EPE'25 – Call for Tutorials

Industrial medium-voltage converters and drives: from components to systems and applications

Name(s) and Affiliation of the Lecturer:

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Tutorial Objectives:

This tutorial provides a comprehensive introduction, overview and assessment of medium-voltage converters and drives. Such converters and drives are vital to decarbonize the planet by generating renewable energy and electrifying transportation systems and heavy industry. A particular emphasis is laid on system aspects, i.e., the integration of the transformer, converter, electrical machine and load into a high-performance drive system. To increase the reliability, redundancy can be added on converter level.

To minimize the cost of such drive systems - or conversely - to maximize their hardware capability in terms of rated voltage and current, model predictive pulse pattern control (MP3C) offers a disruptive way of achieving this, as will be shown in this tutorial. The classic control methods, scalar control, field-oriented control and direct torque control will be introduced as well.

Medium-voltage drives are highly tailored to their specific application. As such, the understanding of the key drive applications is vital, including Marine propulsion, rolling mills of the Metals industry, crushers and mine hoists of the Mining industry, Wind power generation, and pumps and compressors used in the Oil and Gas industry.

Besides the classic motoric applications, non-motoric applications such as static frequency converters (SFCs) and power electronics grid simulators are quickly growing in market size. SFCs provide electrical power to berthed ships or remote locations, whereas grid simulators allow the testing and verification of renewable energy systems. Both applications are much more challenging to control and operate than classic variable speed drives, providing fruitful research problems.

This tutorial will introduce the exciting world of medium-voltage converter and drive systems, it will showcase the opportunities they offer, and will point out challenging research problems for academics and researchers working in industry alike.

Target Audience:

The target audience of this tutorial are researchers from both academia and industry (e.g., university students at, or above, the M.Sc. level, academics, and engineers in industry focusing on research and development) who are interested in the exciting world of medium-voltage converter and drive systems, as well as traction converters used in electric vehicles and trains, as they face similar challenges and requirements.

All attendees will greatly benefit from the tutorial:
1. Novices because the tutorial provides a comprehensive overview of and introduction to medium-voltage converters and drives;
2. Academics and engineers at an intermediate level because the tutorial provides crucial information that is otherwise rarely available, such as system aspects, markets and applications;
3. Experts as the tutorial explains the commercial benefits of novel cutting-edge control methods, introduces non-motoric applications, and discusses open research questions in this exciting field.

The tutorial is a predominantly a traditional lecture with enough time to allow questions and discussions in between the main topics.

Topical Outline:

- Main topologies:
  - Air-cooled converters: neutral point clamped (NPC) converters, cascaded H-bridge converters, current source converters
  - Water-cooled converters: NPC converters, five-level converter topologies, load commutated inverters
- Semiconductors
  - IGBTs
  - IGCTs
  - Thyristors
- Machines
  - Induction machines
  - Externally excited synchronous machines
  - Permanent magnet synchronous machines
- Control methods
  - V/f (scalar) control
  - Field-oriented control
  - Direct torque control
  - Model predictive pulse pattern control
- System aspects
  - Transformer configurations
  - Harmonic performance
  - Protection
  - Semi redundant and full redundant drives
  - Multiple drives sharing one dc-link (multi drives)
  - Scalability and modularity of converter platforms

- Key applications of drives
  - Marine propulsion
  - Metals
  - Mining
  - Wind
  - Oil & Gas
- Emerging non-motoric applications
  - Static frequency converters
  - Power electronics grid simulators
  - Industrial dc applications
- Summary and outlook

Provisional Schedule of the Tutorial:

A three-hour tutorial is proposed for Friday, 4 April 2025. This is a refined version of the highly successful tutorial held at ICEM in Torino in 2024.

Schedule:

09:30 - 11:00 : Topologies, semiconductors, machines and control
11:00 - 11:30 : Coffee break
11:30 - 13:00 : System aspects, applications and summary

About the Lecturer:

Tobias Geyer is a Corporate Executive Engineer at ABB System Drives in Switzerland and R&D platform manager of the ACS6000 and ACS6080, the most well-known medium-voltage drive in industry. His research interest are high-power converters and drives, optimized pulse patterns and model predictive control. Dr. Geyer received the Ph.D. in control theory and the Habilitation degree in power electronics from ETH Zurich in 2005 and 2017, respectively. He was appointed as an extraordinary professor at Stellenbosch University in 2017 and has been teaching a course at ETH Zurich since 2016.

Dr. Geyer received the PELS Modeling and Control Technical Achievement Award in 2022, the Semikron Innovation Award in 2021, and the Nagamori Award in 2021. He was also the recipient of two Prize Paper Awards of IEEE Transactions and four Prize Paper Awards at IEEE conferences. He has filed about 90 patents and co-authored more than 170 peer-reviewed publications. He has organized about 15 tutorials at international conferences and has given 8 keynote lectures. Dr. Geyer has co-supervised more than 25 students, among them 8 PhD students. He is a former distinguished lecturer of PELS and a former associate editor of the Transactions on Power Electronics. Dr. Geyer is a Fellow of the IEEE.