

CHURNING WIND INTO POWER

By Ulrich Bock, Service Engineer
CADFEM GmbH, Grafing, Germany

Systems engineering can aid in designing an efficient wind turbine generator.

A wind turbine generator consists of all the components required for mechanical-to-electrical energy conversion. The turbine blades, generator and electrical converter are the three main functional assemblies for a wind-energy generator.

The most important component within the interacting elements of a wind turbine system is the generator that creates electric energy. The output of the generator supplies power to the converter subsystem, which conditions this electrical power. The power is then transferred onto the grid.

Some of the electrical components used in this conditioning and transfer process include transformers, capacitors, inductors and power electronics, as well as cables and bus bars.

Engineers who design wind turbines face a significant challenge: to accurately determine specifications of various individual components — which often originate from different manufacturers — and

then connect them into an efficient system. ANSYS software provides simulation tools that apply to all the sections of a wind turbine generator, leading to an efficiently designed and optimized system as a whole.

SYSTEM SIMULATION

Without using simulation tools, it is almost impossible to determine the performance of a complex heterogeneous system, such as a wind turbine, that incorporates the high efficiency requirements needed for the electrical system.

The heart of the ANSYS solution methodology for electromechanical systems is ANSYS Simplorer software. Using this technology, the engineer can set up a complex system entirely using analytical models. By employing detailed finite element method (FEM) models and a broad set of ANSYS simulation tools, users have the capability to analyze, optimize and embed all components in the overall end-to-end system.

Many design requirements for these electrical systems are complex and can be determined only via simulation. These include network coupling design and integration of power control based on existing electrical generator characteristics as well

as admissible power fluctuations and/or suppression of harmonics.

Employing simulation tools can be useful for testing critical operational conditions such as a short circuit that might occur in close proximity to (or at a specific distance from) the generator, admissible thermal loads, or the design of networks to protect against other effects, such as electrical surges. Other ANSYS software can be used in conjunction with Simplorer:

- ANSYS RMxpert, a tool specific to design of rotating electrical machines, for modeling the generator, making initial sizing and performance decisions, and preparing the model for simulation using Maxwell
- ANSYS Maxwell 2-D and 3-D tools for finite element simulation of the generator
- ANSYS Q3D Extractor for analysis of parasitic influences in and between cables and/or bus bars
- ANSYS Mechanical for structural analysis
- ANSYS CFD for determining wind speed/turbine speed relationship

ANALYSIS OF SYSTEM COMPONENTS

The capability to analyze systems and components is seamlessly integrated within the ANSYS family of simulation tools. For example, you can analyze the thermal load for, or impact upon, the different elements of the electrical network by employing Maxwell 3-D in combination with ANSYS Mechanical software. In the same way, you can determine the feedback for temperature-dependent parameters via Maxwell and simulate the resulting deformations with ANSYS structural mechanics, or conduct further thermal studies with fluid dynamics tools. As another example, electrical forces between the conductive rails and any resulting deformations can be determined by combining Maxwell 3-D with ANSYS structural mechanics products.

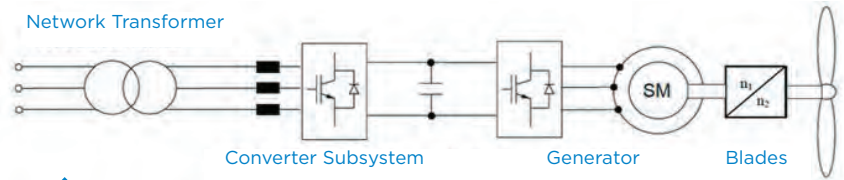
WIND ENERGY APPLICATIONS

Generators

Wind power generation employs various types of generators, such as synchronous generators and doubly fed induction machines. Engineers can analyze and optimize device efficiency with ANSYS tools. Initial design specifications can be entered into RMxpert along with the geometric and material data to obtain a preliminary design, and then a parameterized equivalent circuit diagram can be exported to Simplorer. Alternatively, using information from RMxpert, you can automatically create the generator model in Maxwell 3-D or 2-D and directly link to Simplorer. Using this unique coupling allows you to consider eddy currents in the generator created by switching operations in the converter.

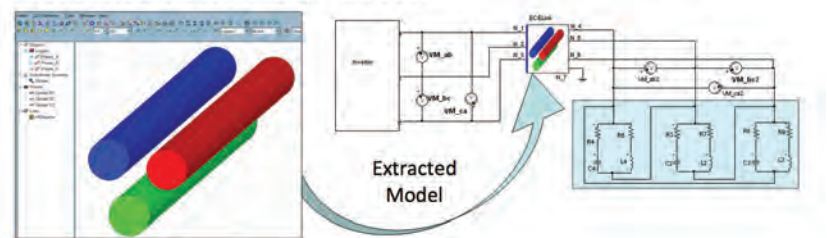
Converters

Both conversion from three-phase current to direct current (rectifier) and from direct current to three-phase current at a defined frequency (power inverter) are relevant in wind turbine design. To enable full design and analysis capabilities, conventional insulated gate bipolar transistor (IGBT) power electronic semiconductor switches, gate turn-off thyristors (GTOs) and thyristors are available in Simplorer in different levels of detail.

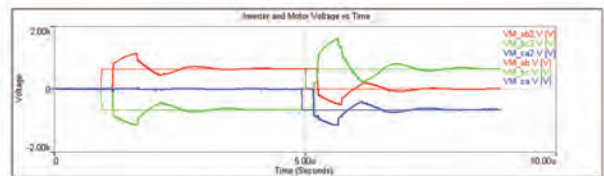


Electrical system of wind energy plant

Three-phase cable in ANSYS Q3D Extractor



Three-phase simulation results with 100 hp motor surge impedance load



Simulation of three-phase cable in ANSYS Q3D Extractor embedded in ANSYS Simplorer

In simple terms, these semiconductor devices represent control switches. Depending upon the level of accuracy needed when investigating the device switching behavior, you can apply Simplorer models of varying details as well as semiconductor valve SPICE models. To allow customization, IGBT parameterization tools allow the appropriate model to be generated and simulated based on the data sheet of the specific type of IGBT.

Transformers

Simplorer enables simulation of different transformer models as equivalent circuit diagrams. Coupling with Maxwell 2-D and 3-D for more detailed testing is available.

Cables and Bus Bars

With the Q3D Extractor tool, you can quickly generate a parameterized equivalent circuit diagram from the 3-D cable geometry, which can then be exported to Simplorer, where it retains its connectivity. This makes it possible to analyze traveling waves, surge voltage and associated parasitic effects.

Controllers

Simplorer depicts controllers directly on the simulation sheet and couples these controllers with the electrical switches.

ANSYS Simplorer, when used as a system simulator in conjunction with the RMxpert, Maxwell, Q3D Extractor, ANSYS Mechanical and fluid dynamics tools, provides an efficient platform for simulating an entire wind turbine electromechanical system. Using systems simulation, wind turbine designers can meet overall requirements as well as specific requirements for components. Finally, R&D teams can integrate structural simulations for robust systems design. 🚀

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