Extremely accurate, fast and robust: EtherCAT measurement technology modules
Beckhoff has extended the company’s measurement technology portfolio with a new high-speed, high-precision measurement device series. The new high-performance EtherCAT measurement modules open up opportunities in terms of accuracy, precision of measured values, cycle times, synchronization and long-term measurement accuracy – the level of which was to date only offered by cost-intensive, dedicated devices when used in automation. Now Beckhoff offers a system-integrated measurement solution, without platform or system gaps, for existing PC- and EtherCAT-based control technology. The product portfolio now spans from simple analog 12-bit terminals to high-precision, 24-bit condition monitoring modules with a sampling rate of 50 ksamples/s.

Customer requirements in machine and plant engineering keep increasing with regard to cycle times, condition monitoring and predictive maintenance. High-precision measurement technology today is an important prerequisite to stay competitive. End-of-line test rigs have become the norm in production and packaging systems. In short cycle times, each end product must be individually checked or measured, and the data must be archived for subsequent tracking. Traceability places high demands on the measurement technology used, e.g. it is necessary to provide factory calibration certificates, and the measuring reliability must be demonstrated continuously. In the past, it was often necessary to integrate external measuring equipment via bus systems, with correspondingly high overhead.

Beckhoff now offers an efficient, system-integrated solution with the introduction of a series of EtherCAT measurement technology modules that are tailored for these requirements. For example, each module has a unique identification number (ID), accompanied by a factory calibration certificate, if required. These EtherCAT measurement modules extend the existing Beckhoff measurement technology – consisting of analog standard measurement technology (12/16 bit), energy measurement and condition monitoring – with a new fourth series: high-speed, high-precision measurement technology.

**Milestone in the world of automation**

The new device class represents a milestone in the world of automation. It...
offers high-performance measurement technology with robust and user-friendly characteristics, designed for industrial applications with short assembly times and standard control cabinet installation environments. An additional feature is comprehensive self-diagnostics, which ensures long-term reliability and low maintenance requirements in unattended operation. The EtherCAT measurement modules automatically and immediately detect any measuring errors, which otherwise would be frequently mistaken for valid data for prolonged periods. Corresponding diagnostic reports can be called up continuously via EtherCAT. The system is realized through:

- comprehensive connection diagnostics for reliable detection of short circuits, broken wires and shunts
- comprehensive self-tests and repeated internal checks
- continuous monitoring of temperature and input for detection of overload

Although features such as high resolution, high measurement accuracy and high sampling rates have been available in laboratory measurement technology for a long time, Beckhoff now makes them available in a standard automation system, leveraging long-standing expertise in industrial automation. The combination of high-precision measurement technology and industrial automation standards opens up new technological advancement opportunities for manufacturers of conventional production machinery, inspection systems and testing equipment.

At SPS IPC Drives 2016, Beckhoff will launch an entry-level class of EtherCAT measurement technology modules with sampling rates of 10...50 ksamples/s. This range will be extended in the future, based on real-world requirements found in customer applications.

**Versatile EtherCAT measurement modules for test and industrial applications**

The new devices are designed for versatile application in industrial and testing environments. The available options include multi-function channels with numerous integrated measuring ranges (30 V to 20 mV, ±20 mA, full/half/quarter bridge, SG (strain gauge), IEPE, thermocouple, RTD) and also price-optimized versions with different numbers of channels.

The main feature of the EtherCAT measurement modules is the superior quality of the acquired data values, which is achieved through a range of measures:

- There is high crosstalk attenuation between the channels.
- High-quality, state-of-the-art components ensure particularly low-noise and dynamic measurement. The high 24-bit resolution, offering theoretically 256 times finer measurement resolution than the usual 16 bit, can be fully utilized. EtherCAT, with its 100 Mbit data rate, provides ample bandwidth for transmitting even hundreds of 24-bit channels with 10 ksamples/s.
- Special pretreatment ex-factory ensures that measurement technology
hardware from Beckhoff is ready for continuous operation and provides long-term stability.

- A shielding concept for analog cables to provide long-term security was also implemented. This offers robust protection against interference and is also effective under vibration load.

- Low measurement uncertainty is achieved through high-quality synchronization in series and precisely logged dependencies of the influences: Beckhoff indicates the individual error components such as repeat errors, non-linearity, offset/gain errors and noise in the specification.

For some measuring ranges, a basic measurement accuracy of 100 ppm (0.01%) at 23 °C is achieved, with high temperature stability. Although this is common in lab measurement technology, it is no doubt revolutionary in the world of automation.

In the new entry-level class different sampling rates are available, depending on the characteristics. The sampled values can be collected by any common EtherCAT master with 100…500 µs cycle time using oversampling, including timestamp, and enable fine time resolution of measurements:

- 10 ksamples/s in multi-function terminals
- 20 ksamples/s in the 2-channel versions U, I, SG (strain gauge)
- 50 ksamples/s in the 2-channel IEPE version

The ExtendedRange function with the so-called 107% extension enables genuine measurement up to the nominal limit and beyond. This enables the full utilization of the respective sensor range. The EtherCAT measurement modules are also flexible in terms of calibration: if preferred, the Beckhoff calibration values can be disabled and replaced with user-provided values. This also applies to polynomial adjustment for compensation of nonlinearities. Another feature is synchronous sampling of all channels and terminals at < 1 µs up to external synchronization with an absolute world time via IEEE 1588 or other EtherCAT networks.

**Designed for industrial use in terms of processing power, installation and connection options**

High-performance control not only characterizes Industrial PCs from Beckhoff, but also the new EtherCAT measurement modules. Advanced microcontroller technology provides significant computing power with high efficiency, enabling individual parameterization of each channel in the module. In this way a large number of calculation functions can already provide pre-processed, interpretable measured values in the EtherCAT measurement module. These include:

- polynomial adjustment for even better linearity
- comprehensive internal temperature measurements and compensations
- adjustment of the sampling rate at runtime without re-initialization of EtherCAT

The robust metal housings contain a flexible plug connector front end for all standard measuring interfaces and enable simple integration in all common measurement technology environments. The new generation of measurement technology hardware ensures very high quality of the measured data through full utilization of EtherCAT system characteristics.
- 2-stage filter machine up to 39th order
- 2-stage integrator/differentiator
- scaler for compensation of nonlinear sensors, e.g. based on interpolation points table
- TrueRMS calculation and PeakHold drag indicator

The specific focus on practical requirements is reflected in the new design as a DIN rail-mountable metal module. It is backplane-compatible with the widely-used EtherCAT Terminals, can directly accommodate an analog cable screen (conduction and mounting) and ensures excellent heat dissipation from the analog electronics to the rear of the cabinet. The metal housing is suitable for harsh environments and works well in low-maintenance areas of application. It also forms a protective barrier for the high-quality electronics and reduces the effect of electromagnetic interference.

Moreover, the EtherCAT measurement modules with high-quality feel and appearance already come with a wire connection solution that is suitable for different applications: The push-in connector with service plug is the reliable long-term solution for standard wiring requirements. It is quick to assemble, with or without wire end sleeves. The BNC hardware for vibration diagnosis can be quickly installed via a bayonet lock. It is well shielded through the coaxial cable and enables rapid wiring modifications. In addition, there are high-quality LEMO connectors for high-end applications. Assembly of these is a little more complex, but they are continuously shielded and can be used as highly reliable operation plugs.

**Measurement technology seamlessly integrated in TwinCAT**

TwinCAT automation software provides a platform for the generation of engineering and runtime modules which can be used to implement PLC, motion control, safety and measuring applications. Microsoft Visual Studio® is the central programming and configuration platform for the entire TwinCAT system. The TwinCAT measurement product family is also integrated into this universal platform. It includes high-performance charting tools for graphical representation of signals in the single-digit µs range. In addition to conventional functions such as trigger, chart synchronization and cursor, TwinCAT Scope View offers multi-core support to fully utilize the computing power in the corresponding system for the display of high-frequency signals, including oversampling values. In conjunction with the TwinCAT Condition Monitoring library, frequency responses can be calculated with the aid of power or magnitude spectrums and graphically represented in Scope View.

TwinCAT Measurement also includes features that are directly geared toward the new EtherCAT measurement modules. The filter designer, for example, has an option to graphically edit filter curves in a chart and to download the
EtherCAT – The measurement technology bus

As the inventor of EtherCAT, Beckhoff still plays a leading role in the ongoing development of this pioneering industry-standard technology and continues to develop innovative new products for EtherCAT, in particular the modular EtherCAT Terminal I/O system.

EtherCAT has become widely established in the area of measurement technology in the meantime. With 100 Mbit data rates, EtherCAT covers many of the requirements for measurement technology in laboratory and production environments. Additional benefits for device manufacturers include simple integration and a huge range of supporters in the EtherCAT Technology Group (ETG), which after 14 years includes almost 4,000 members, 100 of which are master device manufacturers. An EtherCAT interface is now available for almost any sensor type.

With its EtherCAT-based modular I/O system and PC-based control software TwinCAT, Beckhoff provides the complete automation infrastructure for many machines and now extends this system with highly precise measurement technology in a DIN rail-mountable format. This makes control cabinet design more efficient, saves installation space and simplifies procurement, because all components can be supplied from one source.

The direct integration of precise measurement technology into the control system via EtherCAT ensures simple system configuration and reduced complexity as a result. It also comes with fieldbus technology highlights such as simple parameterization based on EtherCAT standards, synchronous sampling through distributed clocks (up to external synchronization with any time sources via PTP/IEEE 1588 and others) and integrated diagnostics from the controller to the I/O level.

A measured value has two main characteristics: the measuring uncertainty (what is the value?) and the precise time determination (when did the measurement take place?). EtherCAT enables high-precision time synchronization of all inputs and outputs based on distributed clocks, typically with time uncertainties of significantly less than 1 µs, both relative between the devices in the network, and absolute to a higher-level global reference time. On the other hand, the EtherCAT measurement modules significantly improve determination of the values with high-precision measurements. Together, these capabilities enable much more precise determination of measured values in terms of time and value when compared with conventional automation technology.

determined filter coefficients into the new measurement modules via simple drag & drop. Digital filters such as Butterworth or Tschebyscheff can be easily designed as low-pass, band pass or high-pass and can be used with the freely configurable I/O filters. Alternatively, the coefficients can be downloaded into filter function blocks within the software environment.

In the spirit of Industrie 4.0 and IoT, the acquired data can also be centrally correlated in networks or cloud systems, since TwinCAT supports communication with cloud systems as standard. TwinCAT Analytics is a special software package for data analysis in cloud systems, as part of the TwinCAT Measurement environment. It facilitates identification and documentation of significant characteristics in signals. A cloud storage provider enables convenient access to historical data in cloud storage systems.

Further information:
www.beckhoff.com/measurement-technology

Product announcement

Estimated market release
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