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Activity Report

NORDPLUS Teacher Mobility Program

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Host Institute: **Tallinn University of Technology, Estonia**

Activity Report

1. Introduction

From 11th of February 2024 to 08th of June 2024, I participated in teacher exchange program at Power Electronics Research Group, Department of Electrical Power Engineering and Mechatronics of Tallinn University of Technology (TalTech), Estonia, focusing on enhancing my expertise in power electronics and knowledge exchange. This opportunity was made possible through funding from the Nordplus Higher Education Grant. This report aims to detail my experiences, and the skills I developed throughout this period.

2. Objectives

- To gain hands-on experience with advanced power electronics, renewable energy sources, battery energy storage systems and advanced microcontroller platforms to control the power converters.
- To integrate new knowledge and skills into my teaching curriculum and thereby improving the quality of education at my home institution, UiT.

3. Activities Undertaken:

- **Alternative Power Converters:**

During my mobility, I had to chance to work with alternative converter topologies:

i. state-of-the-art solution i.e., boost DC-DC converter with a voltage source inverter,
ii. single-inductor buck-boost unfolding inverter,
iii. single-stage current source inverter, and
iv. dual-active bridge-based DC-DC converter.

Besides this, I worked on inductor designing, rework of printed circuit boards (PCB), troubleshooting, testing, and performance evaluation of the power electronic converter. I also got the opportunity to learn the simulation software i.e., Altair PSIM- Power Electronics and Motor Drive software. I also got the experience of using YOKOGAWA WT1800 Precision Power Analyzer, ITECH Online Bi-directional Power Supply and Tektronix MDO034/MDO4034B-3 Mixed Domain Oscilloscopes and DSLogic Series USB-based Logic Analyzer.

- **Microcontroller Programming:**

During my mobility, I learnt about ARM Cortex-M4 microcontroller and acquired proficiency in C language for microcontroller applications. I used the STM32G474 microcontroller and developed the control signals for the dual-active bridge-based DC-DC converter, boost DC-DC converter along with voltage source inverter and for the current source inverter. For the configuration of microcontroller, I used STM32CubeMX software and for the coding, I used STM32CubeIDE from STMicroelectronics.

- **Seminars/Workshops/Lectures/Presentations**

i. **Presentation**

On 12th of February 2024, my very first day at TalTech, I delivered a comprehensive presentation to my colleagues from TalTech. During this, I shared my existing knowledge in

power electronics, renewable energy sources especially photovoltaic, and battery energy storage system. I also outlined my proposed plan for the mobility period. This presentation included an overview of my background, key areas of expertise, and specific objectives I aimed to achieve during my time at TalTech. The session fostered an engaging dialogue, with colleagues providing valuable feedback and suggestions that helped refine my plan and set a collaborative tone for the rest of my stay.

ii. Lecture on "High-Power Medium-Voltage Solid-State Conversion and Teaching Power Electronics" by Professor Drazen Dujic

On 6th of March 2024, my host university, TalTech, organized a visit and a lecture of Professor Drazen Dujic, who is the head of the Power Electronics Laboratory at Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland. From this lecture, I learnt about the high-power medium-voltage power electronics. One part of the lecture was focusing on "Teaching Power Electronics using Realtime-Hardware in the Loop (RT-HIL) system for digital control development". From this lecture, I learnt the how EPFL is using of power electronics teaching setup (PETS) to teach their power electronics and industrial electronics courses to their bachelor level, master level, and PhD students. Figure below shows how a Bachelor level power electronics (EE-365) course is organized and taught at EPFL, Switzerland.

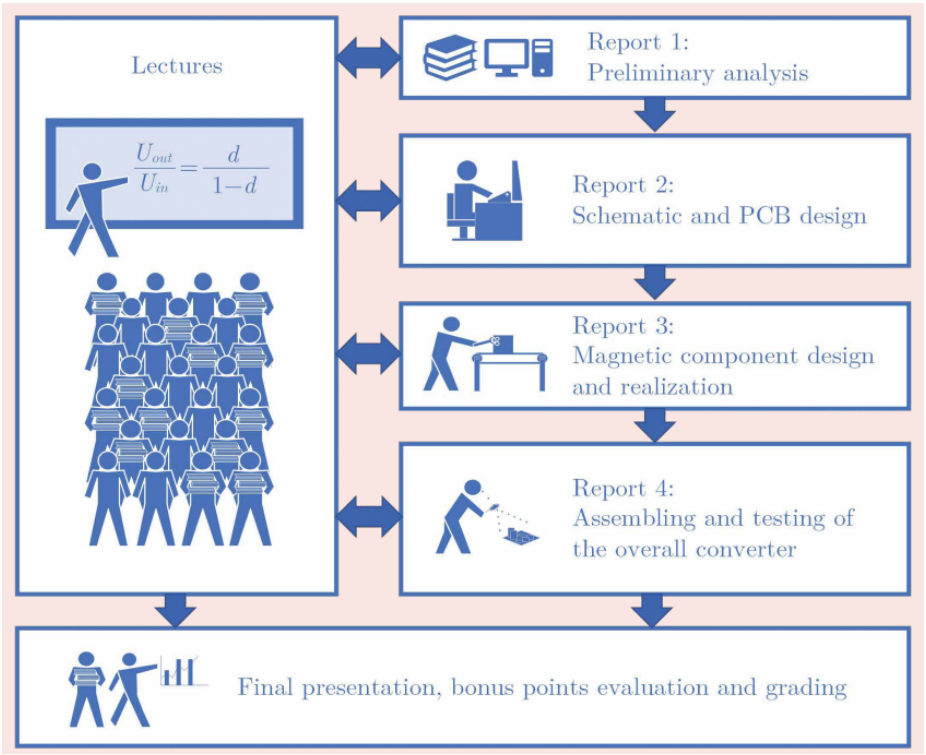

Figure 1. General Structure of the course and link between lectures and laboratory sessions [1]

iii. Workshops on Onboard Charging Technologies for Electric Vehicles – by Infineon

On 11th of April 2024, my host university, TalTech, organized two workshops from Infineon Technologies. One was focusing on cutting-edge semiconductors and new opportunities in electric vehicle charging applications with interesting examples of highly efficient solutions.

The other workshop focused on the CoolGaN devices from Infineon Technologies to achieve high power density isolated on-board electric vehicle chargers with a wide range of DC voltage.

iv. Open Doors Day in the Residential DC Innovation Hub.

TalTech is developing the technology to shift to DC buildings. On 27th of May 2024, TalTech unveiled its unique facility for development and validation of technologies. Through the presentations, I learnt about the DC technologies and their benefits to save a significant percentage of energy and raw materials. This technology also has the potential to improve the power quality and congestion issues in AC utility grids. This knowledge would help my home institute to update our study programs to stay tuned to the needs of the industry and sustainable future.

v. Farewell Seminar

On 7th of June 2024, my host university, TalTech, organized a seminar to reflect on the learning outcomes and experiences gathered during my stay there. During the seminar, I presented a summary of my work, highlighting key achievements and challenges faced. Moreover, I discussed potential for future collaborations TalTech and my home institution, UiT, exploring opportunities for student exchange programs.

4. Reflections and Learnings:

The exchange program significantly enhanced my technical skills and broadened my teaching methodologies. One of the primary workplan goals was to exchange experiences and gain practical experience by using the equipment of TalTech. I acquired a tremendous amount of knowledge on power electronics, renewable energy resources, battery energy storage systems and DC building. These insights will be invaluable as I incorporate them in my teaching, thereby enriching the curriculum and providing students with up-to-date knowledge. I plan to introduce new modules on Modern DC buildings for efficient integration of renewable energy sources and battery energy storage systems in my course.

5. Conclusion

The teacher exchange program at TalTech has been a transformative experience, providing me with valuable insights and skills that will benefit my home institution, UiT. The collaboration with TalTech's staff and the hands-on experience with their equipment were particularly beneficial. I now have a deeper understanding of power electronics, battery energy storage systems, and renewable energy resources, which I will integrate into my course in the upcoming semester. I look forward to continuing this collaboration and exploring further opportunities for student exchange and joint initiatives.

References

[1] D. Dujic, A. Cervone, C. Li, P. Bontemps and Y. Frei, "Teaching Power Electronics: How to Achieve the Desired Learning Outcomes?," in IEEE Power Electronics Magazine, vol. 9, no. 4, pp. 45-53, Dec. 2022, doi: 10.1109/MPEL.2022.3216094.