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Tutorial

Grid Interfaces and Electric Drive Systems in the Era of Monolithic GaN AC-Switches

Duration: 120 minutes

Abstract. Grid interfaces and electric drive systems have traditionally been dominated by voltage-source converter (VSC) architectures, largely due to long-standing limitations of power semiconductors to unipolar voltage blocking devices. In particular, the lack of efficient, compact, and reliable bidirectional/bipolar voltage-blocking switches has restricted the practical adoption of converter topologies such as current-DC-link/source converters. Recent advances in monolithic bidirectional GaN AC switches (MBDSs) fundamentally change this situation by enabling true bipolar voltage blocking with significantly reduced chip area and lower conduction losses. This tutorial provides a comprehensive overview of grid interfaces and electric drive systems in the era of monolithic GaN AC switches. It begins with an introduction to the structure, controllability, and performance characteristics of MBDS devices, including a comparison to conventional unipolar switch solutions. Building on this foundation, converter topologies that directly benefit from bidirectional/bipolar switching capability are revisited, including new rectifier topologies, three-level T-type converters, current-source converters (CSCs), with a focus on operating principles, performance characteristics, dynamics, and reliability aspects in comparison to state-of-the-art VSC solutions. The second part of the tutorial focuses on drive applications enabled by current-source inverters (CSIs). PMSM and reluctance motor drive systems are discussed, covering modulation strategies, control concepts, wide voltage-range operation, and emerging modular CSI architectures for sector and distributed motor drives. Particular attention is given to safety and reliability aspects, including overvoltage behavior and protection concepts inherent to current-source systems. The tutorial concludes with an outlook on future research directions and application opportunities for GaN-enabled PWM rectifier and drive systems.

Duration	Topics covered
10 min	New Monolithic Bi-Directional/Bipolar AC Switches (MBDSs)
20 min	New PFC Rectifier Topologies Benefiting from MBDSs
20 min	Inverter and AC/AC Converter Topologies for Drive Systems Benefiting from MBDSs
30 min	PMSM Drives and new Modular Drives with Current Source Inverters
20 min	New Reluctance Motor Drives with Current Source Inverters
10 min	Summary & Outlook
10 min	Q&A Session

Short bio of the instructor(s) – follow the IEEE journal bio format here, but include email as in the example below

Spasoje Mirić received his B.Sc., M.Sc., and Ph.D. degrees in Electrical Engineering from the University of Belgrade, Faculty of Electrical Engineering. In 2021, he earned a second Ph.D. at ETH Zurich in advanced mechatronic systems and subsequently worked there as a postdoctoral researcher. From 2023 to 2025, he served as an Assistant Professor for Energy and Drive Systems at the University of Innsbruck. Since January 1, 2026, he has been a Full Professor for Electromagnetic Energy Conversion and Drive Systems at TU Wien. His research focuses on novel electromagnetic energy converters, power electronics, particularly current-source inverter topologies, high-precision actuator systems, and wireless power transfer for moving systems. He has authored over 50 scientific publications, holds more than ten patents, and has received multiple IEEE Best Paper Awards. Email: spasoje.miric@tuwien.ac.at

Johann W. Kolar is Professor Emeritus of Power Electronics at ETH Zurich and former Head of its Power Electronic Systems Laboratory. He received his M.Sc. (1997) and Ph.D. (1999, summa cum laude) from the Vienna University of Technology. A pioneering figure in power electronics, he introduced breakthrough converter topologies, including the VIENNA Rectifier, Sparse Matrix Converter, and SWISS Rectifier, and advanced ultra-high-speed motor systems and automated multi-objective converter design. Since 2024, he has also been a Guest Professor at TU Wien, contributing to research and academic exchange in advanced power electronic systems. He has personally supervised 94 Ph.D. students to completion, authored over 1,000 publications, and holds more than 200 patents. His honours include the IEEE William E. Newell Power Electronics Award, the IEEE PELS R. David Middlebrook Achievement Award, the EPE Outstanding Achievement Award, and the 2025 IEEE Medal in Power Engineering. He is an IEEE Life Fellow, NAE International Member, and Fellow of the National Academy of Inventors. He has co-founded four ETH Zurich spin-offs and continues research in wide-bandgap converters, artificial intelligence in power electronics, and solid-state transformers. Email: johann.kolar@tuwien.ac.at and kolar@lem.ee.ethz.ch