VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Assel Zhaksylyk**

The public defense will take place on **Monday 9th September 2024 at 4:00 pm** in room **I.0.03** (Building I, VUB Main Campus)

To join the digital defense, please click here
Meeting ID: 313 534 455 947
Passcode: KbXwvN

DEVELOPMENT OF SMART AND MODULAR ACTIVE FRONT-END SYSTEMS TOWARDS EFFICIENT DC-CHARGING FOR ELECTRIC VEHICLES

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Abstract of the PhD research

The growing number of electric vehicles (EV) and consequently of EV charging stations exert additional stress on the electric grid. Moreover, the everincreasing power levels of EV charging stations require higher efficiency and reliability, while the higher power rating also imposes constraints on the component selection. The objective of this PhD research was to investigate methods for improving existing rectifiers in EV charging applications through various approaches, including modularity, active rectification, wide bandgap devices, bidirectional power flow and smart control.

First, a system architecture for truly modular, scalable AFE system was developed. In this system each module has the capability to function independently or as part of a larger system. A distributed masterless control system with dynamic resource allocation and faut handling is developed. Various models, including a high-fidelity electro-thermal model, reliability model, cost model in MATLAB, and a 3D thermal model in Ansys, were employed within the framework of this doctoral research to analyze the impact of modular design on system efficiency, lifetime, cost, and its implications for the power grid.

Design optimization tool to select the optimal number of modules in the AFE system for higher efficiency, reduced cost, and longer lifetime is developed. Furthermore, fast electro-thermal models of the AFE systems based on analytical equations and state-space models have been developed. Research was conducted on an algorithm for optimizing the LCL filter design. A scaled 15 kW hardware prototype of a modular AFE has been designed and built to validate the masterless control concept.

Along with the main EV charging use case, two additional use cases for modular AFE have been studied: Battery Energy Storage Systems for grid support and industrial drive application.