Measuring lightning intensity

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Croatian wind farms experience significant problems due to lightning strikes. The lightning measuring system from Phoenix Contact is therefore used to monitor the turbines and optimize their service

Due to their height and exposed location, wind turbines prove to be perfect lightning catchers. Damage due to lightning strike is often considered an 'extraordinary event', meaning that it drives additional costs during the operation and beyond standard service. With a solution from Phoenix Contact, tracking the incidence of high keraunic levels and monitoring adverse effects on performance of individual wind turbines can be significantly improved.

Nils Lesmann

The risk of a lightning strike is continuously increasing as wind turbines (WTGs) become larger and their rotor blades longer and more susceptible.

Likewise, the amount of initially small damage is increasing, which often grow undetected and can thus result in large rotor blade damage, influencing the structural integrity of the blade. New technology from Phoenix Contact can measure considerably more lightning.

The installation of a lightning measurement system in WTGs has long since ceased to serve only to monitor the wear of the receptors on the rotor blade. The international standard IEC 61400-24 now also recommends the use of a monitoring system to optimize the operation and maintenance intervals of the turbines. In addition, the values recorded are to be used for future risk assessments.

Some regions of the world experience a significantly higher risk of lightning strikes. According to the Vaisala Annual Lighting Report, this includes Croatia[1]. This offers the perfect conditions for studying the impact of lightning on wind turbines.

In addition to the aforementioned research project, the latest product of the Blade Intelligence family from Phoenix Contact can also be tested here. With this solution, the Blomberg-based company is adding another element to its lightning measurement portfolio that enables the detection of lightning intensities between 1 kA and 50 kA, see Figure 2.

Joint research project to identify lightning protection systems

Porzana Ltd is the project operator on one of the most productive wind farms in Croatia. The Voštane-Kamensko wind farm consists of 14 Siemens swt 3.0-101 WTGs. It has 42 MW of installed power and a yearly capacity factor of more than 30%. It is situated on a hilly terrain in Split-Dalmatia County in Croatia, near the border with Bosnia and Herzegovina.

The faculty of electrical engineering and computing of the University of Zagreb and Porzana Ltd, are involved in a research project entitled 'Development of an expert system for measuring lightning strokes parameters and protection of wind turbine blades in order to reduce failures and downtime'. This is partly financed by The European Regional Development Fund (ERDF).

The goal of this project is to obtain the necessary data for the improvement of lightning protection and surge protection systems, with the aim of reducing the number of failures, downtime of wind turbines and making greater use of wind potential through statistical analysis of the collected lightning parameters.

Together with the Phoenix Contact Lightning Monitoring System (LM-S) installed on all of the turbines, the improved system is also installed on the highest

1 www.vaisala.com/en/annual-lightning-report

turbine on site. The prototype measurement system, based on the Rogowski coil, is developed and installed around the base of the wind turbine tower to supplement the measurements inside the WTG blade. Here the recorded lightning waveform will be processed and compared to the improved system from Phoenix Contact, lightning location system and other available measurements.

The specific goals of the project are automatic collecting and processing parameters of lightning strikes in wind turbines; processing of collected data on lightning strike parameters characteristic of the coastal area of the Republic of Croatia; development of wind turbine models in EMTP, simulation of measured shocks, comparison with measurements and the final improvement of the lightning protection system by identifying the desired characteristics of the lightning receptors.

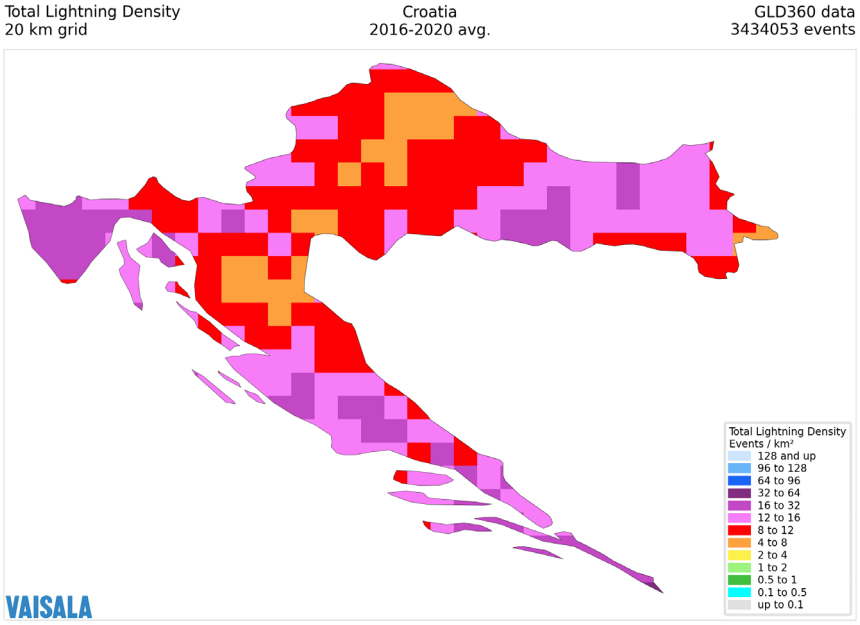

Figure 2: Illustration of lightning intensity in Croatia according to Vaisala: In some cases, up to 64 lightning events/square kilometer occur annually. (Credit: Vaisala Annual Lighting Report)

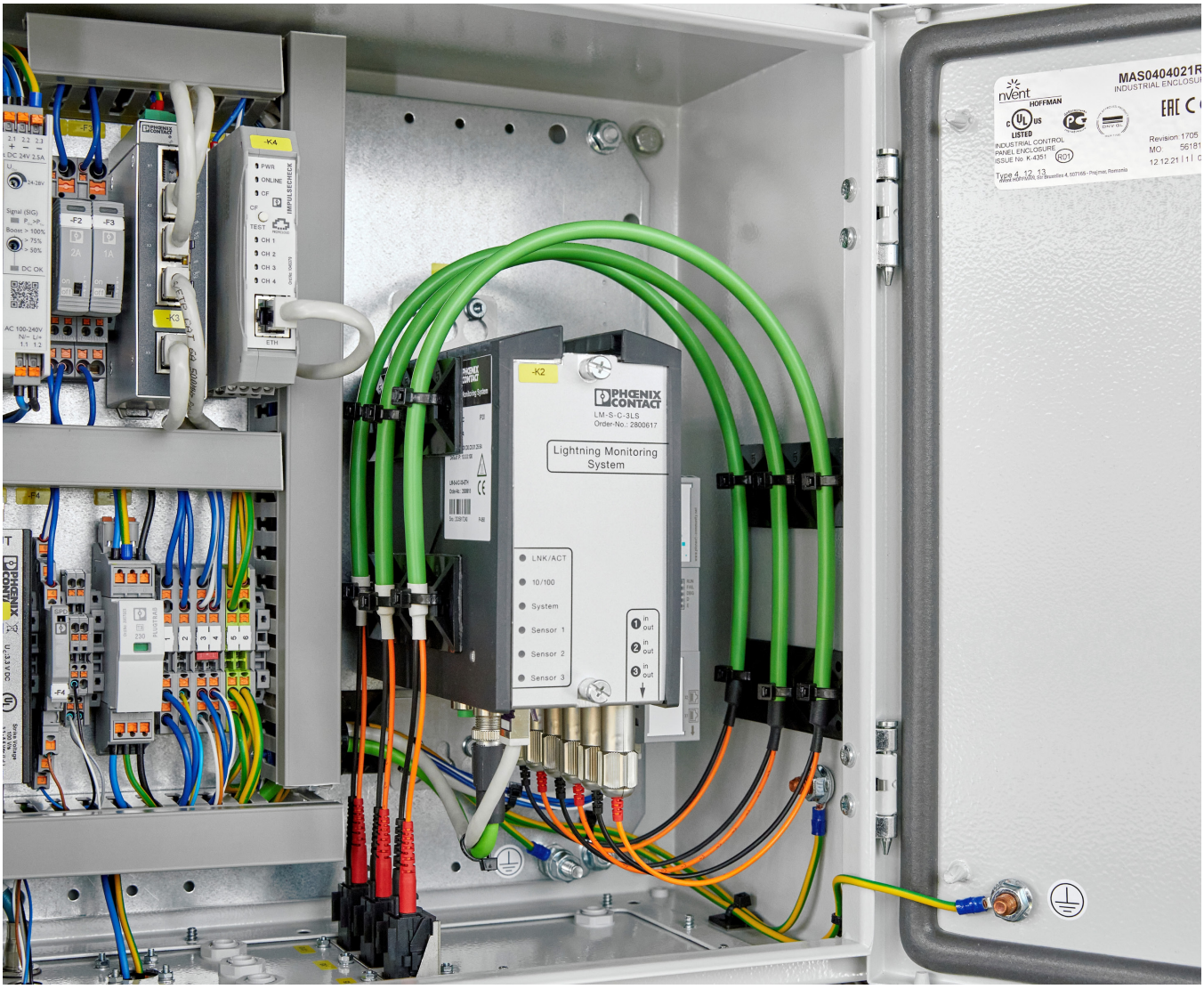

Figure 3: In the Croatian wind turbine, the modular solution consisting of the previous LM-S system and the extension in terms of low lightning intensity detection is used

Figure 4: Nikola Pletikosa works as a project engineer and technology transfer coordinator on a lightning research project at Porzana Ltd., Croatia

Figure 5: The sensor can be easily attached to the lightning arrester

Varying severity of blade damage

As described at the beginning of this article, the trend in wind turbines is toward ever larger systems with longer and more delicate rotor blades, which results in an increasing number of lightning strikes.

What challenges does this pose for the maintenance of WTGs, and how can the new solution from Phoenix Contact help?

Occasionally, extreme thunderstorm events with high lightning activity occur. By analysing the local characteristics of lightning strikes, the company's wind team aims to improve its existing operation and maintenance strategy.

With the lightning measurement system integrated into the Croation WTG, the team were able to track the occurrence of high keraunic values as well as monitor their negative impact on the performance of individual wind turbines. The team is also working on a corresponding research project in regard to mitigating turbine damage caused by lightning: Figure 3.

Tall structures are particularly susceptible to lightning. This is especially true for wind turbines installed in a complex, hilly terrain. Practical results show that most lightning damage is concentrated at the tip of the rotor blade.

The severity of blade damage can vary significantly, ranging from superficial scratches to blade tip breakage, which may compromise the structural integrity of the blades. Therefore, precautions should be taken to determine how severely the rotor blade was exposed to the lightning strike.

Greater accuracy at low lightning levels

The previous solution for lightning current measurement from Phoenix Contact records all lightning parameters according to IEC 61400-24 and stores them on an internal server.

With the improved version, even lower lightning values can be measured with greater accuracy. The lightning waveform can be recorded for further investigation, and several consecutive strikes can be logged within a short period of time. In the research project, the new lightning current measurement system proved to be easy to use, robust and reliable.

By adding small currents to the system, it is now possible to record values that are below the noise of the previous measurement system. Lightning is expected to occur in a measuring range of 1 to 30kA in relation to the Croation WTGs. Even if the current intensity is low, an influence on the rotor blades as well as the entire wind turbine is expected due to the number of flashes.

The combination of both lightning current systems opens up a very large measuring range from 1 kA up to 400 kA. This is unique on the market and significantly exceeds the requirements of IEC 61400-24. The solutions can be used in all worldwide wind farms without a special site assessment.

Easy data extraction for external analysis

For insurance claims, it is often necessary for the recorded lightning to be checked by an external meteorological system. Phoenix Contact's PLCnext Technology open control platform allows the current lightning strike values to be queried in the Vaisala lightning detection networks, Global Lightning Dataset (GLD360) and National Lightning Detection network (NLDN).

In terms of connectivity, the platform supports almost all standard bus systems,

Figure 6: The sensors can also be bonded to a laminated arrester

Figure 7: Commissioning of the first prototype by the wind energy experts from Phoenix Contact

from Profinet and Modbus TCP to OPC UA and the company's own cloud solution, Proficloud.io.

Added to this is the ability to view the exact lightning curve delete itself the evaluation unit and extract the data for external examination. Nikola Pletikosa has high hopes for this function in particular, as it allows the lightning event to be better analyzed.

'Conclusions about possible damage can be drawn from the results, and multiple impacts that are suspected of causing particularly severe damage to the rotor blade can be evaluated more precisely,' said Pletikosa, see Figure 4.

Installation of the system is designed to be as simple as possible. The sensors are either attached to the lightning arresters with cable ties, see Figure 5. They can also be glued onto the arrester if it has been laminated into the rotor blade, for example, see Figure 6. The robust design of the sensors minimizes damage during operation or service in the rotor blade.

Clever combination of different monitoring disciplines

The expansion of the lightning measurement system fits seamlessly into Phoenix Contact's Blade Intelligence System, resulting in a fully comprehensive solution for monitoring rotor blades. All important disciplines around blade monitoring run on the same controller and use the same user interface.

The combination of lightning measurement, structure monitoring, load detection and ice detection based on impedance measurement outside the rotor blade or by vibration is unique on the market. Due to the flexibility of the systems, the different disciplines can be combined. The interaction of load monitoring during a recorded ice event and the measurement of a lightning strike results in good condition monitoring for early detection of damage, see Figure 7.

At Wind Energy 2022 in Hamburg, Phoenix Contact will present solutions for monitoring gearboxes and large bearings as well as the tower and foundation of the WTG, in addition to the addition of the lightning measurement system. All functions are based on the PLCnext Technology control platform and with the same modularity and operation.

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Renewable energy generation systems as an important part of the All Electric Society

All Blade Intelligence System solutions like lightning current measurement, ice detection, load measurement and structural monitoring, contribute to high availability of wind turbines. This is essential, as wind power is a key pillar of energy generation from renewable sources. Phoenix Contact believes climate change can only be countered by a complete switch from fossil to regenerative energy sources.

The mission statement of the All Electric Society describes a world in which regeneratively generated electrical energy is available worldwide as the primary main form of energy in sufficient quantities well as completely economically. The basis for this is the comprehensive electrification, networking and automation of all sectors of business and industry. With its components, systems and solutions as well as its digitization expertise, Phoenix Contact enables helps with the acceleration of this transformation the implementation of this transformation on the way to a sustainable world.