New Automation Technology
PC-based control for Wind Turbines
Facts and figures

Headquarters: Verl, Germany
Employees worldwide: 3,900
Number of engineers: 1,400
Sales/technical offices in Germany: 22
Beckhoff companies worldwide: 37 countries
Subsidiaries and distributors: 75 countries
Sales worldwide 2016: 679 million € (+9.5 %)
Sales worldwide 2017: 810 million € (+19 %)

as of: 04/2018
<table>
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<th>Components for Industrial Automation</th>
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<td>The IPC Company</td>
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<td>The Motion Company</td>
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Production in Verl
Applications and solutions

Semiciconductor Manufacturing

Medical Engineering

Energy Industry

Wire | Cable | Pipe

End User

Food Industry

Transport | Logistics

Textile Industry

Machine Building
Applications and solutions

Water Treatment
Photovoltaic
Automotive

Building Automation
Process Industry
Test Facilities

Shipbuilding
Stage Technology
Wind Turbines
Condition Monitoring | Current Situation

- Blade Monitoring
- Blade Bearing Monitoring
- Environment Monitoring
- Drive Train Monitoring
- Tower Monitoring
- Power Monitoring
- Black Boxes for each Monitoring Task
- Interface work for each device
- Each device contains own CPU and infrastructure components
- Each device needs additional Data like power, speed, windspeed etc.
- Measured values are not time synchronized
- Different data formats
- Data concentration (loss of data) in many devices
- Many different hardware suppliers
- High cost level
Condition Monitoring | Beckhoff Approach
1 Hardware, 1 Database, 1 Timebase, 1 Infrastructure

Blade Monitoring
Tower Monitoring
Drive Train Monitoring
Blade Bearing Monitoring

Interface to the WTC
Condition Monitoring | The Beckhoff Approach
1 Hardware, 1 Database, 1 Timebase, 1 Infrastructure

- One Hardware, one interface, one solution for all tasks
- Collection of all raw data
- All measured values are time synchronized << 1 µs
- All data could be stored in one data base
- Terminals for all relevant sensors are available
- Interfaces to the WTC are all available
- Power, speed, windspeed etc. are available for all tasks
- 3rd party software suppliers offer software for all monitoring tasks on a turbine
- Licensing for 3rd party software based on TwinCAT3 licensing
- Ability to integrate own measurement campaigns into the system
Measurement technology

< 1 μs synchronisation
100 ppm
24 bits
10,000 samples/s
EtherCAT Terminals
EL3751 | Analog multi-functional input, 24 bit

- 1-channel measurement terminal, parameterisable
  - voltage measurement
  - current measurement
  - resistance measurement
  - electrical resistance $R$ in 2-/3-/4-wire connection
  - RTD measurement in 2-/3-/4-wire connection
  - strain gauge/load cell
    - ¼-bridge, ½-bridge or full bridge
  - potentiometer
- differential input, 2-/3-/4-/5-/6-wire connection
- distributed clocks
- 10 ksp → oversampling possible
- free downsampling to 1 sps
- ExtendedRange 107 %
- measuring error in general ±0.01 % at 23 °C (±5 °C)
- 500 V electrical isolation
Vibration Monitoring with EL3632
EtherCAT Terminals
EL3632 | 2-channel-analog-input terminal for CMS

- Acceleration sensors with ICP / IEPE interfaces can be directly connected
- Flexible and low-priced solution
- TwinCAT Lib is required for analysis or own analysis through the customer
- Max. sampling rate 40 kSamples/s
- Resolution 16 bit
Power Monitoring with EL3783
Power monitoring oversampling terminal for 690 V AC

Measuring range: Nominal * ExtendedRange
- 690 V (AC) * 130 %
- 5 A (AC) * 130 %
- 1 A (AC) * 650 % for detailed error case analysis

Current and voltage measurement of each 3 channels with 20,000 samples per second and measuring error <0.2 %
Measurement technology

< 1 µs time synchronous
100 ppm at 23 °C
24 bit
up to 50,000 samples/s
The new EtherCAT-Measurement-Modules:

**Fast:**
Up to 50,000 samples/sec with 24 bit resolution

**Precise in time:**
exact Synchronisation < 1 μs by EtherCAT-Distributed-Clocks, systemintern and external to reference clock

**Precise in value:**
Accuracy of 100 ppm and better with high temperature stability

**Proactive:**
Integrated wire- and function diagnosis to have a long-lasting high operation reliability
- evaluation of measuring bridges in full-bridge, half-bridge, quarter-bridge configuration
- internally switchable supplementary resistors, integrated feed
- adjustment of supply voltage and other values in the CoE
- 6-pin push-in plug removable for maintenance purposes
- **ELM3504**: 4-channel, max. 100 μs/10 kSps
- **ELM3502**: 2-channel, max. 50 μs/20 kSps
Measuring of
- IEPE sensors (vibration diagnostics, acoustics)
- Voltage AC/DC single ended (0..20V, ±10V …±20mV)

0/2/4 mA constant current feed and flexibly adjustable input characteristics from DC to 10 Hz

Internal scaler function: transform [V] \( \rightarrow \) [m/s²] directly

Connectors:
- 0000: PushIn
- 0002: BNC connector

**ELM3604-000x**: 4-channel, max. 50 μs/20 kspzs

**ELM3602-000x**: 2-channel, max. 20 μs/50 kspzs
over 30 different types of electrical connections possible: ±30 V to ±20 mV, ±20 mA, full/half/quarter bridge strain gauge, IEPE, thermocouple, RTD, all with a 2- to 6-wire connection, depending on the type

**ELM3704-0001**: LEMO connector, for changing sensor configurations on a daily basis (e.g. laboratory use)

**ELM3704/ELM3702**: 6-pin with push-in, fast wiring and less frequent unplugging for maintenance (for industrial use)
Measurement applications

- Where are EL3xxx, ELM3xxx in use?
Automation

- TwinCAT PLC

IPC

- CX5020 Embedded PC

I/O

- EtherCAT
- EL3632 Condition Monitoring terminals
- Further EtherCAT Terminals, e.g.:
  - EL5151 incremental encoder interface,
  - EL3202-0010 PT100 input terminal and
  - EL3702, EL3742, EL3356-0010 XFC terminals
8.2 Monitoring GmbH, Germany
Condition Monitoring system

IPC
- Embedded PC CX5000

I/O
- XFC Terminals
- EtherCAT Condition Monitoring terminal EL3632

Automation
- TwinCAT PLC
Fraunhofer IWES Northwest, Germany
Test bench system for wind turbines

Automation

IPC
- Two 19-inch C5102 slide-in IPCs
- CX5010 Embedded PC

I/O
- EtherCAT
- EtherCAT and TwinSAFE terminals
Measuring in the Beckhoff universe

Software
- User Mode/Engineering
  - TC Measurement – Filter Designer
  - TC Measurement – Scope View/Server
  - TC Measurement – Bode Plot
  - TC Measurement – Analytics
- Runtime
  - Filter Library
  - Power Monitoring Library
  - Condition Monitoring Library
  - PLC C++
  - Time Sync. Library
- Hardware
  - Metrological Automation | Scientific Automation
    - Performance class
      - Standard EL30xx, EL31xx
      - Precision ELM3xxx
    - Application examples
      - Energy Measurement EL34xx, EL37xx
      - Condition Monitoring EL3xxx
    - > 250 analog devices (IP20, IP67)

Database
- Connectivity ADS, OPC UA
- Database Server
- MATLAB®/Simulink®
- Other Lab View

Fieldbus
- EtherCAT
Scenario: new business models with data analytics

Service technician (location-independent)

Machine builder (location-independent)

Dashboard

IPC/VM

MQTT

MQTT

MQTT

MQTT

TwinCAT Analytics Storage Provider

Storage

Machine Control Customer 1

Machine Control Customer 2

Machine Control Customer n
Condition Monitoring | The Beckhoff Approach
1 Hardware, 1 Database, 1 Timebase, 1 Infrastructure

- Interface to the WTC
- Slipring
- Electrical Power Monitoring
- Blade Monitoring
- Tower Monitoring
- Drive Train Monitoring
- Blade Bearing Monitoring
- 8.2 Drive Train Monitoring
- cms@wind Drive Train Monitoring