TUTORIALS

Title:

Advances in Bearingless Machine Design, Control, and Applications

Abstract:

Bearingless machines have emerged as a promising technology that integrates electromagnetic suspension and torque generation into a single system, eliminating the need for mechanical bearings. This integration enables contactless operation, reduced maintenance requirements, and improved efficiency, making bearingless machines highly attractive for high-speed, high-purity, and harsh-environment applications.

This tutorial focuses on recent advances in the design, control, and practical implementation of bearingless machines. On the design side, innovations in electromagnetic topology, multi-degree-of-freedom suspension strategies, and compact integration are enabling higher performance and reliability. Advanced modelling techniques and optimization methods are also improving the precision and scalability of these systems.

From a control perspective, bearingless machines present unique challenges due to their inherently coupled electromagnetic forces and torque production. The session will highlight developments in robust and adaptive control strategies, which enhance stability and dynamic performance under varying operating conditions. In terms of applications, bearingless machines are gaining traction across diverse sectors, including turbomachinery, biomedical devices (such as blood pumps), flywheel energy storage systems, and semiconductor manufacturing. Their ability to operate without mechanical wear or lubrication makes them particularly suitable for cleanroom and vacuum environments.

This session aims to bring together researchers and practitioners to discuss emerging trends, unresolved challenges, and future directions in bearingless drive technology. By fostering interdisciplinary exchange, the session will contribute to accelerating the adoption of bearingless solutions in next-generation electromechanical systems.

Tutorial 1 Speakers

Dr. Mukhammed Murataliyev

Member, IEEE, Principal Research Fellow, University of Nottingham Ningbo China

Biograph:

Dr Mukhammed Murataliyev (Member, IEEE) received the Ph.D. degree from the University of Nottingham, U.K., in 2021, with a focus on novel synchronous reluctance machine design and optimization. From 2018 to 2020, he was a Researcher with the Key Laboratory of More Electric Aircraft Technology of Zhejiang Province, China. Since 2021, he has been with the University of Nottingham, U.K., first as a Research Fellow and later as a Senior Research Fellow with the Power Electronics Machines Centre, Research Institute. He is now a Principal Research Fellow at the University of Nottingham Ningbo China and also serves as a Lead Electromagnetic Design Engineer with Nottingham Drives Specialist Services (NDSS), DER. His expertise includes the design, optimization, and multidisciplinary modelling of high-performance electrical machines for aerospace, automotive, and industrial applications, spanning both academic research and industrial consultancy.

Dr. Meiqi Wang

Member, IEEE, Senior Research Fellow, Power Electronics Machines Centre, University of Nottingham, U.K.

Biograph:

Dr. Meiqi Wang (Member, IEEE) received the Ph.D. degree from the University of Nottingham, U.K., in 2023, with a focus on advanced control of high-speed synchronous machines and power electronic system design. From 2014 to 2019, she was a Research associate at Tsinghua University, Beijing, China, focus on high-speed machine control and Hardware in the Loop System development for MEA application. From 2019 to 2022, she was a Research associate with the Power Electronics Machines and Control (PEMC) Group, University of Nottingham, U.K., where she focused on high-speed machine control and system-level integration. From 2023 to 2024, she was a Research Fellow with the Key Laboratory of More Electric Aircraft Technology of Zhejiang Province, China. Since 2024, she has been with the University of Nottingham, U.K., first as a Research Fellow and currently as a Senior Research Fellow with the Power Electronics Machines Centre, Research Institute. Her research interests include the control high-speed electrical machines, multiphase and bearingless drives, and design of power electronic systems, and their applications in aerospace, automotive, and biomedical systems.

Title:

From Boost-VSI to VSI-Boost and Y-Inversion: new paradigms for truly high performance WBG power conversion

Abstract:

The disruptively fast-and high-frequency switching capability of wide-band-gap (WBG) semiconductors, which enables joint improvement of power converters efficiency and power density, cannot be fully taken advantage of in conventional topologies, due to severe electro-magnetic and electro-thermal performance degradation.

Novel bespoke solutions have been recently presented, which enable major progress in that direction, while also allowing to partly compensate for the higher cost of WBG devices with savings in other parts of the system. Notable examples are the VSI-Boost and the Y-Inverter architectures, conceived as direct alternatives to the traditional Boost-VSI approach. This tutorial will review in detail their fundamental operation, highlight their benefits over Boost-VSI and discuss differences between them and peculiarities of each solution.

Modulation and control aspects will be addressed and covered exhaustively, including continuous and discontinuous modulation techniques, both for single and three-phase, single-or multi-source implementation. The topic will also offer the opportunity for an experimentally-based comparison of silicon carbide (SiC) MOSFETs and gallium nitride (GaN) HEMTs from an application perspective.

Experimental results from real application examples in the electric-traction and renewable energies/smart-grids domains will be used to illustrate the potential of those topologies, when implemented with both SiC and GaN transistors, as well as in hybrid Si-WBG form.

The tutorial is addressed to post-graduate students, researchers and early and mid-career engineers and practitioners.

Tutorial 2 Speaker

Prof. Alberto Castellazzi

Faculty of Engineering, Kyoto University of Advanced Science

Biograph:

Alberto Castellazzi is a Professor in the Faculty of Engineering of the Kyoto University of Advanced Science. He has been active in R&D on power electronics and its enabling technologies for about 25 years, holding positions both in industry and academia. He has published more than 300 papers in specialist international journals and conference proceedings and has held numerous invited talks, seminars and tutorials on SiC power devices packaging and application.