

Intelligent Energy Routers for Grid-Interactive DC Buildings

Summary

This research will target the development of intelligent energy routers interlinking AC grid with DC buildings and associated control methods and algorithms needed to provide services to the distribution grid. Also, it will consider the extension of the DC distribution to energy-efficient smart districts towards new energy services for communities.

Research field:	Electrical power engineering and mechatronics
Supervisors:	Dr. Dmitri Vinnikov Edivan Carvalho
Availability:	This position is available.
Offered by:	School of Engineering Department of Electrical Power Engineering and Mechatronics
Application deadline:	Applications are accepted between January 01, 2024 00:00 and January 22, 2024 23:59 (Europe/Zurich)

Description

The research:

Electrification is the backbone of the future design or refurbishing of buildings needed to achieve the highest energy performance class. A holistic approach would require not only electrifying of heating/cooking but also on-site energy generation, mostly photovoltaic (PV) systems, to achieve synergy in energy efficiency, cost of electricity, and decarbonization. The unfolding paradigm shift to power electronics-enabled Direct Current power distribution (DCPD) technology can further push the energy performance limits by reducing residential electricity consumption by up to 30% compared to those with traditional alternative current (AC) distribution. The residential DCPD allows for much more efficient interaction and control of local generation, storage and consumption assets, and make them independent from the main AC grid. As the residential DCPD is coupled with main AC grid via bidirectional converter (energy router), it will be seen by the utility as a prosumer performing economic dispatch. Therefore, it becomes possible to support the main grid and provide grid ancillary services at the point of common coupling such as power consumption curtailment, phase balancing, reactive power injection or consumption, participation in frequency response services, etc. This project will address the energy management issues in the Direct Current (DC) buildings via the synthesis, development, experimental validation, and early adoption of the intelligent energy router – a highly -efficient bidirectional galvanically isolated power electronic interface between the DC building and the utility grid for enabling the emerging concept of smart prosumer buildings.

Responsibilities and (foreseen) tasks:

- Development of design and control methodologies for the intelligent energy routers
- Development of experimental prototypes and technology demonstrator of the intelligent energy router at TRL5
- Study of grid impact mitigation methods by coordinated control of residential PV, energy storage and smart loads with the help of intelligent energy routers
- Development of the digital real-time simulation, diagnostics, and prediction tools, such as digital twins, for the smart prosumer buildings
- Feasibility analysis, optimization, and integration of aggregated grid services enabled by the virtual power plants formed by the smart prosumer buildings
- Publishing of research findings in top-tier (Q1) journals and dissemination at the flagship conferences of the IEEE IES and PELS

Applicants should fulfil the following requirements:

- master's degree in power electronics;
- B2 English level certificate if English is not native language and language of instruction in MSc study was not English;
- practical experience in the design of power electronic converters;
- experience in the modeling of electronic circuits in PSIM or PLECS software;
- experience with PCB design (preferably using Altium Designer);



- experience with closed-loop control system design with analog/digital sensors and DSPs;
- good understanding of power semiconductor components, basics of their driving and packaging;
- excellent command of English and strong and demonstrable writing and analytical skills;
- capacity to work both as an independent researcher and as part of an international team;
- capacity and willingness to provide assistance in organizational tasks relevant to the project.

(The following experience is beneficial:)

- international publications will be valued;
- internship experience abroad will be considered a plus;
- industrial experience is preferable.

We offer:

- Early Stage Researcher position in one of the leading applied power electronics research centers in EU with a large portfolio of ongoing pan-European and national research and innovation projects
- The chance to do cutting-edge applied research in collaboration with companies Schneider Electric and Eaton
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of power electronics and DC microgrids

About the group:

Research in the Power Electronics Group is focused on the development and experimental validation of new state of the art power electronic converters for such demanding applications as rolling stock, automotive, telecom and renewable energy systems. Key research directions include synthesis of new converter topologies, development of special control and protection algorithms, implementation of new components and elaboration of design guidelines to further improve the efficiency, power density, reliability and flexibility of the on-market power electronic converters. Other research activities are concentrated on the development of power flow control algorithms and new supervision, fault detection, protection and communication methods for the electronic power distribution networks (Micro- and Smart-Grids).

Highlights:

- Well experienced and dynamic team of young researchers and engineers (1 Professor, 4 Senior Researchers, 1 Senior Lecturer, 4 PostDocs, 1 Engineer, and 8 full-time PhD students)
- Long-lasting experience in applied design of power electronic converters for different power ranges and applications
- Since October 2011, the group is the European Competence Centre of Power Electronics and an active member of European Centre for Power Electronics (ECPE)
- Strong record of scientific publications (over 60 annually published research papers)
- Project-based PhD studies with research-oriented theses
- Strong relations and cooperation with Estonian and Baltic industrial companies
- Strong relations with European universities and research institutions
- Modern laboratory facilities and infrastructure:
- Active participation in national and EU funding programs and joint research projects

For further information, please contact Edivan Carvalho edivan.carvalho@taltech.ee and Dmitri Vinnikov dmitri.vinnikov@taltech.ee or visit <https://taltech.ee/en/power-electronics-research-group>



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