration with Beckhoff come about in the development of the new generation of wire EDM machines, and what technological benefits does PC-based control offer from your point of view?

Orio Sargenti: The aim of GF Machining Solutions was to achieve an integrated control platform, in order to standardize the electronics of the wire EDM machines previously developed by our experts at different company sites. An important requirement was that products from third-party manufacturers, such as drives, should be easy to integrate. In addition, the communication structure needed to enable implementation of the 1 ms control loop for the cutting wire controller. This is where we first became aware of EtherCAT, a very widespread and powerful communication system, as well as Beckhoff, the inventor of EtherCAT, and their wide range of products. What ultimately became the deciding factor to initiate the cooperation with Beckhoff was the fact that they not only offer a PC-based control system but, unlike conventional CNC manufacturers, also a truly open CNC solution.

What does the openness and continuity of PC-based control mean for you as a machine builder?

Orio Sargenti: The advantage of the open Beckhoff technology lies in the great freedom for choosing components, such as I/Os. Here, traditional CNC providers are clearly limited. In terms of numerical control, we require a superior CNC kernel, into which our special process knowledge can be integrated as easily as possible. From our point of view, we use standard components from Beckhoff, while from a software point of view, it is our own CNC. In addition, the TwinCAT software suite offers an open framework, where capabilities for the complex communication between the individual components and integrated safety components, for example, are already implemented. TwinCAT is very open and user-friendly in this regard, and it offers much greater functionality when compared with PLCs integrated in conventional CNCs. One of the biggest advantages is that PC-based control enables us to make all the benefits from the automation world available in numerical control.

What are the special requirements on CNC technology from the wire-cutting EDM process?

Orio Sargenti: With conventional machine tools, the tool can be described precisely by one point in space in an ideal case. In contrast, wire-cutting EDM requires more complex control functions, in order to use the wire as a precision cutting tool. For example, the CNC controls the wire guides that are placed above and below the workpiece through a total of five servo axes. In addition, the entire movement of the wire, including its velocity and force, must be precisely specified. Another complicated aspect of numerical control is that the wire is bent and does not enter the working area in a straight line. This is because the wire tends to move away from the working point, depending on the electrical parameters and the force acting on it. Our core expertise is based on our ability to optimally correct these influences. Here, we benefit from the high computing power of the Beckhoff CNC, since it eliminates the need for stopping and adjusting the wire, previously required for compensation, and enables the execution of curved shapes at maximum velocity.
Latest generation of wire EDM solutions

GF Machining Solutions uses PC-based control technology from Beckhoff for the new AgieCharmilles CUT C, CUT E and CUT P series. The individual machine types are designed for different requirements with regard to machining accuracy. CUT C and CUT E are aimed at price-sensitive markets and still offer high accuracy of 3 to 5 μm. The CUT P series, with up to ±2 μm contour accuracy and up to 0.08 μm surface roughness, is designed for high-precision applications. The main differences between the model series are in their mechanics. However, from a control technology perspective, they are identical – in the spirit of the GF Machining Solutions platform philosophy. According to Orio Sargenti of GF Machining Solutions, a great advantage in this context is the high scalability of PC-based control. With the same control hardware, the shorter response time and higher performance required for the CUT P was achieved by simply upgrading the Intel® Core™ i5 processor used in the standard C6920 control cabinet IPC with an i7 CPU.

Why was a dedicated development project initiated to implement these requirements?

Orio Sargenti: The development of the new control platform was, and remains, an important step and a significant investment in the future of GF Machining Solutions. In order to access as much expertise as possible, we signed a cooperation agreement with Beckhoff in April 2012. As part of the development project, additional support was provided by ISG Industrielle Steuerungstechnik GmbH, based in Stuttgart, Germany, particularly for the integration of the process-relevant functions into the numerical controller. The first machine to enter series production at the end of 2014 was the CUT E. Meanwhile, development work for more efficient control of the wire EDM process has been completed. In order to cover further areas of technology, the project will continue until 2020.

What experiences have you had in the development project with regard to the partnership and cooperation?

Orio Sargenti: The cooperation works very well. On the one hand, this applies to the Beckhoff products and the associated support, especially since Beckhoff has an office in Losone as a base for local contacts. On the other hand, the very open communication and discussion among the project partners has been very successful. In addition, all parties involved have essentially the same level of expertise. This is very important because, when implementing highly specific erosion functions, you not only have to know what needs to be implemented, but also why this is the case from a process perspective.

What are the special advantages offered by the openness of the TwinCAT CNC software?

Orio Sargenti: TwinCAT CNC offers TcCOM, an open interface for the numerical controller. This is the key to make optimum use of our own process-specific knowledge as a core competence. The TcCOM modules enable us to use standard control technology and at the same time integrate our own special functionalities. This makes it very easy for our experts to focus on their core competences.

What are the main advantages of the TcCOM modules?

Orio Sargenti: What is crucial is that our intellectual property regarding wire EDM remains in our hands and does not have to be passed on to the control system provider for implementation. The TcCOM modules are the right tool for this and offer integrated, user-friendly intellectual property protection for our own expertise. In addition, we benefit from PC-based control as a forward-looking technology that is continuously developed, and from the high innovation capacity of Beckhoff. Because of the TcCOM modules, the innovation cycles on both sides can be decoupled – there is no need for complex synchronization if one side implements new features.

Which functions have been implemented via the TcCOM modules?

Orio Sargenti: Wire electrical discharge machining requires a control technology where the entire application is governed by the traditional control loops for torque/force, velocity and position with an additional loop for process control. As a consequence, the required velocity is not a fixed value, but rather is provided by the EDM process control module and has to be continuously applied in real-time. It is worth bearing in mind that the spark generator may also operate too fast with respect to the workpiece, so that the interpolation not only has to work in forward direction, but also backwards. This further increases the control complexity, not to mention the need for on-the-fly compensation of the cutting wire deflection and the spark lengths. From the perspective of the
Orio Sargenti, Head of Platform Engineering, Conformity and Norms at GF Machining Solutions, and Gerhard Meier, Key Account Management and Member of the Executive Board of Beckhoff Switzerland, at the customized CP3919 Control Panel on the new CUT P 350 wire EDM machine (from right to left)

The largest wire EDM machine of the new generation is the CUT P 1250, which can process workpieces with a length of up to 1.25 m.
GF Machining Solutions
R&D Strategy Statement

“Our collaboration with Beckhoff on the new CNC development was a very positive experience both technically and in terms of teamwork. We also appreciated that the Beckhoff hardware solutions as well TwinCAT and CNC packages displayed good reliability that is critical for GF Machining Solutions as a Swiss company for which the quality of product is a determining factor of success. We look forward to continued development together with Beckhoff and the ISG team as we work to extend the new CNC platform to cover a broader range of GF Machining Solutions products.”

Dr. Sergei Schurov, GF Machining Solutions Head of R&D Strategy

At its Losone facility, GF Machining Solutions produces around 100 machines per month (the image shows final inspection of several CUT P 350 units).
Orio Sargenti: “The EtherCAT plug-in modules reduce wiring effort in control cabinet construction by almost 40 percent while reducing the error rate.”

The EtherCAT plug-in modules from the EJ series with the customized signal distribution board (on the right), as well as the C6920 control cabinet IPC and the EP6224 IO-Link module with IP 67 protection.

CNC, we change the tool-radius compensation dynamically. All this is realized through four TcCOM modules as interfaces to the CNC kernel: wire bending correction, dynamic tool-radius compensation, corner pre-control and surface speed regulation.

What is the significance of the openness of TwinCAT as an engineering tool?

Orio Sargenti: The integration of TwinCAT in Visual Studio makes work easier for the developers, because they can use a known framework. The implementation of high-level languages is very important for the development of the TcCOM modules, which are all programmed in C/C++. One feature, which GF Machining Solutions uses extensively, is MATLAB®/Simulink® integration. We use this heavily for modelling in order to define the best path for the required machine processes, based on an object model.

Why do you use a customized version of the CP3919 Control Panel for machine operation?

Orio Sargenti: The main reason is the design aspect, which ensures clear differentiation of GF Machining Solutions machines. On top of that, it provides easy operation and suitability for practical application, which has been optimized in collaboration with Beckhoff. For example, special requirements are imposed on the suspension of the Control Panel, since machine operators are accustomed to leaning on its push-button extension.

The I/O system is implemented using a customer-specific signal distribution board and the EtherCAT plug-in modules from the EJ series. What were the reasons for this decision?

Orio Sargenti: The traditional electrical distribution in our control cabinets was installed on DIN rails. GF Machining Solutions started to design control cabinets with signal distribution boards in the late ’90s and the EtherCAT plug-in modules represent the ideal solution for us. This primarily provides two advantages: the error rate is significantly reduced compared to individual wiring, and the EtherCAT plug-in modules reduce the wiring effort by almost 40 percent, resulting in significant cost savings. Building a conventional control cabinet with equipment installed on DIN rails requires about 20 hours of work. With the EtherCAT plug-in modules, it only takes 10 to 12 hours. This is a significant time and cost savings factor. A further advantage is the high number of control cabinet units for the new machine generation, since, according to the platform concept, all wire EDM machines should be equipped with the same control cabinet. The different requirements can then be met effortlessly with the chosen EJ modules and possibly a modified board variant.

The interview was conducted by Stefan Ziegler, Marketing Communications, Beckhoff

Further information:
www.gfms.com
www.beckhoff.ch

Wire EDM (electrical discharge machining) can be used to produce complex geometries.
Innovative hexapod welding cell is ready for series production with PC-based control technology

**TwinCAT CNC software controls 6-axis parallel kinematics with absolute precision**

The high-precision WIG (Wolfram Inert Gas) welding of thin sheet metal or exact circumferential seams is a complicated process, which to-date could not be performed to satisfaction either using conventional machines or by hand. To solve this puzzle, the Augsburg, Germany-based machine builder Castro GmbH has developed an innovative welding cell based on parallel kinematics. With the support of system integrator Böckstiegel Automation in Penzberg, the new machine has quickly entered series production with the help of PC-based control technology and TwinCAT 3 CNC.
The weld seam demonstrated by Udo Massari, Managing Director of Castro, on a titanium catalytic converter for luxury cars looks much like a top-quality silicone seam. "The beading produced is completely uniform. We offer the only solution in the industry that can deliver this level of weld quality. Not even a robot can accomplish this." The secret to this success lies in what is known as the Wigpod, an automated Wolfram inert gas welding cell that operates on the basis of parallel kinematics. The six axes arranged in parallel can change their length and move in all three translational and rotational degrees of freedom. By utilizing the latest automation and drive technology from Beckhoff, the machine is now ready for series production.

The switch from the previously used control technology to PC-based control was surprisingly quick and simple for Udo Massari. "We revamped the complete control system and completed the transformation activities and HMI programming in just four months. As early as the first visit, Sales Manager Raphik Shahmirian from the Beckhoff Munich office was able to recommend potential solutions, with work commencing just a short while later on the actual implementation."

Peter Böckstiegel, Managing Director of Böckstiegel Automation, the company supporting the integration, had the same experience: "I received the best possible support in all projects to-date, which has allowed us as a small company to fulfill challenging customer implementations and accomplish even highly specialized tasks with exceptional reliability, such as in the case of Castro."
High precision and repeatability

Castro has developed systems based on hexapod technology since the 1990s. Initially the company specialized in surgical tables for medical treatment, such as in laser eye treatment and kidney stone disintegration. Working for many years on an implementation of the hexapod technology in industrial machinery, Castro launched the first basic model under the name of Caspod onto the market in 2009. Udo Massari explains: “The main challenge we face when developing a new solution is to implement parallel kinematics in CNC-based control technology. A new era has now dawned, however, because PC-based control helps us reduce complexities and meet the demanding requirements of precision engineering in an ideal way.”

The Caspod series includes 6-axis machining cells with parallel kinematics that can be designed for the most varied applications, such as welding, deburring, milling, polishing or laser cutting. The compact CE-compliant welding cell is characterized by high dynamics, path accuracy and high rigidity. The new Wigpod welding cell can position the 0.5 kg WIG welding torch with the highest level of accuracy even at a feed rate of 60 m/min – and using a fraction of the power input required by conventional machines.

According to Udo Massari, this has been made possible by the parallel arrangement of the six axes whose movable net weight is very low: “What’s special about this is that the movement is executed in an axial direction of six drives rather than only one drive. Conventional systems with a serial arrangement, on the other hand, have to move several units of 100 kg net weight for the same tasks and thus quickly reach power consumption levels of several kW. In a comparable workspace, the Wigpod operates with much more energy efficiency at a power consumption level of just 0.8 kW. This means that com-
A perfect welded seam on an aluminum high-pressure fire extinguisher

Peter Böckstiegel explains: “The perfect interaction of the CNC with the Stewart transformation ensures the smooth and simultaneous movement of the six axes. Beckhoff provides the corresponding mathematical translation tools and kinematic transformations for this purpose in the TwinCAT 3 CNC. This allows especially simple and flexible operation and programming.” TwinCAT 3 CNC offers comprehensive CNC functionality and covers the entire range of classic CNC path controls up to highly complex motion and kinematics requirements. With regards to the Wigpod implementation, Dieter Auer, specialist in application software from the Beckhoff Munich office, explains: “With the control and transformation capabilities provided by TwinCAT, it is now also possible to rotate around an additional axis, which was a limitation of the predecessor system. This is especially significant when the weld head must be rotated around the seam being welded.”

As a highly scalable automation system, PC-based control represents a flexible hardware platform that can suit the needs of every application. Raphik Shahmirian: “The hard real-time of the TwinCAT kernel and the ultra-fast drive system communication over EtherCAT offer ideal conditions for high-precision motion control. The C6920 control cabinet PC is the best-suited hardware to accommodate the Wigpod’s requirements. Operation is based on the application-specific 15-inch CP6942 Control Panel for machine tools with CNC push-button extensions.” Peter Böckstiegel adds: “The innovative TwinCAT CNC HMI serves as the user interface. It can be programmed with ease on the basis of Microsoft .NET standards, and due to its open and modular concept, it enables customized application designs.”

**Safety in motion control**

The welding cell’s six main axes are driven by dynamic servomotors in the AM8000 series from Beckhoff. There are also two auxiliary axes for linear part feeding and rotary positioning of components. Four compact, 2-channel AX5203 Servo Drives are used for a total of eight CNC axes. In particular, they support fast and highly dynamic positioning, optimally fulfilling the requirements of the welding cell according to Peter Böckstiegel. “Yet another advantage of drive technology from Beckhoff is One Cable Technology (OCT), which dramatically reduces wiring overhead and results in significantly lower material and commissioning costs.”

The AX5203 Servo Drives are fitted with the TwinSAFE AX5805 option card to protect machine operators from potential danger in the application. Peter Böckstiegel explains: “A crucial factor, with trial runs of new products in particular or when configuring a machine, is that the operator can also intervene in the workflow manually. With TwinSAFE, the welding cell can also operate if necessary when the door is open or at a reduced speed without introducing any risks to the operator.”

Further information:
- www.boeckstiegel-automation.de/1
- www.castro-online.com
- www.beckhoff.com/cnc
447 stepper motor terminals help control the world’s largest artificial sun

The DLR Institute of Solar Research in Jülich, Germany, put the Synlight high-flux solar simulator into operation on March 23, 2017. This high-power radiator – the only one of its kind in the world so far – consists of 149 radiators, each with the light power of a large cinema projector. Together, they generate light intensity corresponding to at least 10,000 times the intensity of natural solar radiation measurable on Earth’s surface. Three Embedded PCs connected with 447 stepper motor terminals from Beckhoff enable highly precise alignment of the individual radiators.
Synlight consists of a total of 149 high-performance radiators, each with a 7,000 W xenon short-arc lamp as used in cinema projectors.

Unlike natural sunlight, Synlight can melt even metals at up to 3,500 °C.
The focus of the Synlight facility is the development of production processes for solar fuels, i.e. fuels that are generated using solar energy. In addition, researchers and industrial partners in the solar thermal power plant or aerospace industries will find ideal conditions for tests of their full-size components. One such application is the efficient production of hydrogen as a CO₂-neutral energy source. In order to split water into hydrogen and oxygen, the solar simulator heats metal to a temperature of 800 °C. When steam is added, the metal reacts with the oxygen in water and the hydrogen is released. The oxygen is then separated from the metal again by further heating to 1,400 °C.

High radiation power and precise focus capabilities
Synlight’s novel modular design is unique in its use of 149 individually adjustable xenon short-arc lamps with a light spectrum that is very similar to sunlight. These enable radiation powers of up to 1 x 300 KW and 2 x 240 KW in three separately usable radiation chambers, where a maximum flux density of over 11 MW/m² can be achieved. According to Dr. Dmitrij Laaber, the control specialist responsible for Synlight at the DLR Institute of Solar Research, the artificial sun achieves around 10 times higher power output than conventional laboratory systems.

Two of the three test chambers have been specially designed for solar-chemical process development testing and offer direct access to gas scrubbers and neutralizers, permitting the qualification of processes in the production of solar fuels. The shutter sizes measuring 4 m in width and height, as well as room heights of 5 m, offer the possibility to irradiate large elements, such as space-flight components. A fundamental feature of Synlight is its multi-focus capability. This allows the light beam to be precisely focussed (even in subsets) and used as required, either for one large application or divided among a number of small test applications.
Compact and system-integrated drive control

The internally mirrored lamp shades used as reflectors have a diameter of 1 m and are mounted in a honeycomb pattern on an area measuring 14 m high and 16 m wide. PC-based control technology from Beckhoff ensures exact alignment and positioning of the individual reflectors to achieve the desired radiation focus. Each radiator is individually controllable, and as a result, highly diverse layouts and temperatures can be created at the target point – even when three tests take place in parallel. The numerous stepper motors required for this purpose are controlled by a total of 447 space-saving KL2541 and KL2531 stepper motor terminals directly integrated into the modular I/O system. These are, in turn, connected to three CX5130 Embedded PCs via 50 BK9000 Ethernet TCP/IP Bus Couplers.

The KL2541 stepper motor terminals with incremental encoder are designed for the medium performance range with an output of 50 V DC at 5 A. These devices integrate PWM output stages for a wide range of voltages and currents, as well as two inputs for limit switches in the extremely compact form factor of a 24 mm-wide Bus Terminal. The KL2531 Bus Terminals, measuring only 12 mm wide and rated for 24 V DC at 1.5 A, are suitable for integration with a great variety of small stepper motors. According to Dr. Dmitrij Laaber, the advantages
in practical use are immediately apparent, due to the large number of drive controllers: "If we had used conventional stepper motor controllers, the necessary 447 individual devices would have required a huge amount of space. Not only that, we would have had to connect each device with its own network cable, and that would have been enormously complex, intricate and prone to errors. Conversely, the current solution – with directly connected, system-integrated stepper motor controllers in the form of Bus Terminals – is much more convenient and compact, especially when one considers that the terminals are distributed over five levels in 10 terminal boxes. Other benefits have resulted from the fact that both networking and control system integration are very convenient and simple to accomplish via the BK9000 Ethernet TCP/IP Bus Couplers. We have also benefited from TwinCAT software, because a pure automation environment such as TwinCAT is much simpler to program than a solution based on high-level languages, which is what stepper motor manufacturers usually offer."

Further information:
www.dlr.de/sf/en
www.beckhoff.com/KL2541
www.beckhoff.com/KL2531

A total of 447 KL2541/KL2531 stepper motor I/O terminals are distributed across five levels in 10 terminal boxes.
Flexible automation technology for rotary tables and antenna masts in EMC test laboratories

Precise positioning and interference-free communication

Maturo GmbH, based in Pfreimd, Germany, is a global specialist in electromechanical positioning systems for EMC, automotive, radio and radar measurements. The only way to reliably test the EMC properties of heavy trucks and buses weighing tons is using a facility with interference-free control based on fiber optic communication, which supports precise positioning of rotary tables up to 14 m diameter. Flexible PC-based control and drive technology are key factors for Maturo’s ability to cover a wide range of applications and diverse customer requirements.
Maturo offers a wide range of rotary positioning tables for application in EMC cabins and in field installations. The table diameters can range from 0.3 up to 14 m, with payloads between 10 kg and 100 tons. Manual, semi- or fully automatic antenna masts and tripods for different measuring heights or loads and movements are used for positioning the required radiation antennae. The overall facility is operated with three controllers developed in-house, including the new NCD, which can control up to eight multi-axis devices. These can be comprised of any combination of antenna masts, rotary tables, rotary units, sliding tracks or other positioning devices.

Markus Saller, Technical Directory of Maturo, explains the configuration for a classic EMC application: “An EMC-shielded space generally contains a rotary table and an antenna mast with a radiation antenna. A controller, such as the
newly developed NCD based on Beckhoff technology, is connected to the outside via a fiber-optic cable to protect against interference. The NCD is used to control different measuring distances between the test device and the antenna as well as the rotary table and antenna positions. In addition, high-precision applications with a rotary table positioning accuracy of up to 0.01° are becoming increasingly important. This is implemented for antenna calibration or to minimize the necessary measuring distances and reduce the required size of the EMC space, among other applications.

PC-based control offers a wide, scalable product range

Regardless of the basic configuration of an EMC application, the solutions offered by Matuvo must be flexibly adaptable to a wide range of individual customer requirements. According to Stefan Lehner, Manager of Software Department at Matuvo, the high flexibility of PC-based control and drive technology from Beckhoff were major factors in the decision process: “The Beckhoff product range is expansive and has the additional benefits of high modularity and scalability. In this way, both standard and special functions can be quite easily implemented according to the customer’s requirements – for example, through integration of different interfaces or special safety functions. Additional
benefits are offered through the openness of the system, which facilitates the incorporation of third-party components. Here, we are optimally supported by the EtherCAT communication standard, which was originally developed by Beckhoff and is now established worldwide. EtherCAT is tried and tested as an extremely powerful and easy-to-handle bus system.”

The flexibility of automation technology from Beckhoff also benefits Maturo in other ways. One aspect is the use of optical fiber as transmission medium, as Stefan Lehner explains: “Without fiber optic technology, our solutions would not be possible. A key factor is that this type of cabling can be seamlessly integrated with the control technology we use. In contrast to many other systems, PC-based control offers the capability of holistic system integration, without the need for an intermediate LAN-to-fiber converter.” This is implemented in the new NCD controller, which includes four EK1521 EtherCAT fiber optic junction terminals, through which all other devices are addressed. A customized CP6907 Control Panel ensures optimal usability, while a CX1020 Embedded PC provides the required computing power. TwinCAT NC PTP software is used to control the numerous axes in the application. A TwinCAT XML Data Server handles the data management, while a TwinCAT TCP/IP Server supports communication with the higher-level control system.

Flexible and compact control technology with high precision
According to Stefan Lehner, the modularity of PC-based control results in another benefit: “In many cases, our projects are very challenging in terms of limited available space. Therefore, we never use conventional control cabinets since we have to be able to install the automation components in different positions, including horizontal or suspended, not to mention the need for modular, distributed components. The modularity of PC-based control helps us address these challenges, especially since the control technology can be flexibly scaled to individual needs. For example, the I/Os can be used precisely as required for each channel or added later on, which avoids the need to specify large, oversized I/O modules. Another advantage: In conjunction with the EL7041 stepper motor terminals and the EL7211 servomotor terminals, we use the new ZB8610 fan cartridge, which facilitates more compact configurations in installation. In the past, we used an external fan, which required significantly more space and installation effort.”

For high precision, Maturo also uses the options offered by the eXtreme Fast Control (XFC). Stefan Lehner explains: “Via the EL2262 EtherCAT Terminal, we can specify the positions with an oversampling factor of 100 and reach a far higher resolution than would be possible with the underlying control cycle. This is the only way to transfer the required commands to the drive technology at relatively high speeds and with 0.01° resolution. The XFC technology based on the distributed clocks feature provided by EtherCAT is a prerequisite for the hot-connect functionality, which ideally supports the highly flexible bus configuration with EtherCAT.”

Compact drive technology for numerous axes
The high complexity of EMC test facilities is illustrated by the large number of motion axes required in many cases. It is not uncommon that up to 50 axes have to be programmed. In addition to the rotary table axis, these include axes for several antenna masts, which can each have up to seven axes. For the rotary tables this is realized via servo axes. For the antenna masts, which require a higher torque, stepper motors are used. Markus Saller explains: “With our wide range of requirements, we benefit greatly from the diverse Beckhoff drive portfolio. Added benefits come from the simplified installation and commissioning with the One Cable Technology (OCT), including electronic type plates. In particular, we benefit from the compact drive technology, specifically the servo and stepper motor terminals, which we prefer to use whenever possible. Because the drive-train can easily be assembled in a highly compact configuration according to individual needs, maximum flexibility is assured for customer implementations.”

Further information:
www.maturo-gmbh.com
www.beckhoff.com/EK1521
www.beckhoff.com/motion
A fascinating play of water, light and movement

Development of sophisticated and technically challenging trick fountains that entertain and amaze has sparked the imagination of engineers for centuries. The interactive kinetic sculpture revealed for the first time in February 2017 at the ISE trade show in Amsterdam creates a magical interplay of water and colored light. The “3D KineMatrix” was developed by MKT Fine Exhibition Engineering, a proven expert in the design, development and implementation of interactive installations and kinetic sculptures. This project was completed in cooperation with HB-Laser, a world-renowned specialist in laser shows, multimedia and video mapping projects.
The interactive sculpture was designed for indoor applications. The modular design can be easily adapted to the specific architectural conditions of all kinds of sites. "We set a goal to combine our experience and create something unique out of the individual products, i.e. the '3D HydroMatrix' developed by HB-Laser and our kinetics expertise," explains Axel Haschkamp, member of the board at MKT. The result is a magical 3D sculpture using water, light and motion: a white ball appears to float weightlessly above the water matrix, moving in oscillating and circular motions. At times, it balances on the tips of the water fountains. At other times, it submerges below the water. The next moment it seems as though the ball itself were directing the dynamic upward and downward movement of the water matrix. The sophisticated choreography controlling the interaction between water, light and the kinetic sculpture is difficult to decipher, and viewers never tire of watching the interplay.

**Modular and scalable: interactive sculpture flexibly adapts to individual locations**

The sculpture is designed for indoor applications with limited space. These locations include hotel lobbies, malls, corporate foyers, airports, casinos and amusement parks. Essentially, it is ideal anywhere people want to create emotions, entertain or promote relaxation for spectators. The investment in a custom sculpture, which involves an enormous amount of planning and development, often exceeds the budget of the architects or clients. With the KineMatrix, MKT and HB-Laser have now created a modular solution that can be flexibly adapted to individual locations.

The product is based on the 3D HydroMatrix modules developed by HB-Laser. Equipped with 10 jets and 10 RGBW LEDs, they include all of the components required to create water and light installations. Depending on the location and scope of the application, multiple modules can be compiled in individual or serial configurations of any desired size as a star or square shape. According to Harald Bohlinger, Managing Director of HB-Laser, the flexible design and compact size are what make this interactive sculpture so unique: "There is currently no other system on the market that offers this 3D effect from such a short distance. In order to create this stunning effect, the system that we have implemented enables water jet spacing of only 50 mm, while conventional water fountains require a minimum spacing of 300 to 400 mm. Furthermore, the minimal spacing between the LED water fountains also enables the projection of videos or lettering onto the water with pixel-level resolution."

Both the water-light matrix and the kinetic assembly are flexibly scalable and can be adapted to the specific application scenario. Instead of a ball, any desired object can be moved three-dimensionally in the space above the 3D HydroMatrix in order to interact with water and light. The KineMatrix can also be flexibly combined with other media such as video, lasers, light, audio and fog.

**Precision motion control makes a splash**

A prerequisite for the modularity and scalability of the 3D KineMatrix is a compact control platform that can be scaled and adapted to individual project requirements in terms of dimensions and complexity. The three-dimensional movement of the ball, as used in the presentation at the ISE, is created by three winches. The motion control platform consists of a Beckhoff servomotor with an integrated holding brake, an EL7201-0010 servomotor I/O terminal with One Cable Technology (which integrates a complete servo amplifier, including encoder system in a 12 mm terminal housing), and a brake-chopper I/O terminal that provides brake resistance. A Beckhoff CX2030 Embedded PC serves as the central control unit. The control system contains the complete show procedure, with cable lengths and timings taken from an externally generated CSV file. TwinCAT NC PTP Motion Control software then carries out highly-precise position calculations. A TwinCAT Camming function block performs the linear or spline interpolation of the master support points and the corresponding slave positions according to the position table. This creates a seemingly flowing motion for the observers. In order to synchronize the kinetics with the water matrix control sequence, which is saved on a circuit board, the control system sends the values to a higher-level master PC via ADS. This master PC also runs the application’s visualization software.

Further information:

www.hb-laser.com
www.mkt-ag.de/home
eXtended Transport System helps to implement innovative design of specialty pharmaceutical machine with minimized hardware needs

Flexibility boost for a pill bottle cap assembly line
Fully automating production processes that were once manual or semiautomatic presents special challenges when the cycle times involved are extremely short. With workpiece carrier systems operating on a fixed cycle time, accommodating the differences between individual processing stations’ motion profiles involves setting up multiple stations of a given type to operate in parallel. This prompted Goldfuß Engineering GmbH in Balingen, Germany, to deploy its first Beckhoff eXtended Transport System (XTS) on a medical pill packaging line. The XTS uses software functionality for flexible buffering to deliver a highly dynamic solution that ideally meets the line’s transport needs and helps to reduce the number of components to a minimum.

Goldfuß designs and builds a range of handling and production systems, including specialty machinery used in plastics engineering and the food and pharmaceutical sectors. To support high-speed processes with a throughput of up to 60 parts per minute, these systems rely on exceptionally precise feed, positioning, processing and inspection operations to function effectively. XTS offers systems like this a compact transport solution with the flexibility and rapid product changeover capabilities they need. At the same time, XTS, with its advanced software functionality, paves the way for entirely new approaches to implementing highly dynamic machine setups and configurations, where motion tasks that once bordered on the impossible or would have called for highly complex solutions can now be implemented with unprecedented ease and flexibility. As Michael Müller, a member of Goldfuß’s executive management team and head of special-purpose machines sales, explains, “Unlike fixed-cycle-time workpiece carrier systems, which require that we provision as many as four instances of certain processing stations, XTS and its software functions give us enormous flexibility. We can use as many movers as we need, and we can time how they operate to match the way processes execute.”

Goldfuß put this approach into practice in 2017 in a specialty machine that assembles pill bottle caps. These are safety caps that are also filled with a desiccant. The assembly process is not just challenging from a mechanical perspective, it also has to comply with FDA 21 CFR Part 11 regulations to ensure that the packaging used for the medicines is absolutely clean and sterile. For the most part, assembly machines of this kind are located in cleanrooms, so the automation system control cabinets need to conform to Class 8 cleanroom standards as well. In addition, customers expect a rapid output rate, minimum production risk, and a high degree of flexibility and process reliability.

New-found freedom with XTS

Besides exceptional speed, XTS provides outstanding flexibility to accommodate differences in the timing of processing stages in which parts are provisioned, positioned, assembled, inspected and ejected, and so keep cycle times below one second. “We wanted to implement a system that we could set up without having to depend on a specific number of processing stations. Given the cycle time constraint, it was important that we were free to choose components as we wished and could accomplish the flexibility we wanted through the number of movers,” Michael Müller explains. He adds: “We looked at various workpiece carriers and systems with fixed cycle times. However, with a fixed-cycle carrier, you need the same number of systems for all the stations as you do for the bottleneck station if you want to successfully maintain the

The XTS movers can be fitted with mechanical devices or part mounts – in this case, receptacles for bottle caps.
required cycle time. In our case, that would have meant using four camera systems, four processing stations and four assembly stations. This is why we opted for the much more flexible XTS solution instead.”

Injection-molded parts for the safety caps are provisioned in bulk via a spiral conveyor and fed into the system, where they are inspected by a number of cameras, then placed in XTS movers equipped with appropriate mounts. The movers transport the caps to processing stations that punch cardboard disks, carry out ultrasonic welding, and perform various assembly tasks. In between, the parts are inspected repeatedly at camera stations; they are also checked on a weigh scale at the end of the overall process. The processing and inspection stations are connected by an oval XTS transport track with a total length of around 7.5 meters, made up of 20 straight and eight 45° curved motor modules, each 250 millimeters long. 34 movers acting as workpiece carriers travel along the track. The entire system is controlled by a C6930 Industrial PC for control cabinet installation.

The movers on the cap assembly line can be grouped in any number of ways within the product stream – in other words, they can travel to processing stations individually or in groups. Movers are controlled individually, as separate servo axes, but they can be synchronized with other movers or with process workflows, too, if required. Depending on the task in hand, they are able to travel independently (no matter what their absolute position might be) and can operate relative to one another as well. This allows a flexible buffer to be formed from which individual processing stations can be served on a highly dynamic basis to match their actual processing performance.

**PC-based control in an open, compact, end-to-end system**

The system processes granular material, so it is pressurized and therefore completely enclosed to guard against high levels of dust and dirt. The handling equipment – the elements that variously grasp, lift, push against and compress the parts being processed – is controlled pneumatically by valve terminals. A conveyor weigh scale checks the fill weight of the products at the end of the line. The entire system is controlled by a C6930 Industrial PC, operated from a CP3919 19” multi-touch Control Panel connected via a CP Link 4 combined power and data cable. Data communication with XTS takes place on an ultra-fast EtherCAT link; the camera systems are connected via TCP/IP over Ethernet. The ultrasonic welders are fitted with TwinSAFE safety equipment, which includes EL6900 TwinSAFE logic terminals, used to implement safety functions, such as an emergency stop (STO) and safe stops (SS1 and SS2). There are also various analog and digital input and output modules.

XTS’s simple and compact design has distinct benefits, as Michael Müller explains: “The principle advantage of XTS is that the drive and power electronics and the position measurement system are all contained in the motor modules – in other words, in the actual XTS track. Were it not for XTS, our assembly...
line would need somewhere in the region of 200 to 300 motors, and the drive control gear would fill a very large cabinet. With XTS, we need to run just two connecting cables to the control cabinet – one for EtherCAT and one for the 24/48-V power supply. A C6930 Industrial PC with an Intel® Core™ i7 quad-core CPU running TwinCAT software manages the individual movers as servo axes, complete with all the usual motion control functions like electronic gearing and camming. These not only allow the workpiece carriers to queue up and move off jolt-free, they also limit the centrifugal force occurring on curved sections of the track. Due to parallel processing on the multi-core CPU, the compute power available is far greater than would be the case with sequential processing on a single core, making XTS applications like this exceptionally efficient to implement.

Assembly line with increased flexibility and reduced mechanical complexity
As a rule, the XTS movers arrive at a given processing station in series, but they can be sent to multiple stations of the same kind in parallel if the cycle time requires it. For instance, if a processing cycle takes longer than one second, the number of processing stations needs to be increased accordingly – say, to two, three or four. Ultrasonic welding takes between three and four seconds, so to keep within the cycle time constraints, Goldfuß currently operates three ultrasonic welding units in parallel, with a fourth on standby in case the cycle time increases. With the assembly stations, the situation is essentially the same. They put together four caps at once. Leveraging the high speed of the movers, the machine as a whole can compensate for an increased number of stations being used and nevertheless maintain its required cycle time exactly. This enables the line to achieve a throughput 60 parts per minute. The high-speed camera station takes less than a second to return a result, so there is just one, through which all the movers pass.

“The assembly line is now so flexible that we’ve been able to eliminate a number of actuators from it. Compared to conventional systems, XTS needs fewer components, greatly reducing the mechanical requirements,” says Michael Müller, commending the advances achieved. “The system allows us to fine-tune motion profiles to match the cycle time precisely and to flexibly change the way how processing is divided up between multiple stations. We can also switch out, modify and add modules with little effort if product requirements change. Only minor mechanical modifications are involved in such instances because the main adaptations are made in the software. What’s more, the machine is so modular in terms of its design that it will allow us to meet a range of new requirements and address other industry-specific needs effectively in the future.”

Further information:
www.goldfuss-engineering.com
www.beckhoff.com/XTS
Intelligent illumination concept helps Istanbul’s Hagia Sophia shine at night

With its massive dome, the Hagia Sophia dominates Istanbul’s cityscape like no other edifice. Built in the year 532, it stood as for centuries as the city’s largest Christian church until it was converted into a mosque after the Ottoman conquest of Constantinople. Today, the Hagia Sophia has another new life as a museum. To make this landmark just as visible at night from afar, systems integrator Altiparmak Mimarlik designed a modern illumination concept based on Beckhoff building automation technology. This system features an innovative user interface that can be accessed remotely from anywhere via a tablet.
**Altiparmak Mimarlik**

Altiparmak Architecture was founded in 2006 as an architecture engineering branch. The company is active in the field of project production, restoration projects, interior architecture, zoning and zoning consultancy, construction and restoration applications. Especially in the restoration and conservation work of historical buildings, current technologies are combined with traditional methods and history is preserved in the light of science and tradition.

As is common with historical buildings, one of the project’s major requirements involved protecting the building from any kind of structural modifications. Altiparmak Mimarlik installed more than 300 wall washer-style light fixtures on the roof of the Hagia Sophia along with eight floodlights and a total of eight control cabinets. The central control platform is a CX5010 Embedded PC that communicates via EtherCAT with I/O couplers spread over four locations, and with two CX8090 series Embedded PCs using the ADS protocol. Two additional terminal stations with two BC9050 Ethernet Bus Terminal Controllers are connected to the master controller wirelessly via the Modbus TCP protocol.

The approximately 300 installed wall washer lights communicate through EL6851 DMX master terminals, ensuring that all lights can be switched on simultaneously with minimal delay. The color and the dimming level can be individually controlled for each wall washer, in accordance with the desired lighting effects. The dome of the Hagia Sophia is illuminated by eight floodlights mounted on the minarets’ galleries. They are controlled via KL6811 Bus Terminals based on the DALI protocol to ensure that they deliver the right amount of light at the right time.

Since the user interface runs on a tablet, illumination at the Hagia Sophia can be conveniently operated from anywhere with Internet access. The start page of the user interface offers three different lighting scenarios. The scenarios change periodically to make the façade lighting appear dynamic. Additional scenarios can be added in accordance with requests from museum management. For operation via tablet and remote access to the control system, a VPN infrastructure is used, minimizing the need for time-consuming on-site service during software updates and troubleshooting.

The new LED-based design from Altiparmak Mimarlik has reduced power consumption of the lighting system by approximately 66 percent. Another significant energy saving feature was the linking of controls to a timer that turns the wall washer lights on at sundown and off at sunrise, and dims the light output over the course of the night as the daylight hours approach.

Further information:

www.altiparmakmimarlik.com.tr/en
www.beckhoff.com.tr
Compact, yet robust, AGVs from America in Motion move product back and forth in warehouse applications with little or no operator intervention.

Automatic Guided Vehicles with path planning system optimize warehouse logistics

The fantasy that once typified automatic guided vehicles (AGV) in science fiction has become a tangible reality today, such as in warehousing operations. With the new iBOT series, America in Motion is breaking new ground, since the transport vehicles are equipped with a revolutionary path planning system.

America in Motion (AIM), a Charlotte, N.C.-based specialist builder of AGV systems, offers automation solutions tailored to customer needs with respect to their individual warehousing, logistics and distribution applications. Tommy Hessler, CEO at AIM explains: “Because the needs of each AGV installation are so varied, our team takes great care to guide our customers through the process so they discover solutions that are best suited for their automation needs.”

AGVs are autonomous mobile robots that follow markers or wires in the floor, or use vision, magnets, or lasers for navigation. For industrial applications, they are most often used to move materials around a manufacturing facility or warehouse. They can be adapted to a wide range of tasks. Whether handling products, delivering mail or performing other automated jobs, these robust, flexible machines can be almost infinitely configured.

iBOT optimizes warehouse logistics

Approximately three years ago, AIM was approached by a leading U.S. home improvement retailer to help expand their distribution facilities with an AGV system tailored for their new storage and shipping centers. The company specified the mechanical platform with all the typical functions of a forklift, such as forward motion, steering and mast control. Traditional AGV automation systems lacked the flexibility and robust operation necessary to accomplish these tasks, leading AIM to seek out a PC-based control system from Beckhoff for the development of the iBOT. It leverages both Kalman filters and odometry for navigation, as well as the Dijkstra algorithm, a mathematical process for finding the shortest path between two points.

The iBOT is totally autonomous, carrying out instructions with minimal operator input. This is deceptively simple, as the nature of the pallets varies from operation to operation. Hessler explains: “As you can imagine, people don’t buy a whole pallet’s worth of products. Each pallet contains a mix of products, so the size and weight of each pallet is constantly changing. The vehicle picks up the packed pallet and drives it to one of several stretch wrappers and drops it off, all while automatically avoiding warehouse shelves, human workers and the seven other AGVs.”
The scale of this project was daunting, as the 1,200 foot long warehouse necessitated mapping of thousands of positions and for the system to track order numbers and individual products on the pallets, all while relaying this information back to the central computer for collection and monitoring. Complicating matters further, the fleet of AGVs receives around 80 orders at a time, so it was important to optimize the operation of the AGVs by minimizing distances and travel times.

Trend-setting automation of AGVs, with PC control

The iBOT uses a Beckhoff CP6606 Panel PC with integrated HMI, running TwinCAT software. In addition, four 19-inch stainless steel, IP 65-rated Panel PCs are mounted at various locations around the home improvement retailer’s distribution facility. Each device displays the positions and traffic statistics of the eight AGVs and tracks performance, loads per hour and any errors or performance inadequacies.

For much of AGV history, a dedicated, hard-coded system running some sort of path-planning algorithm provided the motion control of the robotic system. Programming and commissioning these vehicles was a time- and labor-intensive process, in addition to being costly and difficult for end user personnel to troubleshoot in the event of an error or other system issue. Tommy Hessler explains: “Most end users have the experience to address any mechanical or electrical issues on an AGV, but when it comes to the controls, they often have no choice but to rely on the vendor for support. With the implementation of the Industrial PC platform, which is based on standard components, we now have an AGV that breaks down that barrier. This is a huge step toward positioning the AGV as a mainstream material handling and logistics solution. In addition, we were able to reduce costs through the scalability of the Beckhoff control components – savings we pass along to our customers.”

Traditional onboard navigational systems use laser sensors and an algorithm to determine X, Y and T (angle) coordinates of the vehicle in relation to obstacles in a warehouse. In the iBOT, this functionality can be accomplished in real-time via TwinCAT software and EtherCAT. TwinCAT TCP/IP Server provides a communication layer between the AGVs and the end users’ corporate networks, facilitating connectivity between the controller and the onboard third-party navigational system components. The processes handled by the controller are especially time-critical, as the navigation system needs to know where the vehicle is at all times to avoid potential crashes and damaged product.

A selection of EtherCAT I/O terminals provides lightning-fast onboard communication for the AGVs. Hessler discusses the advantages of this increase in speed: “Relaying instructions to the navigation system while maintaining low-latency requires a robust, high-throughput method of transmission, and EtherCAT is tops when it comes to speed.” The Beckhoff I/O system also provides flexibility in communication to non-EtherCAT devices via EL6751 CANopen terminals and EL6021 RS422 terminals, which serve as interfaces for routing back to the navigation controller. In addition, an EL6224 IO-Link terminal provides communication for height sensors on the AGV forklift mast. “Precision is key for the height sensors,” Hessler emphasizes. “For example, the tines of a fork may need to travel over a height of 30 feet to reach a pallet located on a shelf. Misalignment of only one or two percent is enough to miss the pallet entirely, which is completely unacceptable in time-critical applications.”

Further information:

www.america-in-motion.com
www.beckhoffautomation.com
Pillow plates are made from two stainless steel sheets, which are joined in a particular pattern through laser or spot welding and then expanded under high pressure to assume the shape of a pillow. With heating or cooling media flowing through them under pressure, they serve as heat exchangers in a wide range of industries, including the food industry, storage tank and equipment manufacturing, and processing systems for a wide range of bulk materials.

The machines required for producing the different types of pillow plates are as varied as the applications they serve. Dutch company Kepps Laser Welding BV, based in Enschede, specializes in special-purpose machines for laser welding of pillow plates. Henk-Jan Keppels, mechanical engineer and owner of KLW BV, states: "We worked with a team of experts at Soft-O-Matic right from the start to develop the automation for our machines. Soft-O-Matic engineers have already implemented many successful projects based on the TwinCAT automation platform from Beckhoff, and we quickly learned to appreciate the benefits of PC-based control." Rogier van Stapele, software expert and owner of Soft-O-Matic, adds: "Laser welding machines demand high dynamics and a high level of quality; both are hallmarks of the Beckhoff system."

A laser welding machine involves numerous processes that must be monitored meticulously. Gases such as argon, nitrogen and helium are used to create the laser weld processes. Since the laser light can only be emitted when the glass protecting the optics is totally clean, comprehensive monitoring functionality was integrated into the control system. Another challenge is to maintain correct oil pressure in the multi-stage hydraulic clamping system, which holds the stainless steel plates in the correct position during welding.

**Lean controller design and easy operation**

Pillow plate laser welding machines from Kepps Laser Welding are sold to storage tank and equipment builders across the world. "One of our primary
goals in the design and construction of laser welding machines is to reduce
the number of parts and suppliers required.” According to Henk-Jan Keppels,
a modular control system which enables efficient machine configuration and
modeling is ideal for achieving a “lean and mean” machine design.

A Beckhoff CX2040 Embedded PC with directly connected EtherCAT I/O Ter-
minals is used as the control platform. TwinCAT NC I automation software
integrates motion control as well as sequential control. “The control platform
is so compact that it fits on a one-meter-long DIN rail in the control cabinet,”
says Keppels. “Moreover, the AX5805 EtherCAT Servo Drives with integrated
safety technology and servomotors with One Cable Technology (OCT) provide
significant space-savings in a complete motion control solution. In the future,
we are also considering the use of EtherCAT P in order to make our machines
even more compact and reduce wiring efforts even further.”

“Another important quality criterion for Keppels Laser Welding’s customers is
easy operation of the laser welding machines,” says Henk-Jan Keppels: “We
use a remote CP3919 Control Panel as the HMI, which is linked to the CX2040
controller via CP-Link 4. It is important for us that the HMI is simple and
intuitive. This means that no specialist-level CNC knowledge should be required
to operate the machine, regardless of job complexity.” The HMI screens show
all process data in the form of a live image, so that operator errors are avoided.

“In the development of the control software, we focused on reducing com-
plexity by using independent, simple modules. This makes the software robust
and manageable for future developments,” explains Rogier van Stapele. “We
modeled and generated the software application using UML (Unified Modeling
Language), which results in code that is easy to expand and easy to reuse. The
detailed coding can then be carried out in TwinCAT based on the UML design
and using the existing editors.”

**Product definition file initiates the production process**

In contrast to many CNC machines, Keppels machine operators do not work
directly with CNC programs. Instead, the production process is guided by a file
that is generated using CAM tools during job preparation. This is based on pre-
selected production parameters and a CAD design provided by the customer. The
file defines the product to be manufactured, creates a visualization on the HMI,
and automatically sets the machine. In other words, when the start button is
pressed, the machine automatically creates a new CNC program and carries out
its execution. Product and machine status are taken into account, so that if the
production process is interrupted, the unfinished product can subsequently be
finished. Processing steps can be repeated or omitted at the operator’s request.
In a double laser machine, the currently set configuration (1 or 2 lasers, only
laser 1, or only laser 2) is also processed in the CNC program. Another advantage
of using the product definition file instead of a conventional CNC program is
that products can be produced on different machine generations or variants
without adjustments, since the product definitions are machine-independent.

**Online process monitoring**

“Since we started using the CX2040 as our control platform, and with the
benefit of communication via Ethernet, we are able to offer a wide range of
additional features in our laser welding machine,” recalls Henk-Jan Keppels.
“Naturally, we use EtherCAT as the communication system. TwinCAT software
scans all I/Os and monitors all events that occur.” A database application logs
diagnostic and event data provided by the PC Control platform. DataLog is
available through the Internet connection on the machine, so data storage is
also automated. “With the PC platform, the machine can be monitored online
and programmed via a remote service module. For security reasons, we use a
VPN connection. The ability to monitor all our machines on a smartphone is
another benefit,” emphasizes Keppels.

Further information:

- www.keppels.nl
- www.beckhoff.nl

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Pillow plates are made from two stainless
steel sheets, which are joined in a specific
pattern through laser welding and then
expanded at a high pressure of 40 bar to
assume the shape of a pillow.
EtherCAT Technology Group honors 500th member in Japan

EtherCAT in practice: Emirates Team New Zealand win America’s Cup in overwhelming victory

The EtherCAT Technology Group is very happy about its member Emirates Team New Zealand winning the 34th America’s Cup 2017, the oldest and most prestigious competition in world sailing sport. The New Zealanders clearly dominated the final stage of the regatta on the Great Sound in Bermuda with a 7-1 scoreline.

The high-tech America’s Cup Class (ACC) catamarans employ sophisticated hydraulics to control the wing sail and the hydrofoils. Super-fast and reliable bus communication via EtherCAT is a key element of the hydraulics control system. As the EtherCAT Technology Group commented: “We are thrilled that EtherCAT has made a not insignificant contribution to taking the Cup back to the Royal New Zealand Yacht Squadron in Auckland.”
ETG brochure now also covers the topics of Industrie 4.0 and IoT

For many years, the brochure of the EtherCAT Technology Group offers a comprehensive overview of EtherCAT as well as the ETG. All important topics ranging from the unique functional principle of EtherCAT to the implementation of the technology in a compact and understandable way is available online as well as in printed form in English, German, Chinese, Japanese and Korean language. Even though the EtherCAT technology has remained unchanged since day one, ETG now presents a general update of the brochure. Besides the reviewed existing parts, the brochure now contains comprehensive information about “EtherCAT in the context of Industrie 4.0 and IoT” to keep up with the latest developments in the industrial world.

The updated version is available in English and German – not only online but also in printed form – at all ETG events and tradeshows. The updates of the other language versions will follow soon.

In the 2nd quarter of 2017, the EtherCAT Technology Group was able to reach two milestones at a time regarding its membership development: First, the ETG, which has been established in Germany in 2003, now counts 2,000 members in Europe. Second, with Suruga Seiki Co., Ltd. the 500th member company has joined the organization in Japan. In total, the ETG now has more than 4,400 members worldwide. Here, it’s interesting to note that, in correspondence to the membership by-laws, only companies, universities and similar institutions can join ETG, a membership as an individual is not possible.

The honoring ceremony of Suruga Seiki was conducted during this year’s ETG Member Meeting Japan held in Yokohama at the beginning of July. Martin Rostan, Executive Director of the ETG, and Masanori Obata, Manager ETG Office Japan, presented Takeshi Marui, President of Suruga Seiki, with an official membership certificate. The company develops and manufactures optical testing and measuring equipment, such as optical axis alignment units or precision positioning stage systems for public research institutes and major electronics manufacturers.

In his speech, Takeshi Marui explained how the company came to know the EtherCAT technology at Hannover Messe 2015: “The technology was so convincing that we decided to use it in a first step. Now we also develop our own devices with EtherCAT interface. That’s why we are happy to become part of the EtherCAT community.” Martin Rostan added: “Japan is said to be a very demanding and challenging automation market. The fact that EtherCAT has become the leading industrial Ethernet system here speaks for itself. Thus we’re glad that our technology does not only convince Suruga Seiki but many more companies all over the world: the ETG membership growth does not only continue but further accelerates. In the last 12 months we welcomed almost 600 new members.”

A total of 175 representatives of Japanese ETG member companies joined this year’s ETG Member Meeting Japan.
Trade shows 2017

Europe

Germany
- EMO
  18 – 23 September 2017
  Hanover
  Hall 25, Booth D42
  www.emo-hannover.de/en
- Motek
  09 – 12 October 2017
  Stuttgart
  Hall 8, Booth 8108
  www.motek-messe.de/en

Belgium
- Cool & Comfort
  18 – 19 October 2017
  Leuven
  Booth 3.4
  www.coolandcomfort.com
- Bedrijvencontactdagen
  06 – 07 December 2017
  Kortrijk
  Hall 4, Booth 4204
  www.bedrijvencontactdagen.be

Denmark
- HI
  03 – 05 October 2017
  Herning
  Hall G, Booth 5754
  www.hi-industri.dk
- Electronics of Tomorrow
  31 October – 02 November 2017
  Herning
  Hall M, Booth 9848
  www.eot.dk

Finland
- AVITA Audiovisual Expo
  26 – 27 September 2017
  Helsinki
  Hall 1, Booth c28
  www.audiovisualexpo.messukeskus.com
- Teknologia
  10 – 12 October 2017
  Helsinki
  Hall 6, Booth b50
  www.teknologia.messukeskus.com

Sweden
- Euro Expo Sundsvall
  20 – 21 September 2017
  Sundsvall
  Hall Main
  www.euroexpo.se/sundsvall_besok

Poland
- Warsaw Industry Week
  14 – 16 November 2017
  Nadarzyn
  Hall E
  www.industryweek.pl

Switzerland
- EuroExpo Borlänge
  18 – 19 October 2017
  Borlänge
  www.euroexpo.se/borlange_besok

Great Britain
- PPMA
  26 – 28 September 2017
  Birmingham
  Hall 5, Booth F50
  www.ppmashow.co.uk

Spain
- ICALPCS
  08 – 13 October 2017
  Barcelona
  Booth 13
  www.icalpcs2017.org
Turkey
Robot Investments Communication
Forum and Exhibition
04 – 06 October 2017
Istanbul
Booth H31
www.robotyatirimleri.com

Asia

China
China Wind Power
17 – 19 October 2017
Beijing
www.chinawind.org.cn

Industrial Automation Show
07 – 11 November 2017
Shanghai
Hall 6.1, Booth E015
www.industrial-automation-show.com

EP Shanghai
20 – 22 November 2017
Shanghai
www.epchinashow.com

India
Engimach
06 – 10 Dezember 2017
Ahmedabad
Hall 14, Booth 33

Japan
System Control Fair
29 November – 01 December 2017
Tokyo
scfmsc.jp/en

Indonesien
Manufacturing Indonesia
06 – 09 December 2017
Jakarta
Hall C2, Booth C-7515
www.manufacturingindonesia.com

United Arab Emirates
Gulffood Manufacturing
31 October – 02 November 2017
Dubai
Hall 1, Booth F1-20
www.gulffoodmanufacturing.com

Adipec
13 – 16 November 2017
Abu Dhabi
Hall 13, Booth 13468
www.adipec.com

North America

Canada
Canadian Manufacturing and Technology Show
25 – 28 September 2017
Mississauga, ON
Booth 1143
http://cmts.ca

USA
Pack Expo Las Vegas
25 – 27 September 2017
Las Vegas, NV
Hall South Lower, Booth 6302
www.packexpolasvegas.com

Automotive Testing Expo
24 – 26 October 2017
Novi, MI
Booth 14005
www.testing-expo.com/usa

Fabtech
06 – 09 November 2017
Chicago, IL
Hall A, Booth 4884
www.fabtechexpo.com

South America

Brazil
ISA Expo Campinas
19 September 2017
Campinas
Booth 15
www.isaexpocampinas.org.br

Further information:
www.beckhoff.com/trade_shows