DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title:	Model-based Reliability Analysis and Optimization for Power Electronic Systems
Location:	Pontoppidanstræde 101, room 1.011
Time:	Monday 16 September at 10.00
PhD defendant:	Ionut Vernica
Supervisor:	Professor Frede Blaabjerg
Moderator:	Associate Professor Yongheng Yang
Opponents:	Associate Professor Szymon Beczkowski, Dept. of Energy Technology, Aalborg University (Chairman) Professor Philip Mawby, University of Warvik, UK Professor Zhengming Zhao, Tsinghua University, China

All are welcome. The defence will be in English.

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Abstract:

Nowadays, power electronics are being widely used in many mission-critical applications such as, renewable power generation, motor drives, traction applications, or power transmission. Due to its essential role within power systems, the reliability performance of the power electronic system is one of the main factors that influences the overall efficiency, availability, and cost of the system. However, previous experience and various studies throughout the literature have shown that in many applications the power electronics tend to be the most fragile components and the “bottleneck” of the entire electrical system with respect to reliability.

Despite the ever-increasing demand for more reliable and robust power electronic systems, the conventional approaches for reliability assessment and design are still mainly based on the "rule-of-thumb" overdesign of critical components and/or, failure information and statistics from field experiences. However, on their own, these methods are not sufficient, and can become relatively inefficient, expensive, and time-consuming.

Thus, this Ph.D. project discusses solutions, which can enable a faster and a more confident model-based lifetime estimation of power electronics for different applications. Within this project, a straightforward six-step model-based reliability assessment procedure has been proposed. The developed methodology has been successfully applied in order to determine the reliability performance both at component level (e.g., power devices, DC-link capacitors, and metal-oxide varistors), and at system-level. Moreover, in order to further facilitate a computational-efficient reliability analysis process, a Matlab-based tool has been developed. The Design for Reliability and Robustness (DfR2) tool platform integrates the proposed reliability assessment procedure under a user-friendly and easy-to-use graphical user interface (GUI). The developed tool is demonstrated on three study-case applications: three-level neutral point clamped (3L-NPC) converter for motor drive applications, two-level voltage source inverter for pump drive systems, and single-stage grid-connected PV inverter. Finally, in order to have a clear understanding of the assumptions behind the models employed within the reliability assessment procedure, the uncertainties introduced by the lifetime model selection, uneven "local" ambient temperature distribution, and mission profile resolution, are explored in this project.