EtherCAT measurement terminals in wind farm monitoring

Accurate and fast data are crucial for the essential synchronization in wind farms

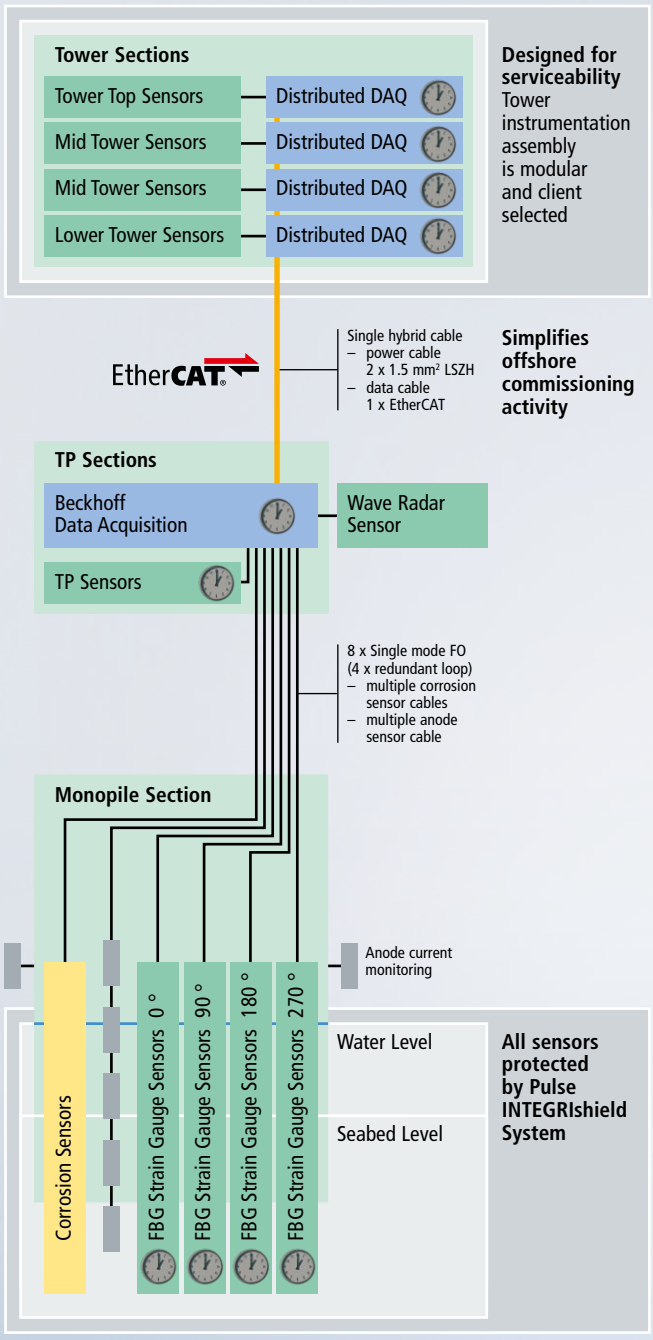
The UK aims to build enough wind farms to power every household by 2030. The potential of wind power was demonstrated by a recent record, when on a single day in January wind farms produced 19,835 megawatts, which is enough to cover more than half of England's electricity needs. The increased investment in renewable energy will be essential to hit the 2050 goal of Net Zero. Pulse Structural Monitoring Ltd, an Acteon company, have been tasked with monitoring selected turbine foundations in new wind farms, the solution is delivered by using Beckhoff technology and EtherCAT measurement terminals in particular throughout the design.

According to Pulse, the UK has become a world leader in offshore wind energy, with more capacity installed than any other country. However, offshore wind farms present difficulties due to the environment, making continuous monitoring of the whole turbine essential. By continuously monitoring the turbine, blades, and foundation performance, you can support decision making on planned maintenance and design validations for example, which in turn can help to avoid unplanned shut down periods or making costly repairs in the event of failure.

Measurement terminals in harsh environments

Environmental and operational loadings on the turbine affect all parts of the dynamically loaded structure. Part of the foundation's role is to support the wind turbine generator (WTG) load, provide stability and absorb additional loadings. The structural health of the foundation, which is considered as the top of the tower downwards, is critical to the performance and support of the WTG's performance. Structural Health Monitoring (SHM) systems for offshore wind turbine structures monitor a combination of corrosion and dynamic fatigue stress. Corrosion monitoring although an important parameter to be measured, due to the nature is less time critical. In contrast fatigue and modal properties monitoring are among the most important SHM techniques for wind turbine structures.

Pulse Structural Monitoring are delivering foundation SHM systems for clients in the renewables industry across the world using Beckhoff technology. Utilising Beckhoff's broad range of I/O terminals for sensor integration allows Pulse to ensure time stamped data acquisition throughout the structure. Pulse use the ELM370x module, which is an analogue input terminal from the EtherCAT measurement range. Due to the high sensitivity and measurement ability of these ELM modules, they are often used within labs but can also be integrated into industrial environments. This terminal can be set to over 30 different



Basic structure of the monitoring system implemented by Pulse

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types of electrical signal, which makes it an exceptionally flexible measurement module for a range of sensors. To accurately determine the structural integrity throughout the full height of the structure, helping to ensure turbine operational efficiencies, the tower itself requires measurement points on four levels. This means that the I/O needs to be distributed, to have accelerometers and full bridge strain gauges terminated close to where they are positioned. Each level, on this top section, demands two ELM3704 modules for the varied signals, an EK1100 EtherCAT Coupler for communication and a power supply PS1011. These are fully enclosed and magnetically attached to the tower wall at defined heights giving accurate data capture across the tower.

For temperature, Pulse use the standard EL3202 terminal, a Beckhoff analogue input RTD EtherCAT terminal which provides data to allow for compensation algorithms to operate. The use of EtherCAT and it's Distributed Clocks on the wind turbine's foundation shows Pulse's dedication to highly accurate monitoring and with this the ability to synchronise data. This synchronisation is key to the critical analysis of the overall structure, taking data from high precision accelerometers, strain gauges and temperature sensors located along the length of the structure, from top of the tower to the foot of the monopile with the exact timing.

Synchronized data communication

Pulse have adopted the EtherCAT fieldbus and deploys this technology with the added benefit of power and communication through a single cable. EtherCAT P and EtherCAT/Ethernet with power (ENP) helps circumvent the common difficulty of getting power to the sensors and distributed I/O at the top of the tower. The EtherCAT P and ENP system can run power and communications through a single cable and daisy-chain the fieldbus throughout the structure. Pulse have even taken it a step further by becoming a member of the EtherCAT Technology Group to develop their own subsea data hub and motion monitoring EtherCAT products called INTEGRIpod-NX2.

"The most important thing in our industry is data," explained Stephen Harford, solutions architect at Pulse Structural Monitoring. "EtherCAT is already

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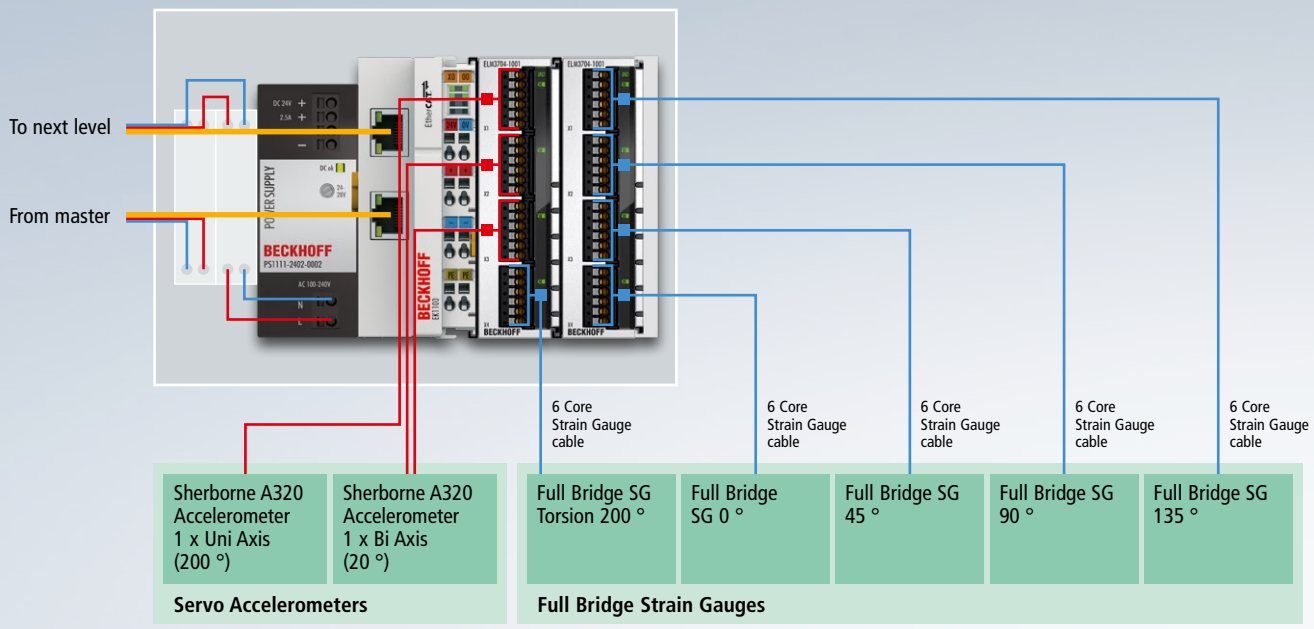


Decentralized data acquisition system for the four upper tower levels, consisting of two ELM3704 EtherCAT Terminals, an EK1100 EtherCAT Coupler and a power supply PS1011

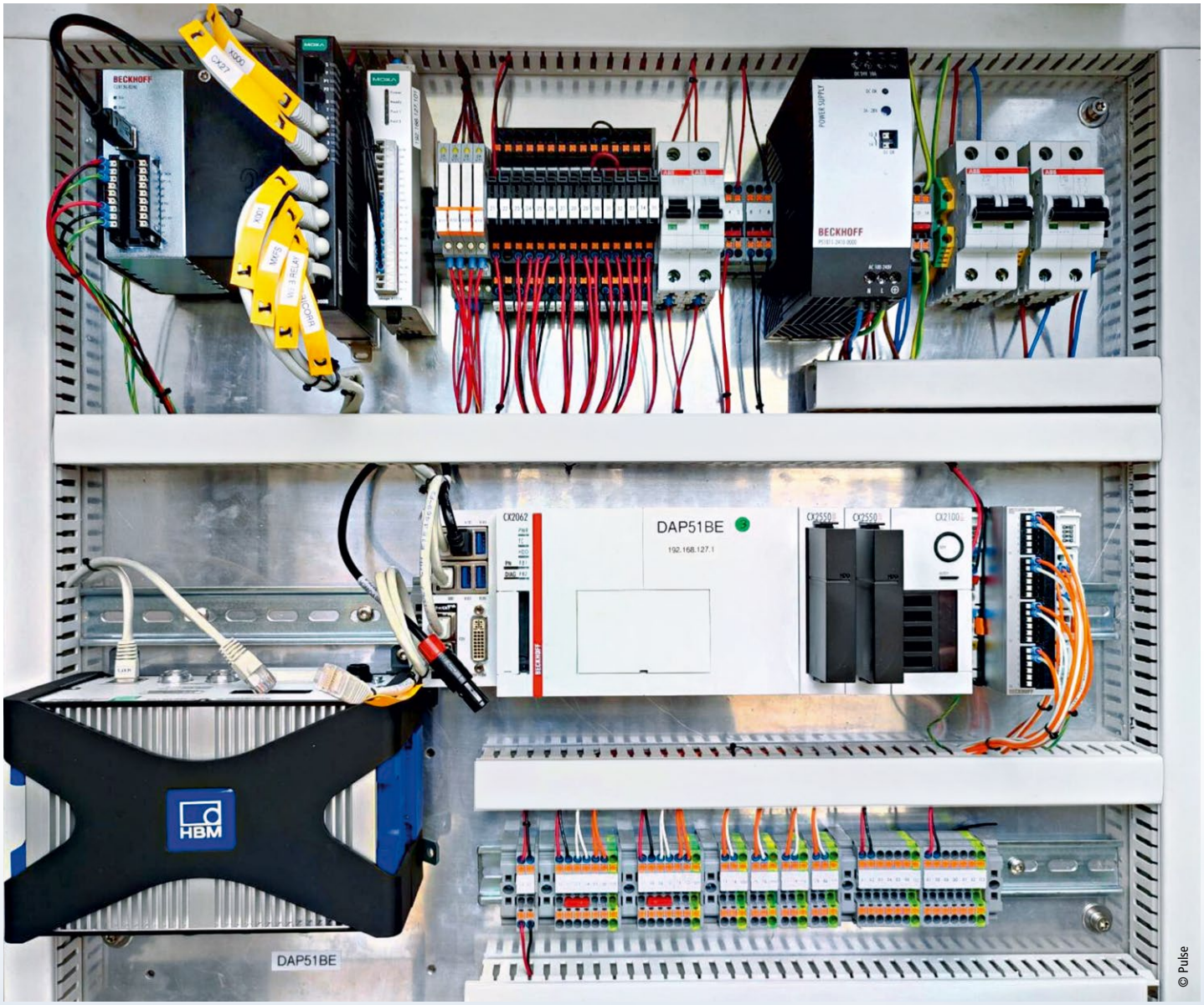
fast, which is essential for synchronization and getting the data we need. But EtherCAT with distributed clocks at every level allows us to take it one step further and keep full synchronization. With Beckhoff the quality of the technology is always guaranteed."

From Stephen Harford's point of view, partnership is also important: "Beckhoff have also made every effort to help us keep to the tight schedule that wind farms have. They have supported us at every stage, coming down to train us when we could not make it due to our tight schedule. This is why we're happy to successfully partner with Beckhoff on other projects we have."

Data management with TwinCAT

All the data from the sensors is centralised and collected in a Beckhoff embedded controller, the CX2062 Embedded PC with TwinCAT PLC (TC1200) and Windows 10 IoT in this case. The CX2062 was chosen for its flexibility in expanding memory, increasing interfaces and processing power to run the TwinCAT runtime software plus the data management and processing application developed by Pulse. Beckhoff provides a free and open DLL to access all real-time data within the TwinCAT system via ADS. This open platform allows Pulse to both analyse data and send it directly to the higher level Scada system, providing key insight to the turbine's health.

"What's been great about this project," explains Beth Ragdale, product manager with Beckhoff UK, "is how we can utilize our previous work in the renewables sector to provide Pulse with our expertise in this area. We've also managed to provide everything from standard I/O terminals to high accuracy measurement modules, and, with a hybrid of power and communication in a combined cable assisting Pulse to simplify their installations. That's why we're excited for the future projects we have together."



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Control cabinet with CX2000 Embedded PC and directly connected ELM series measurement terminals (center of picture) as well as a CU8130 UPS (top left) and a PS2000 power supply unit (top right)

More information:

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