Power Electronic Converters for Particle Accelerator Applications

Summary

Ph.D. student will work on innovative solutions for particle accelerator applications, including but not limited to power supply balancing for high-power klystrons, energy storage integration in power supply system of accelerator magnets, feasibility studies of muon collider, etc.

Research field:	Electrical power engineering and mechatronics
Supervisors:	Dr. Andrii Chub Dr. Dmitri Vinnikov
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, 2025 00:00 and January 24, 2025 23:59 (Europe/Zurich)

Description

Power electronics is an enabling technology for many applications. Among them, particle accelerators present one of the most challenging niche applications. Exploring the nature of the matter, electron-hadron colliders were proposed and implemented. Among these efforts, the ongoing feasibility study of the Future Circular Collider (FCC) aims to achieve 100 TeV collision energy levels. The proposed scale of the FCC yields circumference of 90 km, vastly surprising the existing Large Hadron Collider with only 27 km in circumference.

Increased energy requirements reaching 350 MW and length of the power supply feeders requires feasibility analysis of new energy distribution approaches. Such a high peak power consumption could be satisfied by embedded battery energy storage to minimize energy losses in the distribution system and avoid high fluctuations of power consumption from the utility grid.

Medium voltage DC (MVDC) is currently considered for energy distribution in the FCC to achieve higher efficiency and power quality. Combining this technology with the typical particle accelerator application requires new types of converters that would be low-cost, reliable, and highly efficient to meet expectations of such applications as power supply balancing for high-power klystrons, energy storage integration in power supply system of accelerator magnets, power delivery for muon collider, etc.

This project will be implemented in close collaboration with Electrical Power Converters (EPC) Group, SY Department, CERN. Dr. Davide Aguglia will serve as the external advisor/co-supervisor from CERN.

Responsibilities and (foreseen) tasks

- Synthesis and implementation of new dc-dc converter topologies based on partial/differential power processing principles
- Design and implementation of magnetic components with corresponding MVDC isolation requirements
- Synthesis and verification of novel control methods resulting in efficiency optimization
- Feasibility study and benchmarking of different semiconductor devices against application requirements
- Design of control systems based on small and large signal models
- Optimization of lifecycle cost using FIDES handbook recommendations and yearly mission profiles
- Publishing of research findings in top-tier journals and dissemination at the flagship conferences of the IEEE IES/PELS - 3 Journal and 4 Conference papers as a minimum requirement for defense

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 high-level applied research in collaboration with CERN
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of power electronics and 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 Ph.D. 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

(Additional information)

For further information, please contact Dr. Andrii Chub andrii.chub@taltech.ee and Dr. Dmitri Vinnikov dmitri.vinnikov@taltech.ee or visit https://taltech.ee/en/power-electronics-research-group

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