

# A Novel Mechanical Stress Measurement Method Applied to Wind Turbine Rotor Blades

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## Abstract

Rotor blades for wind turbines are made of glass-fibre reinforced compound material. Their size in off-shore wind farms exceeds 50m in length and 15t in weight. They have to be designed to withstand wind and weather over their approximately 20 years of lifetime. The ability to monitor the mechanical stress is crucial in order to reduce maintenance costs and to maximize operational availability.

This paper presents the combination of SPICE® and COMSOL Multiphysics®, in order to reduce computation time. This allows to focus on design details with COMSOL Multiphysics® while modelling the overall design using SPICE®. The proposed measurement method based on TEM-Waveguides is outlined. The workflow of setting up the combined SPICE/COMSOL-model is described in detail. Measurements and simulation results are compared and discussed.

This work is part of the AGIP founded research project {High-Performance Fibre-Composite Rotor Blades for Wind Turbines through Plasma-Treatment}. The aim of this subproject is to develop alternative strain measurement methods for online monitoring of mechanical stress imposed upon rotor blades. Strain sensors have to be compatible with the glass-fibre compound and its production process.

This Simulation model relies on the combined power of COMSOL Multiphysics® and SPICE®. According to simulation and experiments it is now possible to permanently monitor the strain of rotor blades. Therefore only a few modifications on conventional rotor blades are necessary.

In the model shown in this paper the rotor blade is FEM-modeled by its physical properties and geometry using the COMSOL Multiphysics® RF-Module. All other components included in the hardware that detects the mechanical stress of the rotor blade are described in SPICE®. SPICE® models the circuit elements which need not to be described by their geometry. The SPICE® models are imported into COMSOL Multiphysics® using the AC/DC-Module. The circuit behaviour is computed in the frequency domain. A complete 3D COMSOL Multiphysics® model is necessary in order to describe the geometry of the rotor blade. The use of global parameters describing the geometry eases design optimization in the future [1][2].

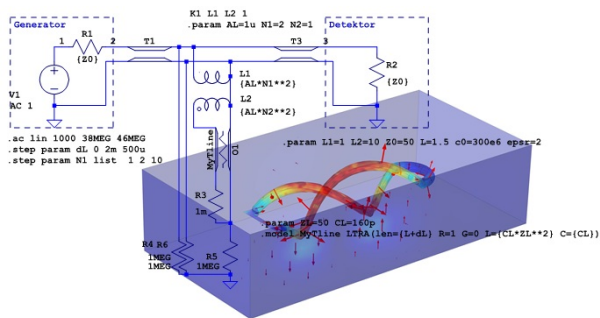
Figure 1 shows the principle structure of the 3D Fiber-Composite Rotor Blade with an integrated twisted pair cable and the detection hardware [2].

## Reference

[1].Dr. Jens Peter Kaerst, Entwicklung alternativer Messverfahren zur integralen Dehnungsmessung in ausgedehnten Strukturen, HAWK Forschungsbericht 2010, unveroeffentlicht.

[2]. Ahmed H. Hegab, Untersuchung einer kapazitiven Kopplung mittels COMSOL Multiphysics zur galvanisch getrennten Messung von Materialausdehnung in Windkraftanlagen, HAWK Masterprojektarbeit 2013, unveroeffentlicht.

## Figures used in the abstract



**Figure 1:** Geometry of a 3D Fibre Composite Rotor Blade with an integrated twisted pair cable and the detection hardware