Wind power and CANopen

Since many years, embedded CANopen networks are used in wind turbines. The market is still growing and some elder turbines need to be retrofitted. Especially in pitch control, CANopen has a significant market share.

At this year's Husum Wind trade show, retrofitting was an important topic. In September, around 600 exhibitors showcased product innovations and cutting-edge technology in the fields of onshore and offshore wind, green hydrogen, energy storage, sector coupling, digitalization, recycling, and repowering. For over thirty years, the industry fair in northern Germany has supported the wind energy markets. More than 12000 visitors from 51 countries came to Husum.

According to the recently published semi-annual figures and wind power expansion report of the German Wind Energy Association (BWE) and the German Engineering Federation (VDMA), the wind energy market is showing significant growth, particularly in onshore wind, with a gross addition of 1565 MW of installed capacity. The upward trend is even more evident in the 3175 MW of newly approved projects. At the biennial trade fair for the wind industry, exhibitors from Germany and abroad presented what the industry can achieve the target of 10 GW of onshore wind capacity per year from 2025.

In addition to new projects, the industry in Germany relies on repowering to accelerate the energy transition and meet expansion targets. By 2025, around 8000 turbines will no longer be subsidized. Companies presented the entire range of second-life solutions for wind turbines, from repowering and recycling to marketing models such as PPAs (power purchase agreement) and trading on the international used-turbine market.

Baerbel Heidebroek, President of the nonprofit BWE, said: "Wind energy will play a central role in Germany's energy supply. The ambitious expansion targets underline this. If more land is available, approval processes are speeded up, and transport issues are solved pragmatically, the targets are achievable."

Hydraulic and electrical pitch control

Since many years, the CiA members Deif, Emerson (formerly Mita-Teknik), and Moog provide hydraulic and electrical pitch control solutions. Moog was one of the fathers of the CANopen protocol development in the 90ties. Deif situated in Denmark, offers customized hydraulic pitch systems as well as electrical pitch motors, pitch servo drives, and sensors.

The primary functions of the pitch system are to optimize the power production as well as to stop the wind turbine in maintenance and emergency situations. Deif designs the pitch system to individually match the specific

Figure 1: Exhibition patron and German Federal Minister of Economics, Robert Habeck, opened the Husum Wind 2023 exhibition: "The trade fair is the beating heart of the energy transition in Germany." (Source: Husum Wind/Marcus Dewanger)

wind turbine design in order to optimize the operation under certain conditions. These are high, medium, low wind as well as extraordinary situations like LVRT (low-voltage ride through) conditions and emergency stop. The offered pitch system design is based on the load data and aerodynamic characteristics of the turbine.

Deif pitch boxes are customized to match the physical size of the hub. Metal, coating, and color are specified by the customer. Two preferred metals are available; construction steel and stainless steel. The cabinets have an important function not only for enclosure but also for damping electrical noise (EMI), an increased demand stipulated by IEC 61400. The cabinets and interconnections are designed with reference to the specific lightning zones inside the hub.

The system can be delivered in different variants, from three to seven box solutions, depending on the space inside the hub. The choice of energy storage affects the required number of boxes and the possibilities customers have. Batteries are to be placed in separate battery boxes for each blade due to the explosive gases they generate during charging. The inverter, pitch controller, and the remaining system units are placed in other boxes. In the seven-box solution, for instance, a center box contains the pitch motion controller, the over-voltage protection and the grid connection point. For each blade there are identical battery boxes, and pitch drive boxes – three of each. Another example is a four-box ultra-cap solution, in which a center box contains the pitch motion controller and three other identical boxes contain ultra-caps and power inverters for each blade.

Figure 2: Retrofitting the pitch control system can optimize the power production of the wind turbine system (Source: Husum Wind/Marcus Dewanger)

An important topic is the design of the pitch cabinet. It should fit to the environment conditions (see "INSERT"). Deif tests its pitch control solutions on EMC (electromagnetic compatibility) requirements and surge protection.

Pitch motion control

The offered pitch motion controller is based on the Deif's advanced wind turbine controller platform. Being the center of the pitch control system, it collects inputs from other units such as sensors, chargers, and drives. The pitch motion controller works by command from the wind turbine controller, or independently, if CANopen communication to the controller is lost.

The application comprises sensors for monitoring of the pitch system itself and for monitoring the service need of the wind turbine. The control system further comprises monitoring of the battery lifetime and the grid connection. The pitch system is self-protected – undetected system faults cannot occur. It monitors also the battery voltage and estimates the lifetime.

The Integrated Motor Drive (IMD) by Deif is developed with offset in decades of accumulated knowhow about the entire wind turbine and its pitch systems. With its integrated motor solutions, the IMD reduces cabling in the system and provides a high reliability at minimum cost, states the supplier: "Engineered to customers' application, the IMD is bound to become a preferred choice for pitch and yaw control." The IMD is an all-in-one solution and comes with units such as I/O (input/output) devices, ballast resistor, EMC filters, charger, power supply, motor brake control, choke, and safety chain designed in accordance with the European Machinery Directive.

Functional safety is a vital function in electric pitch systems, and the IMD is the main part controlling the blade angle during turbine operation and in safe stop situations. In modern wind turbines ranging from kW to MW, the pitch system is the only brake capable of stopping the wind turbine during operation. This makes the pitch drive a safety-related system. The IMD complies with the ISO 13849 functional safety standards due to the failsafe hardware compliant with MTTF-d (mean time to failure) and PL-d (performance level).

Since many years on the market

Emerson has acquired the Danish Mita-Technik. Since many years, the Mita pitch control system is on the market. According to Emerson about 3000 pitch controllers are in the field and more than 60000 wind power controllers have been installed. The modular pitch control system suits wind turbine systems up to 10 MW. For turbines up to 20 MW and for two-bladed turbines, the pitch control system can be customized with load-sharing between the pitch servo motors and the blade units. The pitch control system uses a CANopen-based embedded network connecting the used modules (motors, sensors, energy storage, etc.).

Emerson regards the retrofit business as important, too: "Our retrofit solution upgrades both the control and electrical systems of wind turbines so that they meet the latest local and industry standards. Our experience across more than 40 different wind turbine generator designs provides a safe and simple upgrade path for regaining the maximum performance within your wind turbines." Wind turbines, ranging from kW to MW sizes, can benefit from an upgrade. This includes stall, active stall, pitch, and 2- or 3-bladed wind turbines. An Emerson retrofit includes advanced control algorithms to improve energy production, to heighten turbine availability, and to provide remote access.

The hub unit, the blade unit, and the energy storage unit come in IP65-rated housings. They can be used in onshore and offshore wind turbines. Emerson's pitch control system is developed, tested and manufactured according to the APQP4Wind specifications. APQP4Wind is a non-profit organization endorsed by world-leading utilities, wind turbine manufacturers, and suppliers. The background for APQP4Wind is the continuous quality improvement needed to keep pace with the ongoing trend toward decreases in the levelized cost of energy.

Fiber sensor interrogators

Insensys located in United Kingdom showed on the Husum Wind exhibition its OEM-4030 fiber sensor interrogator (FSI). This is a measurement device, which sends pulses of light through the blade sensor arrays. Each sensor returns a reflection to determine the strain at that location. The ▷

Figure 3: Fiber sensor interrogators with CANopen connectivity can be integrated into pitch control networks (Source: Insensys)

Retrofitting pitch control

Christian Reichmann, a Deif application software designer, explained in a blog: “Poor cabinet build quality is a frequent cause of Suzlon S88 downtime because of moisture and vibration issues. Opting for a retrofit pitch control solution not only solves the immediate problem through better cabinet quality, it also offers a number of additional benefits such as optimized pitch control and full data access while making you independent of expensive OEM support.”

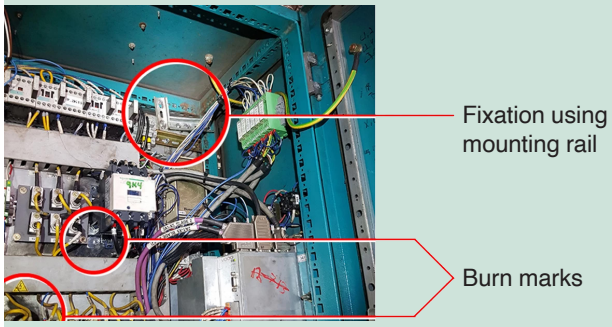

Figure: Short circuits can result in burns inside the cabinet (Source: Deif/Christian Reichmann)

A pitch system on a wind turbine is used to optimize power production. In addition, it is a safety sub-system on the turbine, allowing it to stop in high winds or other unfavorable operating conditions. Reichmann wrote in his blog: “On the Suzlon S88, however, the pitch system has sometimes been a source of turbine failure; not so much because of the pitch system itself as the cabinet housing the pitch control system. The poor build quality of the S88 pitch control cabinet means that moisture can enter the cabinet, causing short circuits and component failures. On some S88s, short circuits have resulted in burns inside the cabinet. Also, on at least one occasion the cabinet mounting plate was fixed with a mounting rail, increasing vibrational stress on the cabinet components and further aggravating the risk of component failure.”

Issues such as these can result in wind turbine downtimes. The situation is further worsened as the pitch controller has limited reporting and monitoring options. Reichmann explained: “You know that the turbine is down, but you do not know why. To find the cause of the problem, you are dependent on OEM support which often comes at a significant hourly fee. Until the problem is identified and solved, the turbine is wasting valuable production time – sometimes for months.”

In cases such as this, opting for a retrofit pitch control system from another manufacturer is a solution. A third-party pitch control system with a better cabinet build quality solves the problem by preventing moisture and vibrational stress from adversely affecting the pitch control system. In addition, the new control system often provides several additional benefits such as more accurate pitch control, better suitability for MW-scale production, and a wider operating temperature range.

Reichmann stated: “Equally importantly, it can also empower you to carry out service and maintenance on the pitch control system yourself, or outsource it to a third-party ISP as required. With detailed error messages and full logging access, you are no longer dependent on OEM support and can take full control of all service activities. You may also have more options for interfacing with SCADA systems or similar, letting you take full control of your wind farm.”

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sensor then outputs all measurements in a data packet to the turbine controller, which uses the data for real-time blade load calculations. The data can be sent by the CANopen interface. Customized CAN communication can be also used. The FSI comes in an IP40-rated housing and measures 240 mm x 120 mm x 97 mm. It is designed to fit into pitch cabinets.

Additionally, the British company offers the TL20 fiber sensor interrogator. It has evolved from the current FSI product line with 17 years of interrogator design and build experience in harsh environments. The TL20 uses lower cost core optical components to achieve a mid-range price/benefit position. The product enhances the existing cyclic pitch control routine by feeding in actual load data, which can compensate for pitch encoder errors, and therefore reduces the fatigue damage to the gearbox. The system offers additional load monitoring alarm capability, e.g. extreme load events and other blade condition monitoring functionality such as damage and de-bonding. It also can provide ice build-up alerts to trigger heaters and prevention systems.

For individual pitch control (IPC), the Insensys sensing system consists of one FSI unit and three sensor arrays (one per blade). Each sensor array comprising four sensor patches each containing an FBG (fiber Bragg grating) strain and temperature sensors. An FBG sensor is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others.

The FSI unit is typically located within a turbine hub electrical cabinet. It measures optical signals, converts optical measurements to electrical signals, and this data can be delivered to the turbine PLC (programmable logic controller), for example, via already existing communication systems such as CANopen or proprietary CAN-based networks. Sensor arrays are installed around the root section of the turbine blade positioned at 90° to each other enabling edge-wise and flap-wise bending moment and load calculations. ◀

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