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Tutorial Title

“Modular Multilevel Converters as a Backbone for Medium Voltage Grids”

Instructor Team

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Abstract

Modular Multilevel Converters (MMCs) have emerged as core technologies shaping the future of medium-voltage power systems due to their scalability, modularity, and superior operational flexibility. This tutorial, **"Modular Multilevel Converters as a Backbone for Medium Voltage Grids,"** systematically explores essential aspects of MMC technologies ranging from fundamental operating principles to advanced applications and fault management strategies.

"Chapter 1: A Basis of Modular Multilevel Converters," lays the groundwork by presenting core principles and basic configurations of MMCs. This chapter will focus on their modular structures, submodule arrangements, and fundamental operating mechanisms. Emphasis is placed on understanding the switching operation, voltage balancing among submodules, and circulating current phenomena, which form the theoretical foundation essential for advanced MMC designs.

"Chapter 2: Topologies of MMCs for Various Applications" will address the practical implementations of MMC topologies in different power conversion scenarios. This session thoroughly examines MMC configurations used for AC-DC and DC-DC conversions, including classical half-bridge and full-bridge submodule structures, hybrid topologies, and dual-active-bridge MMCs. The comparative analysis provided in this chapter emphasizes application-specific considerations to highlight the strengths, challenges, and operational characteristics of each topology. Additionally, MMC-based solid-state transformers (SSTs) are introduced, with discussions centered on architectural features, key technical advantages, and ongoing challenges.

"Chapter 3: Active Thermal Balancing of MMCs and Internal Fault Management" investigates the critical aspects of reliability and operational robustness within MMC systems. This session explores methodologies for actively managing thermal stress within MMC submodules to achieve uniform temperature distribution to enhance overall system efficiency and longevity. Detailed insights into fault identification, localization, and internal management strategies for MMC submodules are presented to focus on the practical implications for maintenance, redundancy, and uninterrupted operation in medium-voltage grid applications.

"Chapter 4: External Fault Management and Strategies" will focus on handling external disturbances and grid faults affecting MMC systems. The session provides comprehensive coverage of MMC responses to grid-side disturbances, including short-circuit faults, voltage dips, and transient phenomena. Effective protection strategies, fault-ride-through capabilities, and coordinated control responses to maintain grid stability and converter integrity are analyzed in depth, complemented by real-world case studies demonstrating successful fault management practices. Overall, this workshop synthesizes fundamental concepts, diverse application topologies, thermal management practices, and advanced fault-handling strategies of modular multilevel converters.

Participants will gain both theoretical knowledge and practical insights, equipping them to apply MMC technologies effectively as robust and adaptable solutions within evolving medium-voltage grid infrastructures.

Instructor Team Biographies

Jun-Hyung Jung, received the B.S., M.S., and Ph.D. degrees in electrical and computer engineering from Pusan National University (PNU), Busan, South Korea, in 2012, 2014, and 2019, respectively. From 2020 to 2023, he was a Postdoctoral Researcher with the Chair of Power Electronics, Kiel University, Germany. He is currently an Associate Researcher with the Fraunhofer Institute for Silicon Technology, Germany. His current research interests include grid-connected converters, parallel-connected converters, multilevel converters, and machine learning for power electronics converters.

Nidhi Bisht, has received the B.Tech. degree in electrical engineering from UTU, Dehradun, Uttarakhand, India, in 2012, and the M.Tech. degree in power electronics and drives from IIT(ISM), Dhanbad, India, in 2017. She is currently working toward the Ph.D. degree in power electronics and electrical machine drives at the Department of Electrical Engineering, IIT Delhi, New Delhi, India. Her research interests include high power electronic converters in power quality and drives applications.

Davide D'Amato, received the M.Sc. and Ph.D. degrees in electrical engineering from Politecnico di Bari, Bari, Italy, in 2019 and 2024, respectively. He is currently a Research Associate with the Fraunhofer Institute for Silicon Technology, Kiel, Germany. His research interests include grid-connected converters, advanced control, and modulation techniques of multilevel converters and SiC devices.

Chang-Hwan Park, has received B.S., M.S., and Ph.D degrees in the electrical engineering from Pusan National University (PNU), Busan, South Korea, in 2012, 2017 and 2021, respectively. From 2022 to 2024, he worked for Power Electronics Laboratory (PEL), EPFL, Switzerland as a Postdoctoral Researcher. He is currently an Associate Researcher in Electronic Energy System (EES), Fraunhofer-ISIT, Kiel, Germany. His research interests include high power modular multilevel converters and DC circuit breakers.