EPE'22 ECCE Europe – Tutorial Announcement

Modular Multi-Level Converter enabling Reliability-Oriented Control and Protection in Multi-Terminal dc Systems

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Scope and Benefits:

The modular multi-level converter is a promising technology for multi-terminal dc grids. In this context, this tutorial is intended to introduce the recent advancements of the modular multi-level converter dealing with control and fault management of such grids. The tutorial will present latest research activities on modular multi-level converter technology and address the increasing importance of reliability and maintenance issues. Not only the audience will understand how to design and control a reliable modular multi-level converter itself, but also how this technology can help to protect multi-terminal dc systems and increase the overall system reliability.

Content:

Due to the great number of devices used in modular multi-level converter, component fault diagnosis, fault tolerance capability and lifetime management become some of the main predominant challenges to ensure the reliable and safe operation. Apart from the converter internal faults, in the dc side fed by the modular multi-level converter, the dc grid faults have high dynamics and inrush currents, which challenge both the grid protection system and converters reliability. This tutorial will start from topology of modular multi-level converter with and without the medium/high frequency galvanic isolation. Then, power routing and active thermal control-based lifetime management for the modular multi-level converter are introduced. Afterwards, the parameter monitoring, internal fault localization, fault-tolerant schemes, and post-fault operation strategies of the modular multi-level converter will be presented. In the last part, the tutorial will present challenges and dc fault current breaking techniques in dc grids, and different hybrid dc breakers, and the coordination between dc breakers and MMC stations to reduce the peak dc fault current as well as fault diagnosis techniques for dc faults are explained.

Introduction: (Estimated time: 10 minutes)

- Introduction, part 1: lectures
- Introduction, part 2: background and motivation of the tutorial

Real Tutorial, Theme 1: Architecture and Topology of Modular Multi-level Converter (Estimated time: 40 minutes)

- Full-bridge and half-bridge Modular Multi-level Converter
- Modular Multi-level Converter with high/medium frequency galvanic isolation
- Field application and trial project introduction in the world

Real Tutorial, Theme 2: Reliability-oriented control and management of the Modular Multi-Level Converter (Estimated time: 40 minutes)

- Remaining useful lifetime model of Modular Multi-Level Converter
- Active thermal control of Modular Multi-Level Converter
- Power routing and graph theory-based lifetime management

Real Tutorial, Theme 3 Internal fault diagnosis and fault tolerant schemes of Modular Multi-Level Converter (Estimated time: 40 minutes)

- Parameter monitoring in the Modular Multi-Level Converter
- Component fault diagnosis of Modular Multi-Level Converter
- Fault tolerant schemes of Modular Multi-Level Converter

Real Tutorial, Theme 4 Challenges and dc fault current breaking techniques in multi-terminal dc systems (Estimated time: 40 minutes)

- DC-Fault currents in MMC-based multi-terminal dc systems
- Fault detection and identification in multi-terminal dc systems
- Hybrid circuit breakers and coordination with MMC stations

Conclusions (Estimated time: 5 minutes)

- Reliability management of the modular multi-level converter.
- Operation of modular multi-level converter during internal and dc grid faults

Schedule:

14:00 – 15:30	Introduction / Theme 1 / Theme 2
15:30 – 16:00	Coffee break
16:00 – 17:30	Theme 3 / Theme 4 / Conclusions

Technical Level:

Researchers from academy and industry are the potential audience. The audience is advised to have the background on modular multi-level converter control and topology, reliability of power semiconductors, and dc fault protection. Technical level: Advanced

About the Lecturers:

Marco Liserre received the M.Sc. and Ph.D degree in Electrical Engineering from the Bari Technical University, respectively in 1998 and 2002. He has been Associate Professor at Bari Technical University and from 2012 Professor in reliable power electronics at Aalborg University (Denmark). From 2013 he is Full Professor and he holds the Chair of Power Electronics at Kiel University (Germany). He got offered and declined professorships at the Technical Universities of Ilmenau, Munich and Hamburg. He has published 600 technical papers (1/3 of them in international peer-reviewed journals) and a book. These works have received more than 42000 citations. Marco Liserre is listed in ISI Thomson report "The world's most influential scientific minds" from 2014. He is member of IAS,

PELS, PES and IES. He has been serving all these societies in different capacities. In PELS he is AdCom member (second mandate), Co-Editor of the IEEE Open Access Journal in Power Electronics, Associate Editor of TPEL and JESTPE, Guest Editor of Several Special Issues of JESTPE, Technical Committee Chairman of the new Committee on Electronic Power Grid Systems and Member of the IEEE Digital Committee, IES-Liaison responsible, eGrid 2021 Workshop Co-chairman. He has received the IES 2009 Early Career Award, the IES 2011 Anthony J. Hornfeck Service Award, the 2014 Dr. Bimal Bose Energy Systems Award, the 2017 IEEE PELS Sustainable Energy Systems Technical Achievement Award, the 2018 IEEE-IES Mittelmann Achievement Award and 6 IEEE Journal Awards. On the topic of modular multi-level converter, he has authored and coauthored more than 50 technical papers.

Marius Langwasser received his M.Sc. and Ph.D degrees from Kiel University, Germany, in 2016 and 2021, respectively. Currently, he is senior post-doctoral scientific staff member and leader of the group "Hybrid Grids" at the Chair of Power Electronics at Kiel University, Germany. He is responsible for the Kopernikus-project ENSURE and Marie Skłodowska-Curie Research Actions Wingrid and SMARTGYsum. His research interests include control and protection of hybrid grids and ancillary service provision with HVDC and Smart Transformers. He has authored and co-authored over 20 technical papers (over 30% of them in international peer-reviewed journals) and held one pending patent on MMC.

Rongwu Zhu received the PhD degree in energy technology from Aalborg University, Demark, Dec. 2015. Afterwards, he was a senior researcher and team leader of the electric power grid group at the Chair of Power Electronics of the Christian-Albrechts Universität zu Kiel, Germany. He is currently a full professor at the Harbin Institute of Technology, Shenzhen, China. From 2016 to 2019, he was a main participator of the ERC Grant project "Highly Reliable And Efficient smart Transformer (HEART)", and the German Federal Ministry of Education and Research funded project "Ensure", and both of them focus on the reliability, control and protection of Modular Multi-Level Converters in grid applications. He has authored and co-authored over 100 technical papers (over half of them in international peer-reviewed journals/magazine, over 12 of the most relevant papers on the topic of modular multilevel converter are published in peer-reviewed journals). He held three granted patents and three pending patents. He has organized and presented 6 tutorials at the ECCE2021/2020, EPE2021, ECCEAsia2019, PowerTech2019 and Electrimacs2019.

Hossein Iman-Eini received the Ph.D. degree in Electrical Engineering jointly from the University of Tehran, Iran, and the Grenoble Alpes University, Grenoble, France, in 2009. He is currently an Associate Professor of Power Electronics and head of the Power Electronics and Energy Systems Lab (PEESLab) at the School of Electrical and Computer Engineering, College of Engineering, University of Tehran. He has published over 150 technical papers (70 of them in international peer-reviewed journals). He also received the Alexander von Humboldt Experienced Researcher Fellowship on the project "MMC topology with dc fault-breaking capability for HVDC grids" and worked for 15 months at the Chair of Power Electronics, Christian-Albrechts Universität zu Kiel, Germany. He is now working on a joint project, "Peak dc-fault current control in MMC-based multi-terminal dc systems," with the Chair of Power Electronics.