The Emerging Role of Preventative Maintenance in Wind Turbines

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Richard Ord, Marketing Director, Amantys Limited, Cambridge, UK

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How many times have you driven past a set of wind turbines on a windy day and noticed that many aren't working? Is it any wonder the anti-green lobby gain traction in debating the move to cleaner energy sources when wind energy companies cannot consistently predict maintenance failures? What's surprising is that the majority of wind turbine issues aren't related to the core structure. In fact, around half of maintenance problems are actually related to the power electronics- a problem that isn't easily fixed.

A recent story highlights one of the challenges of power electronics in offshore wind farms, with the Carbon Trust recommending better barges for the North Sea to cope with the frequent unplanned maintenance demands of offshore wind farms.

This demonstrates one view of the problems created by the hectic pace of development and deployment in the industry, illustrating the need for more investment in infrastructure, maintenance and power electronics. But there's a different way to tackle this problem to improve offshore availability.

Current maintenance challenges

In the North Sea for example, some turbines are almost inaccessible for six months of the year, making quick fault response expensive and prohibitive. The Carbon Trust noted that five out of six annual maintenance visits to offshore wind farms are unplanned, leading then to the suggestion that new barges should be developed to enable greater accessibility.

The offshore industry is therefore investing in maintenance vessels that can access a turbine in heavier seas so that servicing visits can be made more often, but does this actually attack the root cause of the issue? Undoubtedly the industry would benefit from such vessels, but there is no doubt, either, that the industry would embrace advances in technology that can reduce the frequency of such visits and start to tackle those root causes.

Wind turbine power electronics

When it comes to the reasons for wind turbine down-time, around half of all the faults are related to the inverter tripping out or failing. And whilst there are sophisticated control systems for the converter, turbine, and wind farm as a whole, the heart of the power converter is built around IGBT modules; in current systems, this remains an analog world, and only very limited data is available in the control domain.

When the power converter has a fault in the inverter stack, typically the diagnosis available to engineers from the IGBT gate

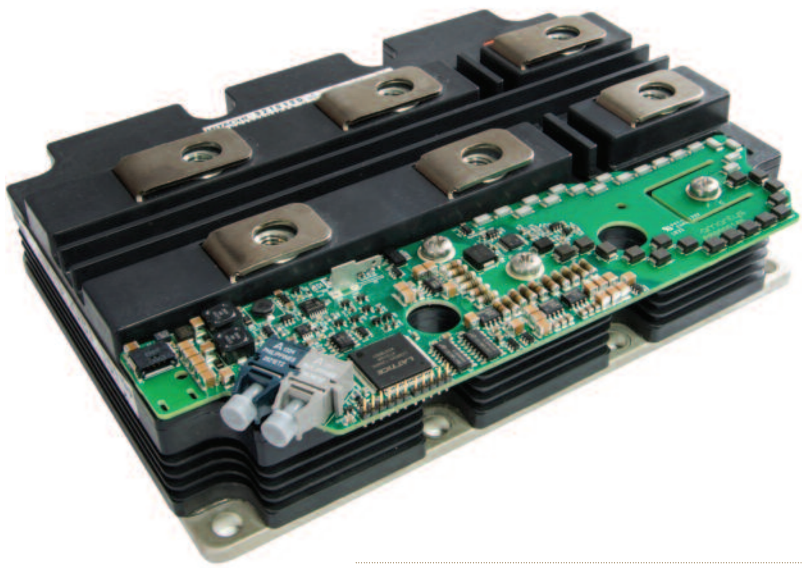

Figure 1: **Bringing digital techniques to power electronics**

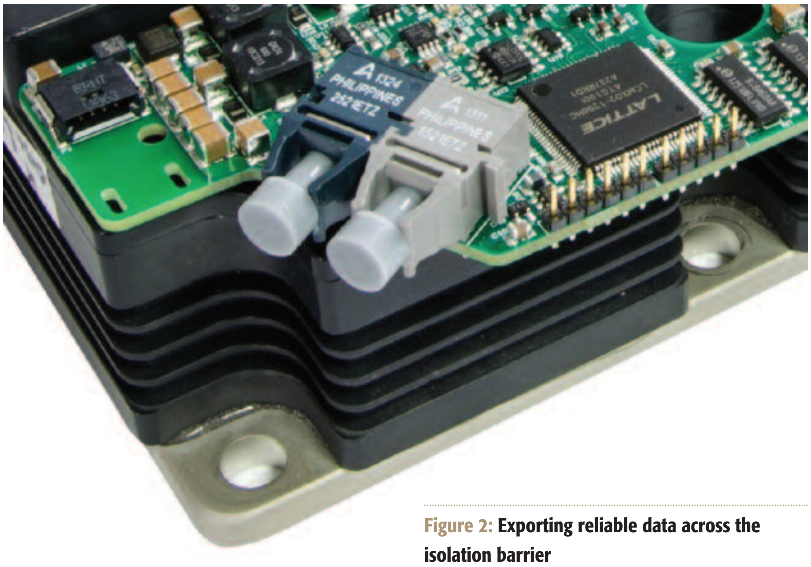

Figure 2: Exporting reliable data across the isolation barrier

drives consists of one of three signals - on, off or fault - and 'fault' can mean anything from a minor problem to a major problem that requires instant attention. There is no communications channel from the gate drive to the control environment, and to explore further demands a visit from an engineer to investigate, thus bringing us back to the problem of turbine accessibility, both onshore and on the high seas.

The consequence for wind turbine maintenance operators is a mixed schedule of planned and unplanned call-outs, resulting in engineers wasting time looking at systems and equipment that is functioning perfectly well – and being dragged away from more pressing issues.

In the absence of systematic data from the converter with respect to the power device performance in varying conditions and environment, and due to the relatively primitive nature of IGBT gate drives, limited opportunity to build up system knowledge exists. Without this, improvement of system reliability is hampered, and the cost of wind farm operations and maintenance remains a high priority.

Understanding the mission profile

The challenge then is to improve the understanding of what fault signals may indicate, what causes different problems, differentiating between trip conditions or non-critical faults, and flagging potential failing components. In fact, greater knowledge of how the system operates (and fails) in varying environmental and load conditions will allow better planning of repairs, increased availability, and fewer call-outs in adverse weather conditions.

Amantys brings a fresh approach, combining the dual worlds of analog power electronics with the digital domain of deeply embedded digital control techniques (Figure 1). Founded on expertise from both areas, the company has developed technology that solves the initial problem – how to export reliable data on key system parameters across the isolation barrier (Figure 2). Amantys Power Insight™ is a unique solution for sensing, monitoring, and communicating vital characteristics and behavior from the power device and gate drive to the control domain (Figure 3).

Intelligent control of power

A system with IGBT drivers enabled with Insight can help tackle these issues with real data on the core power electronics. Amantys Power Drives™ control the switching of IGBT modules from all leading manufacturers, providing more robust electronics at the heart of the switch. Programming of the on-board embedded microprocessor allows the system to determine what data to export and when, as a function of condition, environment and load, thus beginning to build that picture of turbine performance in real-time.

The key to learning about the system is the extraction of information from all the data available, so by analyzing fault codes as a function of the prevailing conditions, and by programming appropriate alarms, thresholds and fault codes, the operator can begin to understand how to adapt the system for better performance and more manageable maintenance schedules, which leads to greater warning that something is wrong, stronger

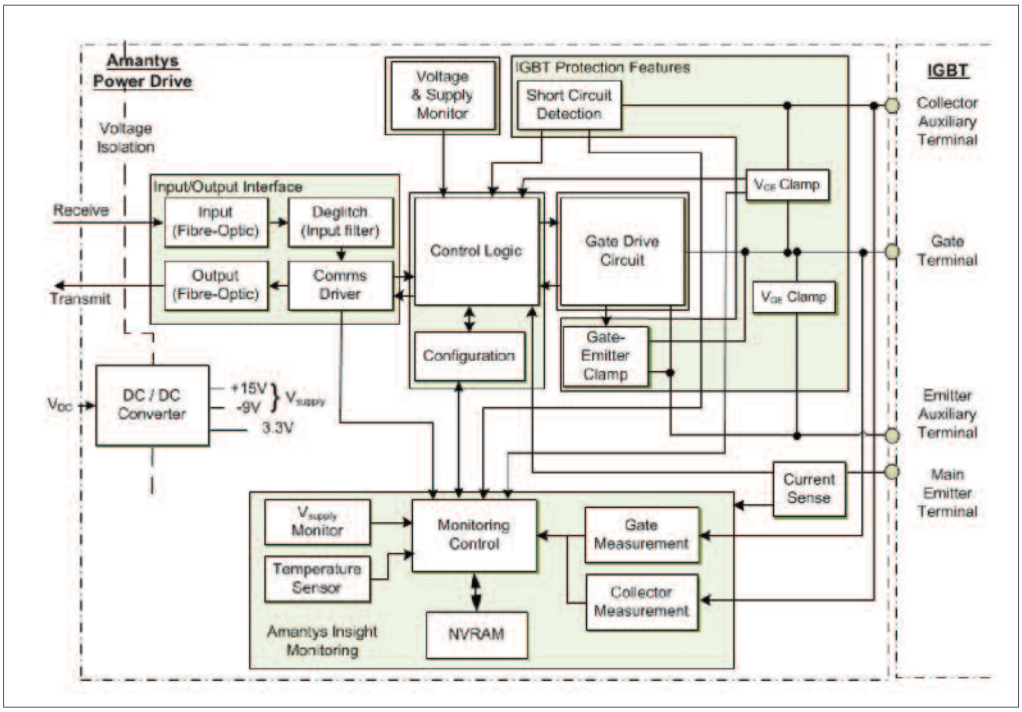

Figure 3: Amantys Power Insight block diagram

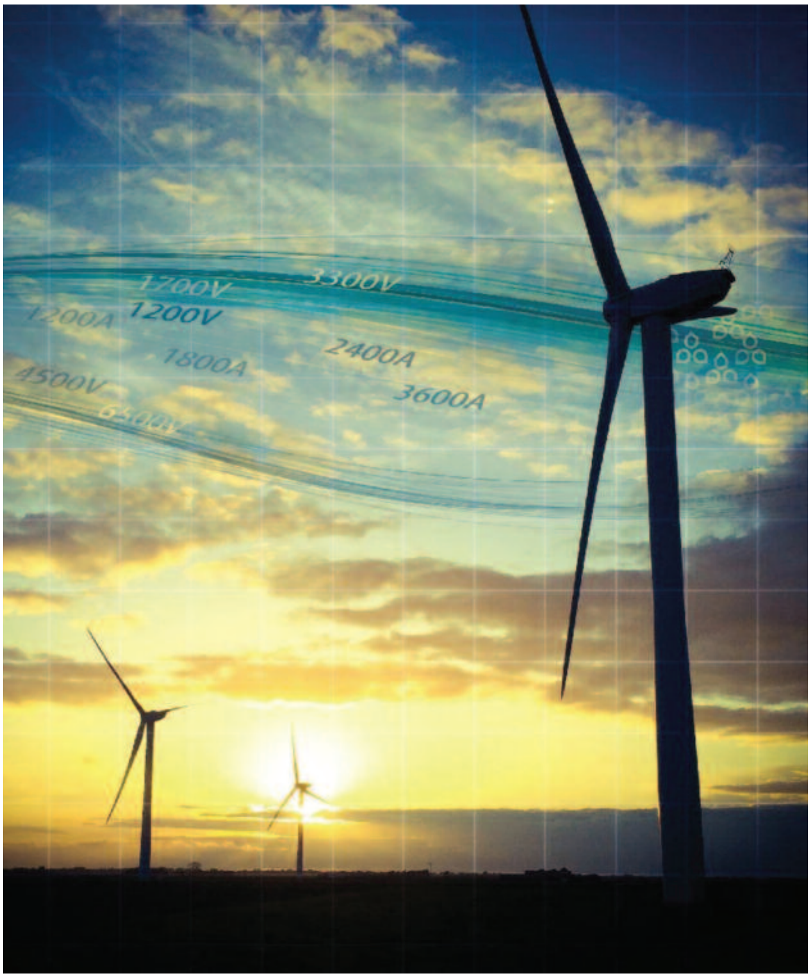

Figure 4: A change in wind-farm operation

understanding of essential component performance, and more cost effective operation all round. In an offshore installation this would also enable the part to be replaced during routine maintenance in better weather conditions, ensuring that availability is kept high.

The Insight protocol provides a future-proof platform for technology evolution, allowing system information to be separated from raw data today, and a vehicle to analyze performance diagnostics further down the road.

The inability to test performance or compare to external factors, and what is happening elsewhere, ought to be a thing of the past. New and innovative technologies are being developed to ensure greater insight is gained into the IGBT when actually operating in a converter to give operators a better understanding of their power electronics components.

Future for wind energy and power electronics

Visibility and analysis of switching performance can change how operators can manage power electronics and key components such as the IGBT modules - Amantys is helping to address this in an area where little intelligence has so far been available (Figure 4).

Industry in general is preoccupied with issues of big data, machine-to-machine communication and the Internet of Things. The key to such advances lies in extracting intelligence from the machines that are communicating with machines, and that demands digital techniques throughout the system.

Companies across the industry are looking for more informed knowledge on every aspect of how things are performing, which is an example of real machine-to-machine communications. The power electronics industry cannot afford to lag behind.

Amantys is already working with some leading companies in the renewable energy space to realize this vision and we expect more companies to follow the trend. The benefits are not just tangible, but quantifiable, and they can't be ignored.

Adaptive Intelligent Parallel IGBT Module Gate Drivers

At PCIM in May Amantys launched an IGBT Gate Driver operating at 3.3 kV, 4.5 kV and 6.5 kV, with significantly improved reliability and protection in high power modules targeting the most demanding applications including wind turbines, locomotive, HVDC, and industrial drives. At these power levels the gate driver must provide reliable and effective protection mechanisms for a variety of fault conditions. This new IGBT gate driver includes a variety of detection mechanisms for different short circuit types including a multi-threshold, programmable comparator which can identify slowly increasing fault currents, a fault mechanism which is not commonly detected in commercially available "plug and play" gate drivers. Once a fault is detected the driver is designed to implement a controlled switch off of the IGBT avoiding the potential for damaging voltage spikes.

This gate driver also includes the Power Insight™ condition monitoring and configuration capability to observe and report on critical power switching characteristics as well as enabling in-system configuration of the driver. Designed for the "intelligent control of power", the Power Drive is fully integrated and can measure and export critical performance parameters during operation as well as allowing configuration over the existing optical PWM and fault interfaces. These capabilities greatly simplify the design-in process.

The new Power Drive gate drive operates is configurable for industry standard 190 mm x 130 mm high isolation power modules from manufacturers including ABB, Dynex, Hitachi, Infineon, and Mitsubishi.