Enhanced lightning effects testing for optimized wind turbine reliability

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Abstract

Lightning related damages and costs are regarded being one of the larger issues for wind turbine operators in certain regions of the world, and the effort in improving designs, manufacturing quality and scheduled maintenance of modern wind turbines has become very important for the manufacturers. Since 2010, wind turbines may have been certified according the IEC 61400-24 Wind turbines – Part 24: Lightning protection, requiring verification of the applied protection measures. The present paper presents a new mean of verification, namely full scale lightning current testing on complete nacelles and wind turbine blades.

The ELITE (Enhanced Lightning effects Testing) project starts by investigating the actual lightning exposure of wind turbines by gathering information from many research communities, wind turbine manufacturers, owners and operators of the systems. This information is compiled into design and test requirements as the basis for the generator design. The generator is designed to inject lightning current pulses (IEC LPL1) into full scale structures like 50-100m blades and 3-10MW nacelles, to investigate the overall exposure and determine the compliance with the lightning protection standards.

Main Objectives of the ELITE project

The overall objective of the ELITE project is to develop and demonstrate a next generation lightning test system capable of handling high-performance tests of full size wind turbine components, including 5-10 MW nacelles and 60-100 m long blades. The wind power industry is very aware of the lightning related problems and of the need for improved testing capabilities.

- Systematic collection and analysis of data concerning lightning protection of wind turbines generated during the past ten years on universities, in the manufacturing industry, on the customer side and from the numerous research projects completed by lightning consultants.
- Design, construction and validation of an impulse current generator to comply with the lightning test requirements raised by the wind turbine industry and defined by the lightning environment identified. To accommodate the requirements to the test pulses set forward in terms of waveforms, amplitudes, energies, etc., this process will require several engineering disciplines. Apart from High Voltage engineering and research into new means of storing and releasing the extremely large quantities of energy, the mechanical design must also ensure safe and reliable operation. The complex system requires a thorough understanding of all processes and involved techniques, and here the research team at DTU along with the experienced engineers at GLPS will work closely together. The generator design and construction will, upon completion, enable wind turbine and blade manufacturers to get the necessary verification tests performed also for future even larger structures.
- Demonstration of the newly developed test system on large full size test setup, nacelle, complete wind turbine blade, etc.

The achieved experiences from previous testing on large-scale systems (see Figure 1 and Figure 2) with high- but not full level lightning impacts, will lead to new approaches for defining test and verification requirements, and thereby assisting manufacturers in increasing the documented reliability of wind turbines.

By pushing state of the art testing to a higher level, including requirements for certification and industrial standards, the entire industry will be driven in a cost effective direction making wind power even more competitive.

The issue of winter lightning can be related frequent occurrence of upward lightning discharges. A small fraction of these incidences lower huge amounts of charge to ground and requires special design considerations. Peak current amplitudes are small compared to downward lightning incidences.

Requirements for New Test Generator System

By combining the results from the parameter study with requirements from the industry, the ELITE project is able to specify the requirements for future test systems in a 10 year horizon.

The new test system should be able to simulate the following lightning waveform parameters:
- Positive and negative First Return Stroke: 10-200KA (10/350us)
- Oscillating waveform with the same values as for the First Return Stroke.
- Continuous current: 0.4-1.2KA
- Subsequent strokes and M-components: To be further considered

The test systems needs to be modulated as shown in Figure 4.

Conclusions

Lightning incidences on wind turbines are of growing concern since plants are getting larger and the consequence of a outage is becoming more critical. This poster addresses the process of developing a new test system for full scale lightning testing on large scale wind turbine components as blades and nacelles. The test system should be able to simulate lightning and to meet the testing requirements from the global wind industry for the next ten years.

The requirements for the new test system is based on a systematic data analysis revealing that the current test parameters, known form the IEC 61400-24 standard are still representitative, but that the occurrence of strikes during the lifetime of the wind turbine needs to be considered carefully as well as testing needs to be performed on full size specimens, which requires special designed test equipment.

The new test system will be able to test with realistic waveforms on full size wind turbine components, including 5-10 MW nacelles and 60-100 m long blades.

References

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