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Multi-Domain Optimization Model for Evaluation of Power Density and Efficiency of Wind Energy Conversion Systems

The prospective development of the wind energy conversion systems is mainly promoted by demand for higher efficiency and power density. These requirements can be satisfied through the use or development of new topologies, modulation strategies or new semiconductor technologies. The gain in performance improvement is reduced over time, once the new concept or technology has been established. After the basic concept has been adopted, a significant gain in performance can only be achieved by allocating the optimal values of design variables during the design process. In the other hand, by detecting the sensitivity of the system level performance on component parameters, the development of components could be adjusted for maximal impact on the system level.

So to achieve such an optimization first a complete model of the converter circuit must be set, including thermal and magnetic component models. This model could be based on analytical equations, on numerical simulations or on a combination of both. The analytical models enable fast calculation but are more complicated and/or have more time consuming to develop, additionally could not be easily adjusted to further topologies or modulation schemes. Moreover, simulations are fairly flexible but could require substantial computational effort to the point of becoming a non-viable option. In order to reduce the burden on the computation, Meta-Modeling will be considered. Basically, Meta-Modeling is a method of further modeling the model, which is, generating a simpler model that captures only the relationships between the relevant input and output variables.

Based on converter circuit model, an optimization for multiple objectives, efficiency and power density, will be performed. The optimization makes best use of all degrees of freedom of a design and also allows determining the sensitivity of the system performance based on technologies like measurement of the efficiency of the power semiconductors or properties of the magnetic core materials. Furthermore, different topologies can be easily compared and inherent performance limits can be identified.

This project is looking for developing a methodology of multi-domain design to optimize the power density and efficiency of the wind energy conversion system in offshore wind farms. Analytical approaches for designing the main functional elements of a wind energy conversion system will be described and arranged to a linear design process in a first step. Moreover, the linking of the component models, i.e. of the electric, magnetic and thermal design domains and an overall optimization of the respective design variables based on the linked models will be considered and including the coupling of the different domains.