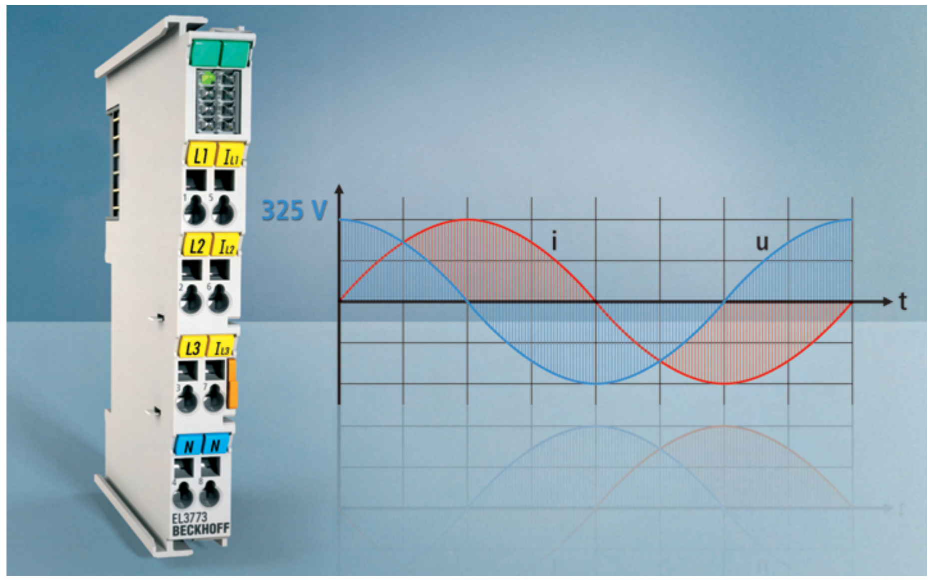
Scientific Automation combines control and measurement

Traditionally the worlds of PLCs, motion control and controls, as compared to measurement technology and "lab applications", have diverged when it comes to data entry and processing. But now PC-based control is offering performance needed to manage both tasks seamlessly with solutions that are scalable and effective.

THANKS TO MOORE'S LAW and its predicted rapid advancement of PC technology, high-performance automation and sophisticated measurement data processing, along with control functions such as condition and energy monitoring, can now be united.

Until just a few years ago, the computing power of control systems was far too limited for handling automation and measurement technology. But just taking the step from conventional PLC technology to PC-based control is not enough, and must be accompanied by a change in thinking that considers the integration of measurement technology during development and design.



PC-based control systems now offer the processing power required for high-end measurement applications.

Measurement standards & functions

With a shift in thinking, measurement technology is no longer restricted to a "black box" that is difficult to integrate. Rather, it can be implemented directly in a familiar and easily upgraded engineering environment that utilizes standard I/O. But the main advantage is in the underlying system structure.

Measured data is captured in a simple and optimally scalable manner directly at the machine using measuring terminals, and is then transmitted for processing to high-performance Industrial PCs via extremely fast EtherCAT communication. All of the software modules including PLC logic, measurement technology and visualization are being combined on a single platform with the purpose of consistently integrating the two worlds of control and measurement technology.

High-end measurement applications and standard measurement technology tasks are capably covered thanks to a comprehensive range of measurement I/O terminals. The numerous analog input terminals with standard resolution will suffice for many applications: For example, the KL30xx Bus Terminals as well as EL30xx EtherCAT Terminals with 12-bit resolution record analog signal voltages in a wide signal range from -2 to +2 V, -10 to +10 V, 0 to 2 V, 0 to 10 V, 0 to 500 mV, 0 to 20 mA and 4 to 20 mA. Standard EL31xx analog input terminals with 16-bit resolution are already suitable for high-precision control processes. In addition, they also support time-critical applications thanks to the extremely fast A/D conversion time – approx. 40 to 100 µs depending on the type – and provide support for EtherCAT distributed clocks.

High-end technology is supported by terminals with 18 and 24-bit resolution and the measurement accuracy for standard current and voltage signals. In addition, highly accurate models are available for connecting thermocouples and resistance thermometers as well as versions for complex signals such as performance measurement or condition monitoring based on IEPE acceleration sensors. The EtherCAT Terminals enable the development of technically demanding solutions using XFC technology from Beckhoff with advanced functions like oversampling.

XFC high-speed data acquisition

XFC technology is based on an optimized control and communication architecture, and I/O response times of under 100 µs can be achieved with a finely tuned system. XFC, in particular, uses functionalities such as distributed clocks, time stamping and oversampling.

The distributed clocks in EtherCAT represent a core XFC technology. This is because, in addition to minimum response times, the crucial factors for control are deterministic actual value acquisition and a corresponding deterministic set value output. Deterministic behavior must be supported by the I/O, but not in the communication or calculation unit. All EtherCAT devices therefore have their own local clocks, which are automatically and continuously synchronized with all other clocks. Different communication runtimes are compensated, so that the maximum deviation between all clocks is generally less than 100 nanoseconds and system time is synchronized with extreme precision.

Time-stamped data types actually contain a time stamp along with user data. This time stamp, together with the synchronized distributed clocks, enables the provision of temporal information with significantly higher precision for the process data. EtherCAT terminals with time stamp latch the exact system time at which edge changes occur. Digital values can likewise be output at predefined times.

Oversampling data types enable multiple samplings of process data within a single communication cycle and the subsequent collective transfer of all data. The oversampling factor describes the number of samples made within a communication cycle. High sampling rates can be achieved easily, even with moderate communication cycle times. Analog EtherCAT input terminals with oversampling enable signal conversion up to 100 kHz and time resolution up to 10 µs. For digital input terminals, values reach 1 MHz and 1 µs.

Analog input terminals with XFC

One-channel analog input terminals enable direct connection of resistance bridges such as strain gauges. The 24-bit XFC variant provides distributed clocks as well as automatic self-cal-

ibration, dynamic filters and a sampling rate of up to 100 µs for fast and precise logging of torque or vibration sensors.

The benefits of oversampling are leveraged by the 2-channel EL3702 analog input terminals for signals in the ±10 V range and by the EL3742 for 0 to 20 mA. The temporal signal resolution can be increased in both cases by an oversampling factor of up to 100 compared with the bus cycle time.

The EL3773 EtherCAT Terminal is a power monitoring device designed for status monitoring of 3-phase AC voltage systems. For each phase, voltages up to 288 Veff/410 V DC and currents up to 1 Aeff/1.5 A DC are sampled as instantaneous values with a resolution of 16 bits. The six channels are measured simultaneously based on the EtherCAT oversampling principle with a temporal resolution of up to 100 µs and passed on to the control system. The system has sufficient computing power for true RMS or performance calculations, and also for complex customer-specific algorithms based on measured voltages and currents.

The two-channel EL3632 analog input terminal also supports oversampling. It is suitable for condition monitoring applications in which fluctuations are to be detected by means of acceleration sensors or microphones. Piezo sensors with IEPE interface (Integrated Electronics Piezo Electric) can be connected directly without the need for a pre-amplifier. The measuring signals sampled at a rate of up to 50 kHz are analyzed on the PC via the TwinCAT Library or alternatively by means of custom software. The terminal can be adapted to individual requirements through configurable filters and supply currents. Through interfacing via EtherCAT and support for the distributed clocks function, the measurement results, and any detected defects, can be precisely allocated to an axis position.

High-precision measured values

Higher resolution analog input terminals are used for recording signals with extremely high precision. Examples include 2-channel input channels with 24-bit resolution for ±10, ±5, ±2.5 and ±1.25 V or input channels for 0 to 20 mA as well as a 2-channel resistance measurement terminal for a measurement range between 10 mΩ and 10 MΩ.

The EL3681 EtherCAT Terminal is a digital multimeter terminal with 18-bit signal resolution. Currents of up to 10 A can be measured as well as voltages up to 300 V AC/DC. The measurement ranges are switched automatically, as is usual in advanced digital multimeters; the measurement type and range can also be adjusted with EtherCAT if required. Excellent interference immunity is achieved through the design of the EL3681 which features full electrical isolation of the measuring system and dual-slope conversion.

The EL3201-0010 (1-channel) and EL3202-0010 (2-channel) PT100 input terminals for direct connection of resistance sensors enable high-precision temperature measurement. They are extremely precise with a resolution of 0.01 °C per digit and are suitable for a temperature range of -200 to +320°C. The calibration result is confirmed in the case of the -0020 terminal versions by means of a calibration certificate. The 4-channel EL3314-0010 input terminal picks up the signals from four thermocouples and can also detect any broken wires. The high 24-bit resolution enables a scaling of 0.1 to 0.001°C per digit and 10 nV per digit. The internal high-precision temperature measurement at the cold junction therefore allows precise temperature measurement in calibrated operation also when using thermocouples.

Full use of multi-core technology

The new TwinCAT 3 software, which includes integration in Microsoft Visual Studio, provides software support for Scientific Automation applications. The environment is designed in such a way that practically any number of PLCs, safety PLCs and C++ tasks can be performed on the same or different CPU cores.

The Condition Monitoring Library exploits these opportunities in particular. Raw data can be sampled with a fast task and processed with a somewhat slower task. This means that measured data will be continuously recorded and can be analyzed independently in a second task with numerous algorithms. The individual functional modules of the Condition Monitoring Library store their results in a global transfer tray or a type of storage table. From here the results can be copied to variables or processed using different algorithms so that an individual measurement and analysis chain can be compiled.

No specific Beckhoff modules or other modifications to the original model are required to create Matlab/Simulink modules. The Matlab and Simulink coders generate C++ code, which is then compiled in a TwinCAT 3 module. Repeated use of the modules is possible through instantiation. The block circuit diagram from Simulink can be displayed directly in TwinCAT and used, for example, to set break points.

TwinCAT Scope enables the graphical representation of all relevant signals from Scientific Automation software. Its viewer component can be used for visualizing signals in charts, while the server component logs the data on the corresponding target device. Scope also allows measured values to be read in the microsecond range to the exact cycle and enables visualization of oversampling values captured by EtherCAT measurement terminals.

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