EPE'22 ECCE Europe – Tutorial Announcement

Bulk DC-DC Conversion for MVDC Applications

Drazen Dujic, Jakub Kucka*, Nikolina Djekanovic, Gabriele Ulissi, Renan Barcelos
EPFL / Power Electronics Laboratory
EPFL STI IEM PEL, Station 11, CH-1015
Lausanne, Switzerland
E-Mail: drazen.dujic@epfl.ch
Phone: +41 21 169 33 656
*Dr. Jakub Kucka was with EPFL and is currently with Large Drives Applications, SIEMENS AG, Germany.

Scope and Benefits:

The tutorial will provide an overview of relevant technologies and concepts for high power DC-DC conversion at MW level, as well as challenges and opportunities in that field. Topics will be covered with sufficient level of details to allow for understanding of design trade-offs associated with these conversion systems, expected performances and impact of various technologies on overall solution.

Contents:

High-power, MW-rated medium-voltage DC-DC converters have not yet reached their full commercial industrial maturity, as applications are not sufficiently well defined and/or supported by a strong business case. Nevertheless, a large body of academic and industrial research work has been done in the field of medium voltage direct current (MVDC) power distribution networks, where high power DC-DC converters is an important technology. The tutorial will explore this field, with a narrow focus on bulk power conversion challenges (in contrast to a modular solid-state transformer concepts made of many blocks rated for the fraction of the total converter power), topologies, high-voltage power semiconductors, magnetic components and relevant control and protection methods. Large number of original results will be presented from the authors' ongoing research activities in the EU-sponsored ERC Consolidator Grant project "EMPOWER".

Schedule:

Schedule is as follows:

Monday, 5 September 2022 - 1st Tutorial Day - Full Day

9:30 – 11:00 Part 1

1 - Introduction:

- MVDC Applications
- Motivations and Challenges
- Power Electronics Converters

2 - Bulk versus Modular Power Conversion:

- High Power DC-DC Conversion
- Modular DC-DC Conversion
- Bulk DC-DC Conversion – DC Transformer concept

3 - Resonant Conversion:

- Resonant DC-DC Converters
- Control Principles
- Scalability for high power applications

11:00 – 11:30 Coffee Break

11:30 – 13:00 Part 2

4 - HV Semiconductors:

- High Voltage Devices
- IGBT versus IGCT
- Design with IGCTs

5 - Gate Drivers for IGCT:

- Operating Principles
- Optimization for the Resonant Operation
- High Frequency Operation

6 - IGCT Resonant Switching:

- ZVS versus ZCS
- Series-connection of IGCTs
- High Frequency Operation

13:00 – 14:00 Lunch Break

14:00 – 15:30 Part 3

7 – MFT Design Challenges:

- MW Design Challenges
- Technologies and Materials
- Electrical and Thermal Modeling

8 – MFT Design Examples:

- MFTs for SST
- MFTs for Bulk Power
- Special Designs

9 – MFT Design Optimization:

- Design Optimization
- Practical 1MW 5kHz Design Experience
- Experimental Results

15:30 – 16:00 Coffee Break

16:00 – 17:30 Part 4

10 - MVDC Power Distribution Networks:

- MVDC Network Modelling
- DC Transformer in MVDC Power Distribution Networks
- Operational Performance Assessment

11 – Direct Current Transformer Features:

- Operating principles
- Power reversal methods
- Practical examples

12 - Summary and Conclusions: (Estimated time: 15 minutes)

Who should attend:

The tutorial attendees should be familiar and with interest into medium-voltage high-power conversion. The high-power DC-DC conversion for medium voltage applications is a popular topic nowadays, yet not fully explored or exploited commercially or industrialized. Advanced high-power converter topologies and their key components, such as high-voltage semiconductors and magnetic devices, are therefore relevant to a broad potential audience, e.g.:

• Master, PhD students and junior research scientists

• Industrial engineers from related sectors

• Senior research scientists from other fields interested in the topic and its challenging aspects

Technical Level:

Technical Level: No particular classification

About the Lecturers:

Prof. Drazen DUJIC is currently Associate Professors and head of Power Electronics Laboratory at EPFL. He received his PhD degree from Liverpool John Moores University in 2008. From 2009 to 2013 he was with ABB Switzerland and has joined EPFL in 2014. He has given several tutorials in recent years and content of the proposed tutorial is strongly related to ongoing research activities on Direct Current Transformer technologies, with all co-speakers being researchers directly involved into the research activities at EPFL.

Dr. Jakub KUCKA received the Dr.-Ing. (Ph.D.) degree from Leibniz University Hannover, Germany, in 2019. From 2014 to 2019, he was a Research Associate with the Institute for Drive Systems and Power Electronics, Leibniz University Hannover, Germany. From 2020 to 2021, he has been a Postdoctoral Researcher with the Power Electronics Laboratory, EPFL, Lausanne, Switzerland, and currently is with Large Drives Applications, SIEMENS AG, Germany. Dr. Kucka was the recipient of EPE Outstanding Young Member Award in 2020 and of SEMIKRON Young Engineer Award in 2021.

Nikolina DJEKANOVIC received her MSc degree in 2018 from Technical University Vienna, Austria. She joined Power Electronics Laboratory at EPFL in 2019 and is currently doing PhD research work related to design optimization of high-power medium frequency transformers for medium voltage direct current applications. She received the Best Paper Award at PCIM Europe 2022, for her work on design optimization of high power medium frequency transformers.

Gabriele ULISSI received his MSc degree in 2017 from EPFL, Switzerland. He joined Power Electronics Laboratory at EPFL in 2018 and is currently doing PhD research work related to design optimization and control of high-power IGCT-based DC-DC converters.

Renan BARCELOS received his MSc degree in 2020 from Universidade Federal de Santa Catarina (UFSC), Brasil. He joined Power Electronics Laboratory at EPFL in 2021 and is currently doing PhD research work related to modeling, design, system identification and stability in domain of DC power distribution networks.