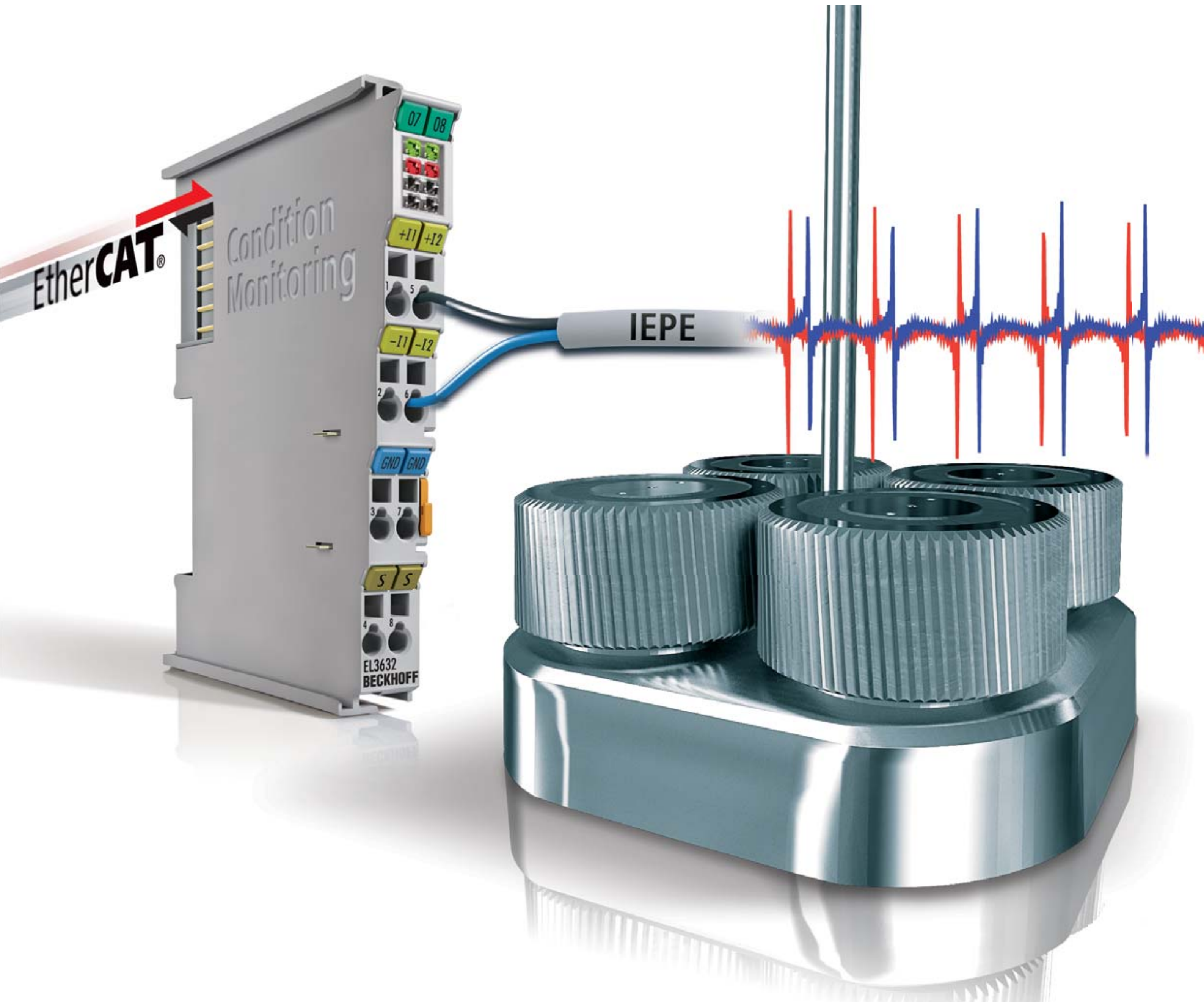
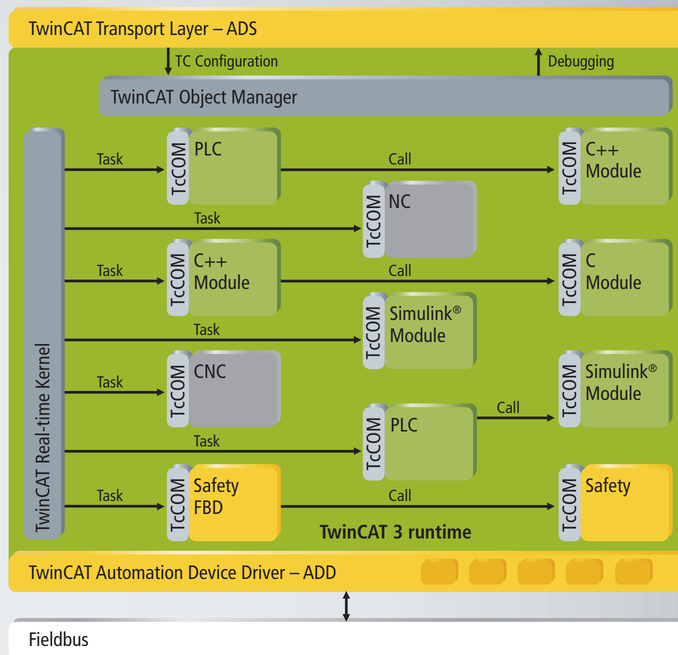
Condition Monitoring as an integrated component of TwinCAT 3

Scientific Automation in wind turbines



The real-time environment of TwinCAT 3 is designed to enable almost any number of PLCs, safety PLCs and C++ tasks to be executed on the same or on different CPU cores.



The compiled TwinCAT 3 modules can call each other during runtime, irrespective of the programming language.

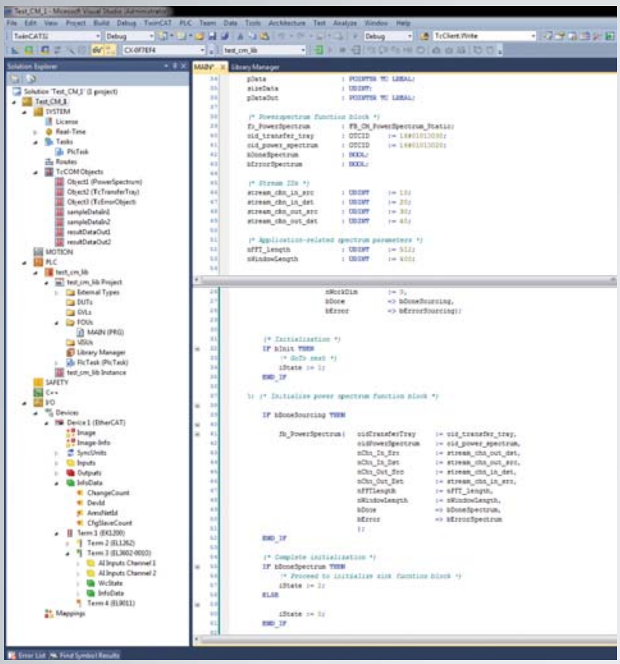
The degree of automation in wind turbines is increasing continuously. In addition to the actual system control, monitoring and networking play increasingly important roles. Many control suppliers that offer conventional controllers are reaching their performance limits. The solution lies in an automation system that is essentially based on a scientific approach and integrates the required measuring equipment in a standard control architecture.

Scientific Automation from Beckhoff represents a combination of high-performance Industrial or Embedded PCs, the highly deterministic EtherCAT fieldbus system and intelligent software. These components are also required for automating modern wind turbines. Wind turbine manufacturers want to use the same system for control tasks, monitoring, grid synchronization and system-wide communication. Just thinking of the complex Condition Monitoring algorithms which are to be processed on the controller, it becomes clear that it makes sense to use multi-core CPUs. With the new CX2000 series from Beckhoff, such powerful CPUs are now available in the Embedded PC format preferred by wind turbine manufacturers. The CX2000 devices are equipped with Sandy Bridge processors from Intel. In addition to economical Sandy Bridge Celeron® types, Intel® Core™ i7 processors are available. Even the CX2030, which is equipped with a 1.5 GHz processor (dual-core), is fanless and therefore exceptionally stable because it has no rotating components.

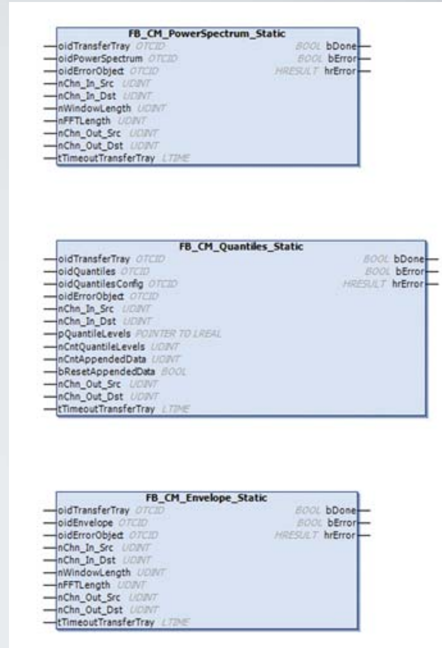
Suitable software must be used to take full advantage of this enhanced performance. This is where TwinCAT 3 control software from Beckhoff comes in. The real-time environment of TwinCAT 3 is designed to enable almost any number of PLCs, safety PLCs and C++ tasks to be executed on the same or on different CPU cores.

Condition Monitoring library for TwinCAT 3

The new TwinCAT 3 Condition Monitoring library facilitates the utilization of these options. Raw data can be logged with a fast task and processed further with a somewhat slower task. This permits measured data to be logged continuously and analyzed with algorithms such as power spectrum, kurtosis, crest factor and envelope spectrum. The user does not have to worry about task-spanning communication, which is automatically handled by the Condition Monitoring library. The results from the individual function blocks in the



Calling up the power spectrum function block in TwinCAT 3



The TwinCAT Condition Monitoring library offers different function blocks for signal analysis.

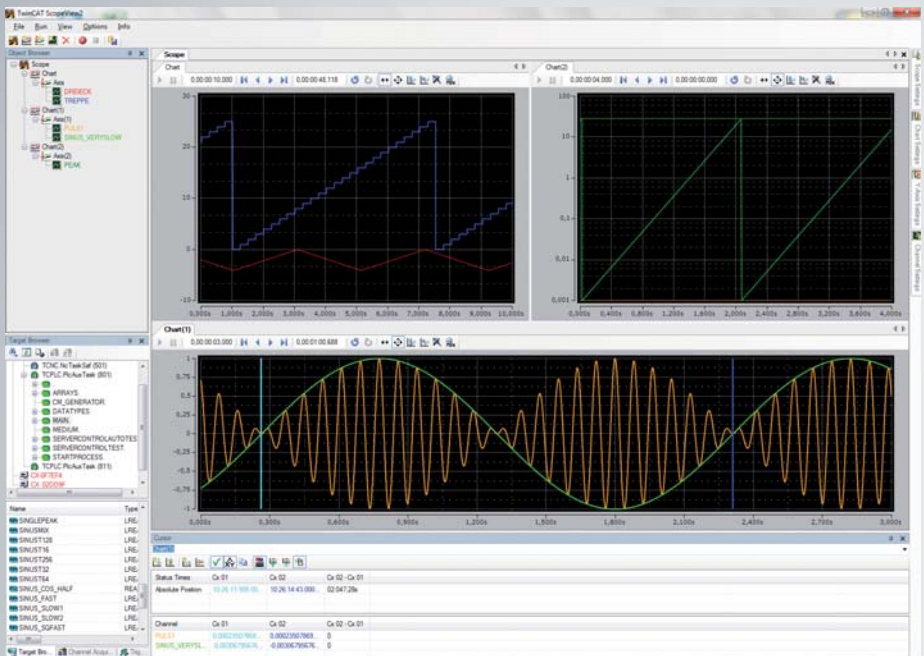
library are stored in a global transfer tray, a kind of memory table. From there the results can be copied to variables or processed further with the aid of other algorithms. In this way users can configure their own individual measuring and analysis chains.

Particularly in the wind industry, such developments must be tested and simulated extensively because once a wind turbine has been commissioned, modifications and updates in the field would be rather time-consuming and expensive. In order to save time and development costs, a Matlab®/Simulink® simulation of the system can be tested against the original control program code in real-time, for example. In this way many problems can be detected and rectified before commissioning. No Beckhoff-specific components or other modifications of the original model are required for creating Matlab®/Simulink® modules for the TwinCAT 3 runtime environment. The Matlab® and Simulink® coders generate C++ code, which is then compiled into a TwinCAT 3 module. Modules can be re-used easily through instantiation. The block diagram from Simulink® can be visualized directly in TwinCAT for setting break points, for example.

In addition to TwinCAT 3 and the auxiliary Condition Monitoring and Matlab®/Simulink® integration packages, TwinCAT Scope enables visualization of all relevant signals of a scientific automation software. The TwinCAT Scope consists of two components. The View component is used for displaying signals in the form of charts. The Server component records the data on the target device. A TwinCAT 3 installation always includes a basic version of Scope. This is particularly suitable for commissioning of systems. The Scope provides the user a quick graphic overview of the machine state. Different cursors enable precise reading of the measured data, even in the µs range. For large value ranges it makes sense to switch to a logarithmic display. The Scope product level enables additional functions such as long-term recording or integrability in custom .NET visualizations. All Scope product levels permit visualization of oversampling values from EtherCAT measuring terminals.

EtherCAT: High-precision measuring technology

EtherCAT as a fast, real-time capable bus system rounds off the scientific automation solution from Beckhoff. EtherCAT has not only become established as a control fieldbus, but also as a measurement fieldbus. Only this Ethernet-based, highly deterministic and fast fieldbus protocol enables complex applications, such as the integration of Condition Monitoring, to be realized. The functional principle of EtherCAT delivers usable data rates far in excess of 90 percent with full-duplex fast Ethernet and bus cycle times of a few microseconds. In conjunction with the oversampling function mentioned above and buffering of values directly in the EtherCAT slave, the sampling rates can be increased far beyond the actual bus cycle: The EL1262 digital input terminals, for example, can scan signals with up to 1 million samples/second. The EL3702 EtherCAT Terminal



Logarithmic signal analysis display with TwinCAT Scope

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samples analog signals of ±10 V with 16 bit resolution and up to 100 kHz. Distributed clocks in EtherCAT slaves ensure time-synchronized data sampling across the network. The jitter is significantly less than 1 microsecond, usually even less than 100 nanoseconds.

The EL3632 is also an EtherCAT oversampling terminal. This terminal is suitable for Condition Monitoring applications, in which oscillations must be sampled via acceleration sensors or microphones. Piezo sensors with IEPE interface (Integrated Electronics Piezo-Electric) can be connected directly to the two-channel terminal without a pre-amplifier. Due to different hardware filter stages, signal sampling frequencies between 0.05 Hz and 50 kHz are possible. The same principle of operation as in the EL3632 is used in the EL3773. The EL3773 is a power monitoring terminal that samples raw grid data, as opposed to raw oscillation data. Current and voltage can be sampled with up to 10 kHz, which makes the terminal suitable for synchronization with other networks.

The main advantage of these 12 mm wide modules is their high degree of flexibility. EtherCAT bus systems offer virtually unlimited expansion capabilities. This means that measuring applications, such as gear unit monitoring, can be implemented in new systems or retrofitted in existing systems. Thanks to the compact size of the controller and the wide range of open TwinCAT interfaces, stand-alone systems are becoming increasingly popular. Such stand-alone systems are currently retrofitted in some onshore turbines for monitoring the main bearing and the gear unit based on a CX5020 Embedded PC. To this end a terminal box is equipped with five EL3632 oversampling terminals and an EL3413 power measurement terminal. UMTS modems and compact heaters can be integrated as additional options. Depending on the available interface, the monitoring system can be integrated with the existing controller.

In summary, Scientific Automation enables the integration of engineering findings in the automation of wind turbines beyond the scope of conventional controllers. The power of the PC Control philosophy offers sufficient capacity to integrate numerous advanced functions beyond standard control. High-performance CPUs, fast I/O terminals, EtherCAT communication and TwinCAT software provide the basic technologies required for this purpose.

Further Information:
www.beckhoff.com/Scientific-Automation
www.beckhoff.com/Condition-Monitoring
www.beckhoff.com/TwinCAT3