

Virtual Conference PROGRAM

October 10-14

Sponsored by the IEEE Power Electronics And Industry Applications Societies







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2021 IEEE ENERGY CONVERSION CONGRESS & EXPOSITION®

Welcome from General Chair





On behalf of the entire ECCE 2021 Organizing Committee it is my pleasure to welcome you to the 13th Energy Conversion Congress and Expo, ECCE 2021, co-sponsored by the **IEEE Industry Applications Society (IAS)** and **IEEE Power Electronics Society** (**PELS**). Joining IAS and PELS this year are STMicroelectronics as a Gold Sponsor and OPAL-RT as a Silver Sponsor. Please visit their booths in the user-friendly virtual exhibit, where you'll also find many other companies which will provide you with information on their newest products and solutions.

Since its debut in 2009, ECCE has become the key annual event to attend if you, like me, are passionate about electrical and electromechanical energy conversion technology and if you enjoy sharing your ideas with other engineers, students and researchers from industry and academia. In the spirit of worldwide inclusion, ECCE 2021 is virtual, on a user-friendly platform, and with a plethora of events focused on giving you the opportunity to learn, network and discover what's new and trending in

integrated energy systems as well as individual energy conversion components.

ECCE 2021's program features four live plenary talks by experts and leaders from Tesla, MagniX, General Electric Aviation, and Intel. They will present the latest energy conversion technologies and their visions for future research and development. Adopting the same live format as the plenary session, several special sessions will provide you with opportunities to participate in panels with experts from industry and academia. The topics are very timely and important ranging from additive manufacturing for electric machines to wide bandgap devices, from power electronics to interface distributed energy resources to standard development, from energy access for all countries to cybersecurity, from power converters as grid-interface to simulations, controls and thermal design.

The tutorial program opens the conference on Sunday with several informative and engaging live sessions. Thanks to the virtual format, you can access the tutorial presentations a few days before Sunday, to get the most out of the live sessions with the tutorial presenters. The topics include grid-forming technology, wide bandgap devices, electric machine design, electric drives, solar photovoltaic and energy storage systems, design practices, electromagnetic interference, resilience, reliability and electro-thermal design.

At the core of ECCE 2021, is the regular technical program, with almost 900 technical papers and as many ondemand oral presentations, which deliver the latest advancements in energy conversion technology with focus both on components and systems. I hope you'll enjoy interacting with the authors, at your own pace, through the chats available for each technical presentation throughout the conference. Two of these sessions are dedicated to Prof. Akira Nabae and Prof. Braham Ferreira, who recently passed away and were attendees of many ECCE conferences. They left their imprint on the field of energy conversion through their research contribution and through their many students; we will never forget them.

Following the tradition of the past few years, ECCE 2021 is co-located with the 2021 IAS Annual Meeting. We share the plenary session, the award presentations and the exhibit hall, which is free for everybody. If you are a student, you have access to both technical programs.

The ECCE 2021 program was created by an extraordinary and diverse team of volunteers, women and men from the industry, government laboratories, and academia who selflessly donated their time and talent to ECCE 2021 for almost two years. The contribution from IEEE personnel, SmithBucklin and Vfairs was also instrumental in organizing this conference. Thank you for making ECCE 2021 as engaging in virtual format as it has been in-person in past years.

I invite you to enjoy the 5 live days, and to also take advantage of the additional 25 days during which the ondemand content, including exhibitor materials, technical presentations, recorded live sessions and panels, product sessions, award presentations and student demonstrations, will be available on the virtual platform.

Thank you for participating in ECCE 2021. Together, we contribute to a more sustainable world!

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Giovanna Oriti ECCE 2021 General Chair

Welcome from **Technical Program Committee**



On behalf of the Technical Program Committee it is our great pleasure to welcome you to the IEEE Energy Conversion Congress & Exposition (ECCE 2021). We were hoping to resume the in-person meeting this year or to have a hybrid conference at the very least. Unfortunately, this turned out to be impossible, but we hope that the virtual mode meets your expectations. We created an exciting program for all virtual attendees with live events such as tutorials, special sessions, plenary sessions and the expo, and we combined it with prerecorded videos for the rest of the technical program.

The world's leading conference on energy conversion systems, ECCE, is sponsored by the IEEE Industry Applications Society (IAS) and IEEE Power Electronics Society (PELS). It offers a multidisciplinary array of topics, ranging from devices to electrical power systems. Almost 900 technical presentations are organized into thematic sessions, with offline Q&A that authors will monitor daily. The material of the conference will be available for 30 days for attendees.

The ECCE Technical Program Committee managed a larger team this year consisting of 27 track chairs and 179 topic chairs who organized and supervised the review process to identify the best papers for ECCE. We had two plenary virtual meetings in April to finalize all paper decisions, and more in July and September to decide on the final program. The conference received a total of 1576 digest submissions from 62 countries. After a rigorous peer review and scheduling process, 892 papers are scheduled for presentation. On average, each digest received over 4 reviews. Our gratitude goes to the valued track chairs, topic chairs and to the generous 1650 reviewers who made all this possible.

The tutorials co-chairs received and reviewed 50 proposals and selected 17 tutorials to offer online this year. We are also proud of offering 24 special sessions on various topics.

We look forward to virtually welcoming you to ECCE 2021–thank you for helping us keeping the ECCE community connected!



Jean-Luc Schanen



Elisabetta Tedeschi



Michael Harke



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Schedule-at-a-Glance

All session times are in Pacific Daylight Time



Sunday, October 10, 2021 Meet the Instructors Tutorial

ALL IN PACIFIC DAYLIGHT TIME	Virtual 1	Virtual 2	Virtual 3	Virtual 4	
9:00AM-9:45AM	TUTORIAL 9AM1 Photovoltaic Systems - From Basics to Advanced Grid Supportive Control	TUTORIAL 9AM2 Pulse-Width-Modulation: with Freedom to Optimize EMI	TUTORIAL 9AM3 A MATLAB/Simulink Approach of Photovoltaic Power Systems: Designing, Modeling, Simulation, and Control		
9:45AM-10:00AM		BRI	EAK		
10:00AM-10:45AM	TUTORIAL 10AM1 Emerging Bidirectional Switches and Their Impact on Future AC Power Converters and Applications	TUTORIAL 10AM2 Interaction Among the Grid-connected Converters through Their Synchronization Mechanism	TUTORIAL 10AM3 Wide Bandgap Power Electronics Based Electric Machine Drives	TUTORIAL 10AM4 Monitoring Power Module Degradation via Lifetime-Varying Parameters	
10:45AM-11:00AM	BREAK				
11:00AM-11:45AM	TUTORIAL 11AM1 Advances in Intelligent Solid-State DC Substations for Future Interconnected DC Grids		TUTORIAL 11AM3 Optimised Electrical Machine Designs for E-Mobility Applications	TUTORIAL 11AM4 Conducted, Near-field "and Radiated EMI Emission Mitigation for Wide Bandgap Converters: Fundamentals, Modeling and Solutions	
11:45AM-12:00PM	BREAK				
12:00PM-12:45PM	TUTORIAL 12PM1 Applying Artificial Intelligence to Battery State Estimation	TUTORIAL 12PM2 Resiliency-Oriented Grid- Interactive Converters: Concepts, Design, and Field Implementation	TUTORIAL 12PM3 Cryogenic Power Electronics Design for Electrified Aircraft Propulsion	TUTORIAL 12PM4 Hybrid Semiconductor Switches based Power Modules, Converters, and Systems	
12:45PM-1:00PM	BREAK				
1:00PM-1:45PM	TUTORIAL 1PM1 Design and Development of Scalable Battery Testers/Emulators and Their Applications for Future Transportation Electrification	TUTORIAL 1PM2 Printed Circuit Boards in Power Converter Applications: Design Considerations and Failure Mechanisms	TUTORIAL 1PM3 Defining, Modeling, and Optimizing for Energy Efficiency in 5G		
Nearly 900 Technical Sessions available for flexible viewing to best accommodate your schedule.					

All session times are in Pacific Daylight Time

Monday, October 11, 2021

ALL IN PACIFIC DAYLIGHT TIME	Virtual 1	Virtual 2	Virtual 3	Virtual 4	
8:30AM-10:30AM	PLENARY SESSION Motor Technology Selection and System Level Optimization Effects in Drive Systems Dr. Konstantinos Laskaris Principal Motor Designer, Tesla				
	Electric Aircraft: From Concept to Reality Roei Ganzarski CEO, magniX				
	Hybrid Electric Systems for the Commercial Aviation Sector Christine Andrews Hybrid Electric Systems Leader, GE Aviation				
	Driving Digital Transformation Dr. Irene J. Petrick Senior Director of Industrial Innovation in the Internet of Things Group, Intel				
10:30AM-12:00PM	EXHIBITS Explore more than 30 booths to learn about the latest products to support your projects and make an appointment to meet with a vendor.				
12:00PM-12:30PM	BREAK				
12:30PM-2:00PM	SS16 Coming Soon: Medium- and High-Voltage Gallium Nitride Power Devices	SS17 Power Electronics-Based Technologies for Grid Stabilization: Grid-Forming Inverters, Control of Inverter-Based Resources (IBRs), and Advanced Testing of IBRs	SS10 Energy Access and Empower Billions of Lives: Technologies, Impact and Opportunities for PELS	SS25 Power Electronics Enabled Power System with High Penetration of Renewables	
2:00PM-3:30PM	EXHIBITS Explore more than 30 booths to learn about the latest products to support your projects and make an appointment to meet with a vendor.				
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Tuesday, October 12, 2021

ALL IN PACIFIC DAYLIGHT TIME	Virtual 1	Virtual 2	Virtual 3	Virtual 4	
8:30AM-9:00AM	PRODUCT SESSION: OPAL-RT HIL Demo of Solar Inverters				
9:00AM-9:30AM	PRODUCT SESSION: STMICROELECTRONICS Evolution of Power Delivery for Cloud Computing				
9:30AM-11:00AM	EXHIBITS Explore more than 30 booths to learn about the latest products to support your projects and make an appointment to meet with a vendor.				
11:00AM-2:00PM	BREAK Don't forget to check out the student demonstrations!				
2:00PM-3:30PM	SS24 Booming the Blue Economy: A New Era for Wave and Hydrokinetic Energy	SS20 PV Inverter Reliability: Industry Status, Technical Gap, and Future Needs	SS6 Energy Storage Systems: Applications, Control and Interfaces	SS7 Advanced Power Electronics Integration for Renewables	
3:30PM-4:00PM	PRODUCT SESSION: GENESIC G3R™ SiC MOSFETs, Unparalleled Performance and Robustness				
4:00PM-4:30PM	BREAK				
4:30PM-6:00PM	EXHIBITS Explore more than 30 booths to learn about the latest products to support your projects and make an appointment to meet with a vendor.				
Nearly 900 Technical Sessions available for flexible viewing to best accommodate your schedule.					

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ALL IN PACIFIC DAYLIGHT TIME	Virtual 1	Virtual 2	Virtual 3	Virtual 4	
8:30AM-10:15AM	SS1 Cybersecurity for Power Electronics	SS3 "ENSURE" Meets the World" the German Strategic Initiative ENSURE Presents Its Energy Outcomes	SS4 Power Electronic Technologies for Distributed Energy Resources	SS5 Wide-Bandgap Bidirectional Switches and the Applications They Enable	
10:15AM-12:00PM	SS1 Cybersecurity for Power Electronics	SS3 "ENSURE" Meets the World" the German Strategic Initiative ENSURE Presents Its Energy Outcomes	SS4 Power Electronic Technologies for Distributed Energy Resources	SS5 Wide-Bandgap Bidirectional Switches and the Applications They Enable	
12:00PM-2:00PM	BREAK				
2:00PM-3:30PM	SS11 Power Electronics Dominated Grids: Dynamic Modeling and Simulation for Reliable and Resilient Operation of Future Grids	SS9 Advances in SiC/GaN Grid Applications to Support EV and Renewable Energy	SS15 Future of Wide-Bandgap Devices SiC, GaN and Diamond and Their Emerging Applications in Power Electronics	SS22 Grid Integration of Inverter-Based Distributed Energy Resources: Operation, Planning, and Guidelines	
Nearly 900 Technical Sessions available for flexible viewing to best accommodate your schedule.					

Thursday, October 14, 2021

ALL IN PACIFIC DAYLIGHT TIME	Virtual 1	Virtual 2	Virtual 3	Virtual 4	
9:00AM-10:30AM	SS2 Energy Storage for Grid of the Future: Emerging Technologies, Applications and Trends	SS8 Thermal Design and Control for High Reliability Power Electronics, Electrical Drives, and Batteries	SS13 Standard Development and Industry Engagement Update from IEEE Power Electronics Society	SS23 EMI and Insulation Related Challenges and Solutions for WBG-based Power Electronic Systems	
10:30AM-12:00PM	SS2 Energy Storage for Grid of the Future: Emerging Technologies, Applications and Trends	SS12 Advanced Design and Manufacturing Techniques for Electric Machines - Simulation and Test	SS21 P2964 IEEE Standard for Datasheet Parameters and Tests for Integrated Gate Drivers	SS18 Additive Manufacturing for Electrical Machines and Power Converters Design	
12:00PM-1:30PM	SS19 Experimental Verification versus Simulation		SS14 Additive Manufacturing for Electric Machines		
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Plenary Session



Monday, October 11



Motor Technology Selection and System Level Optimization Effects in Drive Systems

Dr. Konstantinos Laskaris Principal Motor Designer, Tesla

True optimal design constitutes an important competitive advantage in electric vehicles and requires good knowledge of physics modeling, parametric design, numerical simulations, and decision making. Battery, Motor, Inverter and Gear design space is searched during the optimization process. The efficiency and mass of the resulting powertrain affect the

total cost, depending on the application. Powertrain compaction is key objective, but it comes with reduction in system efficiency and in many cases, at higher overall cost. Moreover, higher speed, more compact systems, exhibit dominant high frequency losses, introducing the need for advanced modeling to capture the phenomena. This keynote outlines key characteristics of motor, inverter and gears to achieve optimal design with particular focus on the motor technology.

Bio: Dr. Konstantinos Laskaris was born in Athens, Greece, received his diploma in Electrical and Computer Engineering from the National Technological University of Athens (NTUA), his master's degree in Signal Processing from the Imperial College London, UK, and his PhD in Electric Motor geometry optimization for variable speed drives from the NTUA, Greece. Since 2012, Dr. Laskaris has been the Chief Motor Designer at Tesla Motors, located in the Silicon Valley, California, where he leads the team of motor design engineers. Some of his most significant projects at Tesla include the drive unit system design and optimization for the Model S, Model X, Model 3, Model Y and Semi-Truck vehicles. His research interests include parametric design and loss modeling of synchronous and asynchronous machines using finite element analysis, as well as development of multi-objective optimization methods using supercomputers. Dr. Laskaris has also worked in education, as a laboratory partner in NTUA, which participates in EV fuel economy contests and holds the Panhellenic fuel consumption record today.

Plenary Session

Monday, October 11



Electric Aircraft: From Concept to Reality

Roei Ganzarski CEO, magniX

There are multiple companies and programs around the world pursuing electric aviation. From pure battery electric, to Hydrogen electric, to hybrid, these programs are mostly run by new entrants into the aviation industry, with some programs also being introduced by the incumbents. We will review from a new entrants perspective, what it really means to take electric propulsion and aircraft from concept to reality including challenges, pitfalls,

and successes. What practical real-world lessons should be considered when taking on such an audacious goal.

Bio: Roei is CEO of magniX, an electric aviation propulsion company. With a vision of connecting communities with low-cost, clean air transportation, magniX is disrupting aviation as we know it. Roei is also executive chairman of Eviation, the electric aircraft OEM bringing a newly designed all-electric aircraft to market. Prior to magniX, Roei was CEO of BoldIQ - a provider of dynamic real-time scheduling optimization software. Under Roei's leadership, BoldIQ grew from seed software startup to multi-million-dollar profitable SaaS company. Before BoldIQ, Roei was with the Boeing family of companies in continuously increasing roles of responsibility. His last role was Chief Customer Officer for Boeing's Flight Services division where he led worldwide customer and market facing organizations and was responsible for revenue growth and customer service. Other experiences prior to Boeing include investment banking, corporate finance, advertising, and the military. He is a graduate of Wharton's Advanced Management Program, earned an MBA from the University of Washington, and a BA in Economics from The University of Haifa. Roei lives with his family in Redmond, Washington, USA.

Monday, October 11

9:30AM-10:00AM



Hybrid Electric Systems for the Commercial Aviation Sector

Christine Andrews Hybrid Electric Systems Leader, GE Aviation

GE Aviation is committed to a more sustainable future of flight. One of the enabling technologies the jet engine maker is pursuing to help the aviation industry reach its decarbonization goals is hybrid electric capability for single-aisle aircraft. Single-aisle air transport is the largest civil aviation market, where emissions-reducing technologies would have a major impact. In this presentation, GE Aviation will provide an overview of the challenges and opportunities for making hybrid electric systems a reality

for this commercial aviation sector and the integration of motors and generators with gas turbine engines, electrical power distribution systems, electrical power converters, electricity storage and more.

Christine is the Hybrid Electric Systems leader for GE Aviation, responsible for the advancement of all power electronics technology development and integration with the gas turbine. Previously, Christine served as the Business Program Manager for the Aviation business at GE Research, where she evaluated future technologies and developed relevant aviation technologies from supporting next generation platforms to servicing existing fleet to improve revenues.

Christine has been at GE for 8 years, and has held various leadership positions across many disciplines within aviation engineering that have yielded many technology advancements in both the combustor and augmentor modules. She has an excellent track record of establishing and maintaining strong customer relationships by consistent execution of government programs. Prior to joining GE, Christine held various engineering positions at Gulfstream Aerospace.

Monday, October 11

10:00AM-10:30AM



Driving Digital Transformation

Dr. Irene J. Petrick Senior Director of Industrial Innovation in the Internet of Things Group, Intel

Industry 4.0 harnesses digital tools to make industrial operations smarter, more efficient, and ultimately to operate autonomously. At the heart of this transformation lies data and its ability to drive proactive decisions. To accelerate the digital transformation journey you need both a long term vision and a digital architecture. It's not just applying digital tools to current operations. Instead, successful companies have had to rethink

complex interactions between people, processes, organizational culture and technology. This presentation highlights lessons learned during Intel's three year study of over 500 people at over 400 companies.

Bio: Dr. Irene J. Petrick joined Intel in 2015 and is Senior Director of Industrial Innovation in the Internet of Things Group. Irene focuses on emerging technology, social, and global trends and their combined impact on the industrial space. Her work highlights the industrial internet of things, edge computing, the transition to intelligent manufacturing and the needs of the future workforce, 3D printing and distributed manufacturing and the new business models that are enabled by intelligent manufacturing. Prior to joining Intel, Irene was a professor at Penn State and has been actively engaged with companies in their innovation and technology strategies for over 25 years, including work with twelve Fortune 100 companies, the U.S. military, and a wide variety of small to medium sized enterprises. Petrick is author or co-author on more than 200 publications and presentations.

Special Sessions

These presentation-only sessions are focused on timely and practical topics in the field.



Wednesday, October 13

8:30AM-10:00AM | 10:00AM-12:00PM

SS1 | Cybersecurity for Power Electronics

SESSION ORGANIZERS:

Prof. Alan Mantooth, Distinguished Professor, The Twenty-First Century Research Leadership Chair in Engineering, University of Arkansas, USA

Prof. Frede Blaabjerg, Danish Professor and Villum Investigator, Aalborg University, Denmark

Prof. Sudip K. Mazumder, Professor, University of Illinois at Chicago

The growing threat of cyber-physical attacks targeting electric power grids is rising in number and sophistication. This special session covers several aspects of trending secure power electronic design, intrusion detections, and resilient control schemes. The concept of cyber resiliency in the realm of power electronics at the system level will be presented. The special session hosts demonstrate the importance of designing power electronics with security features in mind in the context of increasingly connected power electronics as a result of IoT, Industry 4.0, and 5G. Device-level attacks that aim to compromise the controllers, intentional noises and denial of service will be presented considering their impact and potential mitigation approaches. Subsequently, this special session presents the significance of the power electronics at the device-level resiliency as it supports a system-level resilience framework, targeting the new trend of securing the edge following the "resilience by design" principle, and an approach for combining fault-tolerance techniques with cyber-attack surface diversification to make legacy real-time control systems resilient against classes of attacks will also be discussed. More importantly, this session will present several industry-oriented topics (e.g., standardization, HVDC applications, among others), covering the latest development of DER community in the areas of stakeholder education programs, standards development, and cybersecurity research.

- > Cybersecure Power Electronics Why You Should Care Alan Mantooth, Distinguished Professor, The Twenty-First Century Research Leadership Chair in Engineering, University of Arkansas, USA
- > On Resiliency of Power Electronics Against Cyber Attacks Frede Blaabjerg, Danish Professor and Villum Investigator, Aalborg University, Denmark
- Control Resilience and Cybersecurity Analytics of Power Electronics Dominated Grids Sudip K. Mazumder, Professor Mohammad Shadmand, Assistant Professor, University of Illinois Chicago
- > Power and Energy Programs at the US National Science Foundation Aranya Chakrabortty, NSF Program Manager
- > Cyber Attack Resilient High Voltage Direct Current (HVDC) Systems
- Reynaldo Nuqui, Senior Principal Scientist, Hitachi-ABB Power Grids
- > DER Cybersecurity Stakeholder Engagement, Standards Development, and EV Charger Penetration Testing Jay Johnson, Principal Member of Technical, Sandia National Laboratories
- > The Role of Power Electronics in Edge Resiliency Salam A Baniahmed, Lead Engineer, Eaton Corporation

Thursday, October 14

SS2 | Energy Storage for Grid of The Future: Emerging Technologies, Applications and Trends

SESSION ORGANIZER:

Dr. Tu Nguyen, Sandia National Laboratories

As the electric grid is rapidly transforming to be more renewable and distributed, there are significant technical issues imposed on the grid due to the highly variable renewable generation (e.g., wind and solar). Furthermore, the increasing threats of natural disasters and cyber/physical attacks have created a significant need to improve the resilience and reliability of current grid infrastructure. Grid energy storage systems (ESSs) can be a flexible grid asset that can help mitigate those issues by providing multiple services to grid operators, utilities, and end-users.

Even though the application space for grid energy storage has grown rapidly over the last few years, there are multiple challenges that need to be addressed in order to further facilitate the incorporation of ESSs in the grid. Therefore, this special session gathers the experts in this field to provide an overview and updates on emerging challenges, recent technologies, applications, and trends in the energy storage area. The information provided in this panel will benefit not only the industry but also other key stakeholders such as policymakers, project developers, and researchers in this area.

SPEAKERS AND PRESENTATIONS:

- > Opening Remark: Energy Storage: Key Component of The Future Grid Imre Gyuk, U.S. Department of Energy, Office of Electricity, Energy Storage Program Manager
- > Energy Storage Standards Development Charlie Vartanian, Senior Technical Advisor, Pacific Northwest National Laboratory
- > Cold Storage Making Energy Storage Work in the Far North Jim McDowall, Business Development Manager
- > Enabling Energy Storage for Grid Applications Through Advanced Power Electronics Jacob Mueller, Senior Member of Technical Staff, Sandia National Laboratories
- > Long-Duration Energy Storage: Emerging Technologies and Applications Erik Spoerke, Energy Storage Materials Lead, Sandia National Laboratories

Wednesday, October 13

8:30AM-10:00AM | 10:00AM-12:00PM

SS3 | "ENSURE" Meets the World: the German Strategic Initiative ENSURE Presents Its Energy Cosmos

SESSION ORGANIZERS:

Prof. Dr. Marco Liserre, Christian-Albrechts-Universität zu Kiel (Kiel University)

Maximilian Dauer, Siemens AG

In 2050, the German power generation will mostly rely on renewable sources such as wind and PV and will face a variety of new electrical consumers such as electric vehicles, which requires a restructuration of the entire energy grid. In the German strategic project "New ENergy grid StructURes for the German Energiewende – ENSURE" partners from industry, academia and civil society are developing a holistic solution for the future German energy grid called "Energy cosmos ENSURE" based on new technological concepts, such as sector coupling, innovative power electronics-based assets and profound ICT-integration and automatization, which fit in the actual social-economic framework. Along the way, a digital twin of the entire system is built for co-simulation and advanced testing purposes and selected pilot plants are installed in northern Germany to demonstrate the systematic interaction of the novel

assets, control and protection strategies in the "Energy cosmos ENSURE". In the first part of the special section the challenges and conceptual solutions of ENSURE will be presented including: Power Electronic Transformer, MVDC grid coupling, dynamically meshed operation of hybrid distribution grids, and Co-Simulation as advanced testing facility for large grid infrastructure projects. The second part is dedicated to international strategic projects to expand the vision of future power grids to a worldwide perspective, including topics such as Hybrid AC/DC networks in the US, new HVDC technologies in China and soft-open points and DC links in the distribution network in UK.

SPEAKERS AND PRESENTATIONS:

- > Unlocking the Hidden Capacity of the Electrical Grid through Power Electronics Marco Liserre, Kiel University
- > High Power Charging System with Power Electronic Transformers Stephan Rupp, Maschinenfabrik Reinhausen
- > Flexibility in Distribution Grids with Medium-Voltage Direct Current (MVDC) Technology and Use Cases

Javier Iglesias, Hitachi ABB Power Grids

- > Evaluation of Dynamically Meshed Network Topologies for Improved Power Flow Allocation and Network Capacity Enhancement Silas Reigardt, SW Kiel Netz GmbH
- > Co-Simulation Test Bench for Grid Integration of Power Electronics Under Usage of Power-Hardware-in-the-Loop Frank Jungnickel, Siemens AG
- > Hybrid HVDC and HVAC Networks with Hybrid Substations for a Carbon-neutral Grid by 2050 Johan Enslin, Clemson University
- > Innovation of HVDC Technology to Support the Power Grid to Integrate More Renewable Energy Shukai Xu, China Southern Power Grid
- > Back-to-Back Converters and DC links in UK Distribution Networks Tim Green, Imperial College London; Jun Liang, Cardiff University

Wednesday, October 13

8:30AM-10:00AM | 10:00AM-12:00PM

SS4 | Power Electronic Technologies for Distributed Energy Resources (DERs)

SESSION ORGANIZERS:

Liuchen Chang, University of New Brunswick

Sonny Yaosuo Xue, Oak Ridge National Laboratory

Hanh-Phuc Le, UC San Diego

Sudip Mazumder, University of Illinois Chicago

Minjie Chen, Princeton University

Yongheng Yang, Zhejing University

Gab-Su Seo, National Renewable Energy Laboratory

Xiaonan Lu, Temple University

Jin Wang, Ohio State University

Prasad Enjeti, Texas A&M University

Juan Balda, University of Arkansas

Xiongfei Wang, Aalborg University

Ke Ma, Shanghai Jiaotong University

Jose Fernando Jimenez Vargas, Los Andes University

This special session will present a comprehensive overview of the state-of-the-art technologies of power electronics for distributed energy resources (DERs). The topics and their contents include:

Introduction to Distributed Energy Resources: DER definitions and values to electric grids, market drivers (including climate change, energy transformation, regulatory policies), world DER market growth in terms of the revenue and capacity, DER grid interconnection requirements and standards, DER grid interoperability requirements and standards, and evolving DER technology trends.

Integrated Power Components and Subsystems: Power semiconductor devices: their roles and types including SiC and GaN, photoconductive semiconductor switches based on wideband gap devices, power semiconductor device modules and reliability, passive components, storage technologies, power management, integrated power circuits, power-systems-on-chip, and packaging.

Power Conversion for DERs: Overview of the power electronics technologies and converter-level roadmaps for distributed energy resources, including the roles and requirements of power electronics for DER systems, and design and implementation of future DER systems including solar photovoltaic, wind energy, charging infrastructure, and grid-scale energy storage, with focus on power electronics technologies featuring high efficiency, high power density, and advanced functions that are needed to support the future grid.

Integration and Control of DERs: Summary of the recent developments in integration and control of DERs, covering the state-of-the-art DER technologies for grid integration and control including power system support functions from DERs, control of individual DERs including grid-forming inverter controls, stability of power systems with inverter-based resources, microgrids and networked microgrids, and protection with a high level of converters for distribution and transmission systems.

Security, Protection and Resilience for DERs: Cyber security at the device level and system level, protection (including solid-state protection), reliability, safety, grid system restoration, resiliency-oriented controls, and communication protocols.

MV and HV Technologies for DERs: medium-voltage (MV) and high-voltage (HV) power electronic interfaces for distributed energy resources, including the following main topics: energy storage systems (ESS), PV farms and hybrid PV-ESS, wind farms, solid-state transformers, DC networks, and fast chargers for electric vehicles.

Testing and Validation: Overview of grid emulation technologies including the hardware-in-the-loop testing methods, along with the challenges and prospects in the end.

- Introduction to Distributed Energy Resources, and their Market & Standards Liuchen Chang, Professor, University of New Brunswick Sonny Yaosuo Xue, Oak Ridge National Laboratory
- Integrated Power Components and Subsystems Hanh-Phuc Le, Assistant Professor, UC San Diego Sudip Mazumder, Professor, University of Illinois at Chicago (UIC)
- > Power Conversion for DERs Minjie Chen, Assistant Professor, Princeton University Yongheng Yang, Professor, Zhejiang University
- Integration and Control of DERs Gab-Su Seo, National Renewable Energy Laboratory Xiaonan Lu, Assistant Professor, Temple University
- > Security, Protection and Resilience for DERs Jin Wang, Professor, Ohio State University Prasad Enjeti, Professor, Texas A&M University
- > MV and HV Technologies for DERs Juan Balda, Professor, University of Arkansas

Wednesday, October 13

8:30AM-10:00AM | 10:00AM-12:00PM

SS5 | Wide-Bandgap Bidirectional Switches and the Applications They Enable

SESSION ORGANIZERS:

Dr. Thomas M. Jahns, University of Wisconsin - Madison

Dr. Victor Veliadis, North Carolina State University

Monolithic bidirectional switches hold the potential to trigger a revolution in the future of power electronics technology. Unfortunately, an impressive catalog of high-performance power converter topologies designed to use bidirectional switches has never achieved marketplace success for the lack of commercially available monolithic BD (M-BD) switch devices. No silicon-based M-BD switch technology has emerged that has successfully crossed the threshold into large-scale production. New widebandgap power device technology using GaN and SiC has opened intriguing avenues to WBG-based M-BD switches that hold much higher promise for overcoming the barriers to commercialization. Both lateral and vertical M-BD device topologies have been proposed using GaN and SiC that have resulted in prototype devices with ratings as high as 1400V and 100A. The purpose of this special session is to showcase promising state-of-the-art WBG-based M-BD switch technology in a manner that objectively evaluates both their strengths and technical challenges. This session also highlights some of the most promising applications for this prospective new generation of M-BD switches as well as the most likely power converter topologies that will take the fullest advantage of their availability. These application areas cover a wide spectrum extending from ac solid-state circuit breakers to static power converters to motor drives.

SPEAKERS AND PRESENTATIONS:

> WBG-based Solid-State-Bidirectional-Circuit-Breakers: Device Technology, and Opportunities and Barriers to Mass Market Adoption

Victor Veliadis, Chief Executive & CTO, PowerAmerica

- > Monolithic SiC-based Bidirectional FET (BiDFET): Exploring Opportunities & Challenges Subhashish Battacharya, Professor, North Carolina State University Dr. B. Jayant Baliga, Professor, North Carolina State University
- > Bidirectional Power Semiconductor Switches: Challenges and Opportunities John Shen, Professor, IIT
- > How Solid-State Circuit Breakers Enable the Energy Transition and How WBG Semiconductors Play a Critical Role

Ryan Kennedy, CEO, Atom Power

- > Solid-State Circuit Breaker: Opportunities and Challenges Xiaoqing Song, Sr. Research Scientist, ABB US Corporate Research Center
- > Monolithic Bidirectional Switches X-Technology of 3-Phase AC/DC Mains Interfaces Johann Kolar, Professor, ETH Zurich
- > The Re-Emergence of Current-Source Inverters in Future Machine Drives Enabled by WBG-Based Bidirectional Switches Thomas M. Jahns, Professor, University of Wisconsin - Madison
- > Power Scaling of Current-Source Inverter Technology with WBG-Based Bidirectional Switches to 100 kW for Electric Vehicle Applications
 Defense Series Invertee Seri

Bulent Sarlioglu, Assoc. Professor, University of Wisconsin - Madison, WEMPEC

Tuesday, October 12

2:00PM-2:30PM

SS6 | Energy Storage Systems: Applications, Control and Interfaces

SESSION ORGANIZER:

Juan Carlos Balda, Professor, University of Arkansas

Power systems are rapidly evolving from few large generating stations into many distributed generating stations ranging from several megawatts to few kilowatts. Higher penetrations of distributed generation are leading to system operating modes not experienced in traditional power systems, for example, intermittent distributed generation and bidirectional power flows. Energy storage systems making use of power electronic interfaces complement intermittent distributed generation and may also provide services like reducing peak demands, particularly in constrained distribution systems, and frequency regulation. Additionally, energy storage is the enabling technology for green transportation, including electric vehicles. Governments are enacting regulations to accelerate the deployment of these systems. This special session will focus on energy storage systems by bringing speakers from different points of view; in particular, government, electric utilities, manufacturers, and academia.

SPEAKERS AND PRESENTATIONS:

- > Special Session Outline and Introduction Juan Carlos Balda, University of Arkansas
- > Power Conversion Challenges and Opportunities with Flow Batteries Paolo Piagi, Lockheed Martin
- Integration of Energy Storage Systems in Solar PV Systems Francisco D. Freijedo, Huawei Nuremberg
- Design and Evaluation of High Capacity Lithium-ion Battery Energy Storage Systems Rui Li, Shanghai Jiao Tong University
- Energy Storage Power Electronic Systems Integration Research at ORNL Michael Starke, Oak Ridge National Laboratory

Tuesday, October 12

2:00PM-2:30PM

SS7 | Advanced Power Electronics Integration for Renewables

SESSION ORGANIZERS:

John Seuss, United States (US) Department of Energy (DOE)

Suman Debnath, Oak Ridge National Laboratory (ORNL)

As hybrid resources (like photovoltaic [PV]) and energy storage systems [ESS]) are integrated into the grid and the interconnection standards are upgraded, it is important to understand newer power electronic topologies that can be utilized to reliably integrate these resources like providing advanced grid services. With the increasing maturity shown by silicon carbide (SiC) devices and their corresponding adoption in certain sectors (like industrial drives), there is a need to explore the next-generation power electronics topologies that can utilize the SiC devices to integrate hybrid resources and provide fast/efficient grid services. In this talk, several ongoing research efforts will be discussed to discuss these newer integration approaches of SiC devices and the corresponding advanced control functionalities that they can introduce.

SPEAKERS AND PRESENTATIONS:

> Overview of Solar Energy Technologies Office (SETO) and Funding Efforts in Power Electronics John Seuss, United States (US) Department of Energy (DOE) > Multi-port Autonomous Reconfigurable Solar Power Plant (MARS) - Next Generation Hybrid PV-ESS Plant with Integrated Services

Suman Debnath, Oak Ridge National Laboratory Jiuping Pan, Hitachi ABB Power Grids Research

- > A Cascaded Power Electronics Architecture for Transformerless Medium-voltage PV Systems Brian Johnson, National Renewable Energy Laboratory
- > M4 Inverter: An enabling technology for utility scale PV plus storage integration Alex Q. Huang, University of Texas at Austin
- > Power Converter Architectures for Utility-scale Combined Solar Photovoltaic and Battery Storage Systems

Giri Venkataraman, Wisconsin Electric Machines and Power Electronics Consortium Mahima Gupta, Portland State University

- > All SiC High Power Converters for Combined Integration of Solar PV and Energy Storage Yue Zhao, University of Arkansas
- > Monolithic SiC-based Bidirectional FET (BiDFET): Exploring Opportunities and Challenges Subhashish Bhattacharya, North Carolina State University

Thursday, October 14

9:00AM-10:30AM

SS8 | Thermal Design and Control for High Reliability Power Electronics, Electrical Drives, and Batteries

SESSION ORGANIZERS:

Prof. Marco Liserre, University of Kiel, Kiel, Germany

Prof. Rik W. De Doncker, RWTH Aachen University, Aachen, Germany

Temperature has a major effect on both batteries and power electronics (PE) performance and reliability. The development of the electromobility sector and the spreading of PE throughout society (e-mobility, industry, grid, consumer electronics, etc.), together with the trend towards increasing power- and energy- densities, and the rise of PE-based critical applications (more electrical aircraft, grid applications, etc.), therefore puts the spotlight on thermal management and reliability issues. Consequently, limiting peak temperatures, temperature gradients, and thermal cycling of power devices and batteries gains great relevance.

Limiting thermal stress can be achieved by combining high performance cooling technics (jet impingements, phase-change-materials, etc.) and temperature- and reliability- oriented control algorithms (active thermal control, loss reduction strategies etc.). At design stage, achieving high power density call for the use of improved modelling technics for complex and multi-physic systems. Furthermore, lifetime estimation and condition monitoring play an important part in reliability assessment. To reach these targets, high performance temperature measurement, imaging systems, and estimators are required during design and for field monitoring.

The industrial and academic speakers involved in this special session will tackle these issues with both conceptual- and application- oriented presentations. Altogether, they cover a broad area of expertise, including reliability of PE and batteries, thermal-guided design & control strategies, cooling technics, temperature sensing, imaging, and estimation, electromobility, and PE systems.

- > Design Challenges of High Power Density Dc-Dc Converters Rik W. De Doncker, Professor, RWTH Aachen University
- > Reliability Driven Control of Power Converter Marco Liserre, Professor, University of Kiel, Kiel

> Artificial Neural Network based Thermal Model Considering the Cross-Coupling Effects of Power Modules

Frede Blaabjerg, Professor, Aalborg University

- State of the art Thermographic Cameras for Testing Power Electronics and Batteries Stefan Kayser, InfraTec
- > Electro-thermal Co-Design of Traction Drive Inverters H. Alan Mantooth, Professor, Arkansas University
- > Design of eAxle Propulsion Drives for Electric Vehicles Jin Hwan Jung, Hyundai Motor Company
- > Influence of Thermal Gradients on Battery Performance Florian Ringbeck, RWTH Aachen University
- > Experimental Thermal Analysis and Reduced Order Modelling of Direct Oil-Cooled PMSM Henning Sauerland, *Hitachi Europe GmbH*

Wednesday, October 13

2:00PM-3:30PM

SS9 | Advances in SiC and GaN Grid Applications to Support EV and Renewable Energy

SESSION ORGANIZER:

Dr. Victor Veliadis, Executive Director and CTO of PowerAmerica

The power grid will soon need to accommodate a large EV charging infrastructure while at the same time incorporating more solar and wind energy sources. Panelists will address the following issues specific to medium voltage SiC technology in the context of grid capability:

- MV SiC MOSFET on-resistance, capacitance, and current ratings
- The design/modeling/fabrication of SiC Super junction (SJ) FETs and IGBTs
- Determine optimal SiC device for each grid application domain and device characteristics important to support the grid
- SiC SJ FETs and IGBTs in switching circuits
- Bipolar conduction induced defect generation is impacted by the higher current densities in SJ and IGBT devices

- > Co-Existence of GaN & SiC: Present and Future Francois Hebert, GLOBALFOUNDRIES
- > The High and Low (Power) of SiC and GaN Transistor Applications Tim McDonald, Infineon Technologies
- > Advances in Applications of SiC and GaN Technology Rick Eddins, GE Aviation
- > Advances in GaN to Support EV and Renewable Energy Larry Spaziani, GaN Systems
- Design of a 6.6 kW Bidirectional On-Board Charger Using GaN with Integrated Driver, Protection and Temperature Reporting Brent McDonald, Texas Instruments

Monday, October 11

SS10 | Energy Access and Empower a Billion Lives: Technologies, Impact and Opportunities for PELS

SESSION ORGANIZERS:

Deepak Divan, Professor, Georgia Institute of Technology

Jelena Popović, Associate Professor, Delft University of Technology

Issa Batarseh, Professor, University of Central Florida

Sanjib Kumar Panda, Associate Professor, National University of Singapore

Ensuring universal, affordable, and sustainable energy access is one of the biggest societal challenges of our time. As of 2020, close to a billion people worldwide live without having access to electricity, and another two billion have unreliable access. The centralized electric grid is not the optimal choice for remote and rural applications, due to environmental impact, cost, mismatch to user needs and challenges around financial feasibility. Decentralized approaches, such as solar home systems and microgrids, have emerged as a response to shortcomings of the centralized grid approach, but affordability, scalability, interoperability, societal and technical sustainability remain as key challenges. Power electronic technology is one of the key enabling technologies for context-appropriate and sustainable energy access solutions. The IEEE Power Electronics Society (PELS) engaged with Energy Access through organizing a global challenge – Empower a Billion Lives (EBL-I), and by including Energy Access as a new and core topic in its long-range planning. Following on the success of the first EBL-I round, a strong expression of interest in the technologies underlying energy access, and a burgeoning need for decentralized power systems with more autonomous control, the Global Energy Access Forum and the Technical Committee – 12: Energy Access was formed by PELS to provide global technical leadership in this important area.

SPEAKERS AND PRESENTATIONS:

> Segment 1: Welcome and Framing of Technology Opportunities and Issues leading to the formation of the Global Energy Access Forum and Empower a Billion Lives

Deepak Divan, Georgia Institute of Technology, USA - Welcome and Moderator of Segment 1 Global Energy Access Forum, Empower a Billion Lives, TC-12 Energy Access

Three Panelists to address the topics of technology opportunities and issues:

- 1. Silard Liptak, Agsol, Kenya
- 2. Shreyas Kulkarni, Endeavour Energy, USA
- 3. Rajan Kapur, IEEE Smart Village, Larenkelo Ventures, USA
- > Segment 2 Empower a Billion Lives II Global Competition to Crowdsource Solutions to Energy Access

Jelena Popovic, University of Twente, The Netherlands (moderator) Empower a Billion Lives, PELS TC-12 Energy Access

Three Panelists to address the establishment of PELS TC-12 Energy Access and launching the Empower a Billion Lives -II

- **1. Issa Batarseh,** University of Central Florida, Member PELS TC-12 Energy Access, Empower a Billion Lives, USA
- 2. Sanjib Kuamr Panda, National University of Singapore, Member, PELS TC-12 Energy Access Chair
- 3. Deepak Divan, Georgia Institute of Technology, USA, Steering Chair PELS Global Energy Access Forum

Wednesday, October 13

2:00PM-3:30PM

SS11 | Power Electronics Dominated Grids: Dynamic Modeling and Simulation for Reliable and Resilient Operation of Future Grids

SESSION ORGANIZERS:

Suman Debnath, Oak Ridge National Laboratory (ORNL)

Kemal Celik, United States (US) Department of Energy (DOE)

With increased penetration of power electronics based resources in the grid like photovoltaic (PV), energy storage systems (ESS), electric vehicle (EV) chargers, among others, there is a need to understand the impact on the reliability and resilient operation of future grids. Towards the same, next-generation tools and control methodologies are required for stable, reliable, and resilient operation of future grids. In this talk, the opportunities in future power grids with increased penetration of power electronics will be presented followed by the presentations on ongoing research activities in development of next-generation tools, models, and control functionalities.

SPEAKERS AND PRESENTATIONS:

- Collaborative Sensor Networks to Assist Data-driven PV Systems Dynamic Modeling Marissa Enid Morales-Rodriguez, Solar Energy Technology Office (SETO) from the US Department of Energy (DOE)
- > High-Fidelity Electromagnetic Transient (EMT) Modeling of Power Electronics in Future Grid Suman Debnath, Oak Ridge National Laboratory
- > Holistic Modeling Methods to Improve the Stability of Inverter-Dominated Power Grids Maozhong Gong, GE Research
- > Dynamic Model Development of Inverter-Based Resources through Experiment Measurements and Real-World Event Data

Lingling Fan, University of South Florida

- > Dynamic Modeling and Fault Simulations of an IPRB Microgrid with Multiple Grid Forming Inverters Lisa Qi, ABB US Research Center
- > Advanced Generic Dynamic Models for Screening of Reliability and Resilience Challenges of Future Grids

Jens Boemer, Electric Power Research Institute (EPRI)

Thursday, October 14

10:30AM-12:00PM

SS12 | Advanced Design and Manufacturing Techniques for Electric Machines – Simulation and Test

SESSION ORGANIZER:

Prof. David Lowther, Professor, McGill University

The session is intended to provide a series of presentations highlighting the industrial needs and processes for electrical machine design and manufacture and recent university research which is targeted at addressing these needs. The topics covered will range from the design process, as illustrated by the V-cycle approach, and including the multi-physics performance of a proposed motor-drive system; the use of additive manufacturing technologies to enable the implementation of machine topologies which cannot be constructed using conventional, mostly subtractive, manufacturing techniques; and the use of state of the art machine learning techniques to enhance and assist in the design of novel electrical machine architectures. Finally, while "digital twin" technology is driving simulation to new levels and, hopefully, reducing the number of prototypes needed, the physical implementation must be tested to verify the performance of the real device and the issues involved in fast and accurate testing will be discussed.

SPEAKERS AND PRESENTATIONS:

- > Fundamental Design Process of Common Electric Machines James Hendershot, MotorSolver LLC
- > Multi-Physical Simulations in Electric Machine Design Challenges and Opportunities Tanvir Rahman, Siemens Digital Industries Software
- > Machine Learning Techniques for the Topology Optimization of Electrical Machines David Lowther, *McGill University*
- > Additive Manufacturing of Complex Shape Hard Magnetic Materials for PM Machines Pragasen Pillay, Concordia University
- > Fast, Accurate and Comprehensive Testing of Traction Machines Narayan Kar, University of Windsor

Thursday, October 14

9:00AM-10:30AM

SS13 | Standard Development and Industry Engagement Update from IEEE Power Electronics Society

SESSION ORGANIZERS:

Johan Enslin, Chair of PELSC, Clemson University

Matt Wilkowski, Vice chair of PELSC, EnaChip

Xu She, Secretary of PELCS, Carrier Corporation

IEEE power electronics society (PELS) is the driving force behind numerous standard activities and international technology roadmap initiatives relating to power electronics. With the motivation of providing our community the latest update of the standard development within IEEE PELS as well as promoting better involvement especially from industry, this special session brings together the leading experts who are actively leading the development efforts of power electronics standards. The topics span from component (capacitor, magnetics, etc.) level development to system level integration (grid forming inverter, etc.).

- > Activities of the IEEE PELS Standards Committee and Industry Engagement Johan Enslin, Professor of Clemson University and PELS VP of Standards
- > Updating ETTC Standards for Magnetic Components to Keep Pace with Technology George Slam, Senior Applications and Content Engineer Wurth Elektronik, Chairperson ETTC
- > Keeping IEC TC 51 Standards Relevant to Market Applications of Magnetics Mark Swihart, Vice President of Technology and Product Development Magnetics division of Spang and Company
- Impact of Near Magnetic Field Characteristics on Performance of Converters Matt Wilkowski, Vice President of Magnetics Technology and Engineering EnaChip Fang Luo, Director of Spellman High Voltage Electronics Laboratory Stoney Brook University
- > Development of IEEE 2988: Recommended Practice of Use and Functions of Vitual Synchronous Machines Qing-chang Zhong, Professor, Illinois Institute of Technology
- > Update on Grid-forming Inverters Working Group and Standard Development Leo Casey, *Google X*

Thursday, October 14

12:00PM-1:30PM

SS14 | Additive Manufacturing for Electric Machines

SESSION ORGANIZERS:

Franco Leonardi, Ford Motor Company

Leyi Zhu, Ford Motor Company

The special session will focus on what is currently available in terms of additive manufacturing solutions for electric machines, and also on what is coming in the near and far future.

SPEAKERS AND PRESENTATIONS:

- > Arian Aghababaie, PhD, Holo Inc.
- > Additive Manufacturing of Copper Hairpin Windings Jakob Jung, Additive Drives GmbH
- > Design Concepts for Electric Machines leveraging Additive Manufacturing Jagadeesh Tangudu, Raytheon Technologies Research Center
- > Additive Manufacturing of High Performance Stator and Rotor Structures for Electric Machines M. Parans Paranthaman, Oak Ridge National Lab
- > 3D Printed Permanent Magnets: From Material Fundaments to e-Motor Applications Jaćim Jaćimović, ABB Switzerland
- > Rapid Development of Electric Machines Casting with AM Keith Denholm, Grainger & Worrall

Wednesday, October 13

2:00PM-3:30PM

SS15 | Future of Wide-Bandgap Devices SiC, GaN and Diamond and Their Emerging Applications in Power Electronics

SESSION ORGANIZER:

Dr. Tanya Gachovska, Solantro Semiconductor Corp.

The need for high-voltage devices operating at high frequencies and temperature is growing, especially for advanced power electronics. Si-based power devices has some limitations. They are not able to meet these requirements without connecting many devices in series and in parallel, using snubbers and expensive cooling systems. Thus, the market of Si power devices have started to decrease and wide band gap semiconductors have attracted considerable attention. Research into SiC, GaN, and diamond as materials for power devices has been carried out over the past two decades.

SiC, GaN and diamond have wide-bandgap energy resulting in higher breakdown strength for a given blocking voltage. Therfore, SiC, GaN and diamond defices have smaller drift layers or channel lengths as compared to Si devices. As a result, the storage of the minority carriers or the input and output capacitance and, therefore, the switching losses are reduced. This leads to an increase of the switching frequency high than 0.5 MHz, reducing power systems passive components size and cost. In the last 5 years, more companies manufacturing SiC and GaN have come to the market and new startup companies have arised. The prace of SiC and GaN devices have decrease draticaly and more application.

This special session will offer insights into the future and trends for SiC, GaN and diamond devices and their emerging applications in power electronics.

SPEAKERS AND PRESENTATIONS:

- > The Future of SiC Devices and Their Emerging Applications in Power Electronics Anuj Narain, Director Power Platforms and Applications at Wolfspeed
- > The Future of SiC and GaN Devices and Their Emerging Applications in Power Electronics Filippo Di Giovanni, WBG Strategic Marketing Manager within the Power Transistor MACRO Division at ST Microelectronics, based in Catania, Italy
- > The Future of Diamand Devices their Emerging Applications in Power Electronics Julian Styles, Director Business Development at GaN Systems LLC Manpuneet Benipal, PhD Co-founder & CEO, Advent Diamond, Inc.

Monday, October 11

12:30PM-2:00PM

SS16 | Medium- and High-Voltage Gallium Nitride Power Devices

SESSION ORGANIZERS:

Yuhao Zhang, Assistant Professor, Virginia Polytechnic Institute and State University

Dong Dong, Assistant Professor, Virginia Polytechnic Institute and State University

After two decades of relentless development, GaN power high-electron-mobility transists (HEMTs) have been commercialized in voltage classes up to 650 V. In the last few years, strong momentum has emerged in industry and academia to extend the application space of GaN devices into the medium-voltage applications. Several industrial companies are developing 650-1200 V lateral GaN HEMTs, either discrete devices or modules. For example, VisIC is developing 800-1200 V GaN HEMT modules for EV applications. Meanwhile, 600-1200 V GaN transistors based on the vertical architecture are being manufactured on 100-mm GaN-on-GaN platform by several companies in the U. S. and Japan. For example, NexGen Power Systems has demonstrated the production of 650-1200 V vertical GaN JFETs with avalanche capabilities; Toyoda Gosei has demonstrated 1200 V vertical GaN MOSFETs with over 100 A current. In academia, high-voltage GaN devices have been demonstrated up to 10 kV recently. All these progresses suggest that the industrial medium-voltage GaN devices will be available to power electronics engineers very soon. This special session provides a timely overview of the state-of-the-art medium- and high-voltage GaN devices and an industry-centric discussion on the benefits and applications spaces of these coming devices.

- > Unlocking the Full Potential of GaN in Power Systems Dinesh Ramanathan, Founder and Co-CEO, NexGen Power Systems
- > Development Status of Vertical GaN SBDs and MOSFETs Tohru Oka, Project General Manager & Senior Principal Engineer, Toyoda Gosei
- > Vertical Gallium Nitride Devices for Medium-Voltage Power Electronics Robert Kaplar, Manager of the Semiconductor Material and Device Sciences Department, Sandia National Laboratories.
- > 650V Lateral GaN Devices and Modules for 400V and 800V EV Applications Tamara Baksht, CEO, VisIC Technologies
- > Healthcare Applications of GaN Power Devices Juan Sabate, Senior Principal Engineer, GE Global Research Center

Monday, October 11

SS17 | Power Electronics-Based Technologies for grid Stabilization: Grid-Forming Inverters, Control of Inverter-Based Resources (IBRs), and Advanced Testing of IBRs

SESSION ORGANIZERS:

Jing Wang, National Renewable Energy Laboratory

Andy Hoke, National Renewable Energy Laboratory

Recently, power inverters with grid-forming capabilities have attracted broad interest because these inverters do not rely on external voltage sources to generate power, which pertains better stability and reliability than traditional grid-following DERs. Thus, research and development work on grid-forming inverter has extensively carried out in academia and industry. In this panel, we will first introduce the grid-forming inverter manufacture, ABB, to present their latest development in grid-forming battery inverters. Then, one researcher from Siemens will present their research work on performance comparison of different grid-forming control strategies. Apart from the grid-forming inverter related topic, power electronics control and hardware-in-the-loop is also covered. A senior researcher from NREL will demonstrate the operation of a transmission system (Maui in Hawaii) at and near 100% IBRs.

The professor from University of Alabama will share his latest research work on investigating many abnormal operations of IBRs and IBR plants and present an eye-opening discovery of the shortcomings of traditional *dq* control. In the end, the research engineer from NREL will present the advanced testing and validation of grid-connected inverters through power-hardware-in-the-loop simulation from small scale (single inverter) to large scale (100+) inverters. This panel will include power electronics-based technologies for grid stabilization, which will be informative, educational and insightful to learn the state-of-the-art and future directions of power electronics-based resources and systems.

- > Development of Grid-forming Inverters for Supporting Robust and Reliable Future Grids John Glassmire, Hitachi-ABB power Grids
- > Performance Comparison of Parallel Grid-Forming Inverters Amit Pandey, Siemens
- > Operation of a Transmission Electric Power System At and Near 100% Inverter-based Resources Andy Hoke, NREL
- Impacts of Equivalent Dynamic Grid Impedance and Dynamic Inverter P-Q Capability on Reliability and Harmonic Stability of Inverter Based Resources Plant Shuhui Li, University of Alabama
- > Advanced Power-Hardware-in-the-Loop Evaluation of Inverter-based Resources (IBRs) Jing Wang, NREL

Thursday, October 14

10:30AM-12:00PM

SS18 | Additive Manufacturing for Electrical Machines and Power Converters Design

SESSION ORGANIZERS:

Bulent Sarlioglu, Jean van Bladel Associate Professor, University of Wisconsin

Ayman El-Refaie, Werner Endowed Chair, Marguette University

Will Sixel, NASA Glenn Research Center in Cleveland

In aircraft electrification, increasing the specific power and efficiency of electrical components is critical to make more electric/hybrid/electric propulsion physically and economically feasible. Additive manufacturing enables unique geometries that conventional manufacturing techniques cannot achieve. Additively-manufactured applications in electric machines and power electronics include permanent magnets, shafts, and housing designs, thermal management systems, integrated motor drives, additively manufactured coils, and highly optimized traditional designs. Additive manufacturing techniques also allow for increased design flexibility and co-design of related components and subcomponents, allowing for greater system-level performance optimization.

SPEAKERS AND PRESENTATIONS:

> Exploring Potential of Additive Manufacturing for Next Generation Electrical Machines and Power Electronic systems Peter de Bock, ARPA-E, US Department of Energy

- > Additive Manufacturing of Fe-Si Soft-Magnetic Alloys Alex Plotkowski, Oak Ridge National Laboratory
- > 3D Printed Magnetic Cores for Electrical Machines Shanelle N. Foster, Assistant Professor, Department of Electrical and Computer Engineering, Michigan State University
- > Developing the Supply Chain for the Next Generation High-speed, High Voltage Synchronous Reluctance Motor Ozge Taskin, Ricardo
- > Additive Manufacturing of Next Generation Electrical Machine Windings Nick Simpson, Senior Lecturer, University of Bristol
- > Design of a Highly Saturated High-frequency Electric Machine with Additively Manufactured Coils Max Liben, Chief Technology Officer, H3X Technologies Inc.

Thursday, October 14

12:00PM-1:30PM

SS19 | Experimental Verification versus Simulation

SESSION ORGANIZER:

Peter Wung, Adjunct Professor, University of Dayton

A fundamental issue that is inherent in engineering work regards how we can verify our theoretical calculations. For some applications, prototyping is relatively convenient, and the experimental results are preferred as proof that the theory is correct, but in the motor and drives world, while some prototyping is possible – most of those cases involve smaller machines and lower power drives as well as less demanding measurement accuracy; but electric machines and drives testing generally become more expensive and time consuming as the machine and drive rating increases, which require massive resources in terms of hardware, software, and manufacturing expertise to conduct valid experiments with confidence. In this era of powerful computational capabilities, many simulations tools have developed to the point where the accuracy of the simulation results have grown and the time it takes to do these simulation calculations have minimized over the years. Complex analysis of interconnected systems can also be done in a timelier manner, and the development of HIL has made the simulation environment more flexible and more realistic. Ultimately, the question is whether the simulation results are trustworthy enough to be accepted as the proof of the proposed technical solution and design? Has the simulation software attained a level of accuracy which matches and/or surpasses the accuracy of experimental results?

SPEAKERS AND PRESENTATIONS:

Panelists:

Ayman EL-Refaie, Professor, Marquette University Andy Knight, Professor, University of Calgary Mike Degner, Ford Joel Van Sicke, MathWorks Sudipta Chakraborty, Director - Energy Systems, OpalRT Takeshi Yamada, JMAG Philippe Wendling, Altair

First session topics

- > Discussion on testing accuracy (measurement, stackup, numerical specifications).
- > Discussion on simulation accuracy (modelling errors, computation errors, stackup).
- > How to determine testing accuracy.
- > How to determine simulation accuracy.
- > Calibration issues
- > Uncertainties.

Second session topics

- > Open discussion on open questions:
 - At what point can simulation results be considered adequate to testing during the intermediate steps of the R&D cycle? If ever?
 - At what point can simulations results be considered adequate to replace testing as the final proof of verification prior to manufacture, if ever?
 - At which stage during the R&D cycle should simulation results be adequate to push the R&D timeline forward?
 - How to determine the optimal way of employing simulation and experimentation in a product R & D cycle? In a research cycle?
 - Reviewer discretion: when should reviewers insist on experimental results?

Tuesday, October 12

2:00PM-2:30PM

SS20 | PV Inverter Reliability: Industry Status, Technical Gap, and Future Needs

SESSION ORGANIZERS:

Zheyu Zhang, Assistant Professor, Clemson University

Ramanathan Thiagarajan, National Renewable Energy Laboratory

Motivated by the fact that field data from PV power plant operators show that power electronics converter contributes most to operation and maintenance (O&M) events, responsible for between 43% and 70% of the service calls, it is essential to initialize a conversation focusing on the PV inverter reliability with a wide range of stakeholders' participation. This could benefit the research community to better understand the industry status, technical gap, and future needs. In this panel, the audience will hear diverse opinions shared by five distinguished panelists from PV power plant operators and PV inverter manufacturers to U.S. DOE Solar Energy Technologies Office and National Renewable Energy Laboratory, and their visions to improve PV inverter reliability in the field. This panel will include the effects of PV inverter reliability on the overall energy yield of PV Power plants from a PV plant operator. This will be followed by presentations on the effects of PV inverter design on inverter reliability by two leading PV inverter manufacturers. Following this, speakers from DOE and NREL will describe the past and current efforts on inverter reliability and standards development work performed within the DOE space.

SPEAKERS AND PRESENTATIONS:

- > Importance of Inverter Reliability on Operating PV Power Plants Nick de Vries, SVP of Technology and Asset Management, Silicon Ranch
- > Solar Inverter Reliability: DOE-funded R&D and Future Directions Tassos Golnas, Technology Manager, U.S. DOE Solar Energy Technologies Office
- > Insights into Reliable PV Inverter Daniel Clemens, Reliability Technical Manager, SMA Solar Technology
- > Design of Reliability for PV Inverter Matt Ursino, Senior Reliability Engineering, YASKAWA Solectria
- > Overview of IEC 62093 ed 2- The PV Inverter Qualification Test Peter Hacke, Senior Scientist, National Renewable Energy Laboratory

Thursday, October 14

10:30AM-12:00PM

SS21 | P2964 IEEE Standard for Datasheet Parameters and Tests for Integrated Gate Drivers

SESSION ORGANIZER:

Dr. Tanya Gachovska, Solantro Semiconductor Corp.

Power electronics applications employ power switches. Every switch requires a gate driver, a power amplifier that receives a low-power input from a controller and produces a high-current driving output for the gate of high-power switches such as an IGBT, MOSFET, JFET, or HEMT. Some gate drivers have protection features such as fast short-circuit protection (e.g. DESAT), active Miller clamp, shoot-through protection, shutdown, and overcurrent protection, which make them well-suited for both silicon and wide-bandgap power devices.

However, it is difficult to compare the IC gate drivers using their datasheet parameters. Every company names the drivers' pins and parameters with different approaches. The parameters are tested at different conditions and methodology or in most of the cases the conditions and the methodology are not given. Only some companies give the selected test circuits. IEEE-IAS-PEDCC has initiated a working group for a standard to provide datasheet parameters and tests for integrated gate drivers, which include
Special Sessions

non-isolated gate drive, level-shifted gate drive, and isolated gate drive. The standard scope includes terminology, mnemonic, and pins' description; parameters and definitions; and test methods and conditions to obtain the parameters. The special session will include an update on the working group.

SPEAKERS AND PRESENTATIONS:

- > Standardization of "Active Miller Clamp" Wolfgang Frank, Infineon Technologies in Munich/Germany
- > Gate Driver Absolute Maximum Ratings Zheyu Zhang, Assistant Professor, Clemson University
- > Why Do We Need a Standard for Gate Cong Li, *General Electric*
- > Desaturation Protection Requirement Inki Park, ON Semiconductor
- Comparing Gate Driver Timing and Drive Strength Specifications Ryan Schnell, Analog Devices iCoupler
- > Gate Driver Pin Naming Standard Srivatsa Raghunath

Wednesday, October 13

2:00PM-3:30PM

SS22 Grid Integration of Inverter-Based Distributed Energy Resources: Operation, Planning, and Guidelines

SESSION ORGANIZERS:

Dr. Jianzhe Liu, Argonne National Laboratory (ANL)

Dr. Kun Zhu, Midcontinent Independent System Operator (MISO)

Dr. Jens C. Boemer, Electric Power Research Institute (EPRI)

Dr. Reza Ghaemi, General Electric Research (GER)

Dr. Xuan Wu, American Electric Power (AEP)

The US power system will be undertaking an monumental transformation as it moves forward to being 100% clean energy powered by 2035. In the meantime, the extreme weather events and increasingly stressed loading conditions have put grid stability, reliability, and resilience at risk. The growing power electronics intensive inverter-based resources (IBRs) have a promising potential in contributing to the clean energy transformation while improving system performance. Challenges for IBRs grid integration inlcude: 1) how to design stability guaranteed control for the power electronics interfaced resources that usually have low inertia and high stochasticity; 2) the grid planning issue of IBR could be significantly different from the conventional ones; 3) what the industrial guidelines for IBRs integration would be in the future as they have already undertaken significant changes; 4) how we should control a large-scale fleet of IBRs as the problem is high-dimensional and computationally challenging; and 5) how we should optimize the location of energy storage systems given their critical role in IBR's grid integration and considering the numerous choice of location and capacity. This special session will provide useful industry insights into all the aforementioned issues.

SPEAKERS AND PRESENTATIONS:

- > Robust Optimal Power Flow with Stability and Feasibility Guarantees for Systems with Large-Scale IBR Integration Jianzhe Liu, ANL
- > NERC SPIDER Working Group Update Kun Zhu, MISO
- State of The Art and Potential Improvements to Existing IBR Distribution Interconnection Practices & Studies

Jens C. Boemer, EPRI

Scalable Demand Side Control for High Renewable Penetration Distribution Grid: Solutions and Challenges

Reza Ghaemi, *GER*

> Optimal Planning & Operations of Batteries in Distribution Systems to Enhance Reliability and Attain Market Revenues

Xuan Wu, AEP

Thursday, October 14

9:00AM-10:30AM

SS23 | EMI and Insulation Related Challenges and Solutions for WBG -based Power Electronic Systems

SESSION ORGANIZERS:

Bulent Sarlioglu, Associate Professor, University of Wisconsin

Jin Wang, Professor, Ohio State University

Wide bandgap device-based power converters are expected to bring significant efficiency and power density improvements for a wide range of applications. Through the effort from both industry and academia, many circuit implementation and system-level related challenges for implementing WBG devices have been solved. But EMI and insulation degradation are still two significant concerns because of the high dv/dt and di/dt switching of WBG devices. Thus, the organizers of this proposed special session has invited speakers from NASA, industry and academia to present details of EMI and insulation related challenges and solutions.

SPEAKERS AND PRESENTATIONS:

- > Reliability as a Barrier for More Electrification Isik C. Kizilyalli, the Associate Director for Technology at the Advanced Research Projects Agency - Energy (ARPA-E)
- > Challenges of Megawatt Scale Electric Aircraft Propulsion Andrew Woodworth, Hybrid Electric Aircraft Materials Technical Lead, NASA Glenn Research Center
- > Presentation Title: On Some Problems and Solutions Related to High Voltage in Aviation Thierry Lebey, High Voltage Team Leader, Safran
- > Minimizing EMI Suppression Penalties in Motor Drive Applications using Wide-Bandgap Current Source Inverters

Dr. Thomas M. Jahns, Professor, University of Wisconsin - Madison, WEMPEC

> EMI Noise Signatures of Si- vs. WBG-based Traction Inverters Chingchi Chen, Technical Leader, Ford Motor Company

Tuesday, October 12

2:00PM-2:30PM

SS24 Booming the Blue Economy: A New Era for Wave and Hydrokinetic Energy

SESSION ORGANIZERS:

Dr. Yue Cao, Assistant Professor, Oregon State University

Dr. Jing Sun, Michael G. Parsons Collegiate Professor, Univ. of Michigan - Ann Arbor

Dr. Ted Brekken, Professor, Oregon State University; Co-Director, Pacific Marine Energy Center (PMEC)

The Pacific Northwest (including Oregon, Washington, Alaska, and British Columbia-Vancouver area), among other global coastal regions, has access to abundant renewable energy embedded in ocean and river. The energy, known in either a wave form (vertical motion) or a current form (horizontal motion), still

has limited power generation capacity to local grids due to several challenges, especially at the core of mechanical to electrical energy conversion. In 2019, the US Department of Energy (DOE) launched the Powering the Blue Economy initiative to explore the billions of dollars worth of such hydro energy potential alongside the coastline and riverine communities. This decade marks a new era for research and development to bring the highest efficiency, highest reliability, and lowest cost for such blue energy usage, enabling a wide range of adoption. In this session, four industry and one government panelists and three academia organizers will present and discuss the technology needs, innovations, and demonstrations of converter-level design, interdisciplinary control co-design, and system integration to the microgrid/grid connection. The panel organizers and panelists especially represent recently funded projects by the DOE ARPA-E SHARKS program and several DOE Water Power Technology Office initiatives.

SPEAKERS AND PRESENTATIONS:

- > Establishing the ARPA-E SHARKS Program Mario Garcia-Sanz, Program Director, DOE ARPA-E
- > Sustainable, Predictable Renewable Hydrokinetic Energy for Off-Grid Communities Alexandre Paris, President & CEO, ORPC Canada
- > Irony & Urgency: Environmental Review of Wave and Hydrokinetic Energy Projects Paul T. Jacobson, Principal Technical Leader, Water and Ecosystems, EPRI
- > Direct Drive Wave Energy & Pulsed Power Conversion Joseph H. Prudell, Director Oregon Corporate Operations, C.Power
- > Impact of Control Methodology on MHK Device Design Alan McCall, Centipod Program Director, Ecomerit Technologies

Monday, October 11

12:30PM-2:00PM

SS25 | Power Electronics Enabled Power System with High Penetration of Renewables

SESSION ORGANIZERS:

Dr. Rui Yang, Senior Research Engineer, National Renewable Energy Laboratory (NREL)

Dr. Mahshid Amirabadi, Assistant Professor, Northeastern University

The recent advancements in power electronics, solid-state technologies and artificial intelligence are reshaping the traditional view of power distribution systems. The number of power inverters and converters increases significantly due to the high penetration of renewable energy sources and energy storage devices. While much progress has been made in advancing power grids and power electronics technologies, less attention has been paid to bridging the gap between these two traditionally disjoint areas. This session will cover a broad range of contents in the area of power electronics enabled power systems, to address topics such as the impacts of high penetration of renewables and power converters to the power grid and electricity market.

SPEAKERS AND PRESENTATIONS:

- > Transportation Electrification and Its Grid Impacts Xi (Lucy) Lu, Ford Motor Company
- > Impacts of High Penetration Renewables on Voltage and Frequency Stability Yizhe Xu, *Grid-Bridge*
- > The Application of Siemens SCUC Engine On Various Electricity Markets Ting Dai, Siemens
- > On Board Charger: Transforming EV/HEV into Distributed Energy Resources Zhe Zhang, *Eaton*

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- More robust: offline driver optimized for GaN HEMT for fast, effective and safe driving and layout simplification

Board area and weight are becoming limiting factors as power demands increase. Reducing size and weight can **cut the total cost of ownership** by making **installation and maintenance both easier and quicker.**

Part number	General description	Supply voltage max (V)	Key features	Output Current max (A)	High side R _{DS(on)} (mΩ)	Low Side R _{DS(on)} (mΩ)
MASTERGAN1	High power density 600V half-bridge high voltage driver with two 650V enhancement mode GaN HEMT	11	Undervoltage lockout, interlocking function, Over-temperature, Bootstrap diode	10	150	150
MASTERGAN2				6.5	225	150
MASTERGAN4				6.5	225	225









Tutorials



Tutorials are pre-recorded and available on demand for 30 days. The Sunday sessions give an opportunity to meet the instructors and ask questions.

Sunday, October 10

9AM1 | Photovoltaic Systems – From Basics to Advanced Grid Supportive Control

INSTRUCTORS: Yongheng Yang

Zhejiang University, China

Photovoltaic (PV) is one of the renewable favorites with a fast-growing rate, and much more are expected in the future. However, the massive installation of grid-connected PV systems creates many challenges to the grid. Many attempts have thus been made and being explored to better integrate PV systems as grid-friendly systems, which not only minimize the impact on the grid but also offer smart controllability and flexible manageability to enhance the grid performance. To master and then further advance the PV technology, we should understand the basics of PV systems like how the power conversion works, what the technological bottlenecks are, and what is the potential impact for largescale adoption of power electronic-based PV systems? And, how do we address the increasing issues outlined, e.g., by grid codes and standards, IEEE Std. 1547-2018, through advanced control strategies? The tutorial is proposed, and it is dedicated to tackling the technological challenges of nondeterministic power generation in grid-connected PV systems. It provides a step-by-step design of grid-friendly PV systems including the PV modules and power converters, and then a comprehensive understanding of the basics of PV systems. The focus is to innovate and improve the operability by means of advanced control to create more sustainable, grid-friendly, and reliable PV systems that comply with grid regulations and contribute to reducing the cost of energy. This enables the grid-supportive operation of PV systems, e.g., inertia emulation, to improve the grid performance. The tutorial is intended for intermediate and advanced audiences in the field of power electronics, engineers, and researchers, who are looking for advanced control solutions to power converters, especially focused on PV conversion systems for distributed generation. Researchers and engineers who seek for the basic knowledge for the PV technology are welcomed.

9AM2 | Pulse-Width-Modulation: with Freedom to Optimize EMI

INSTRUCTORS: Dong Jiang¹, Zicheng Liu¹, Qiao Li²

¹Huazhong University of Science and Technology, China; ²Hunan University, China

This tutorial focuses on studying of electromagnetic interference (EMI) reduction oriented advanced pulse-widthmodulation (PWM) technologies. EMI is a serious threat to the reliability and operation of the power electronics converters as motor drives. PWM is one of the most important factor for EMI in power electronics converters. Advanced PWM methods can be developed with freedom to optimize EMI and other parameters. In this tutorial, series work of advanced PWM which used freedom to optimize performance will be presented. The tutorial begins with the introduction of EMI problems and PWM technologies in power electronics converters. Then, PWM's impact on the converter performance is discussed for power losses, current ripple and EMI. With current ripple as the control target, the prediction model is studied as the basis for PWM. On the basis of the prediction model, variable switching frequency PWM (VSFPWM) is proposed. This method can improve the EMI and power losses together with control of current ripple or other related parameters. For the general issues of VSFPWM, including the impact on harmonics and feedback control will also be illustrated. For common-mode (CM) EMI issue, this tutorial is with special care. PWM can help to reduce the CM voltage of regular two-level converter, but cannot eliminate it theoretically. For three-level converter, zero CM PWM is possible but with many penalties. A novel zero-CM PWM method for paralleled converters is introduced, together with its further improving methods. This method can be integrated with electric machine and further improve the power density. This tutorial is based on the series work of the presenters' group as well as researchers all over the world. The major contents are included in the newly published book "Advanced Pulse-Width-Modulation: with Freedom to Optimize Power Electronics Converters" by Springer Press.

9AM3 | A MATLAB/Simulink Approach of Photovoltaic Power Systems: Designing, Modeling, Simulation, and Control

INSTRUCTORS: Weidong Xiao¹, Jimmy Chih-Hsien Peng², Qiang Han³

¹University of Sydney, Australia; ²National University of Singapore; ³BC Hydro, Canada

This tutorial provides a practical introduction to photovoltaic (PV) power systems regarding the theoretical analysis, design, modelling, control, and simulation. The objective is to expose the audience to all facets of PV power systems with emphasis on the hands-on tools required for executing academic research and for meeting industry expectations. The development of this tutorial is based on the diverse experience and expertise of the presentation team in both the academia and power industry. The tutorial will first begin with the fundamentals of PV systems regarding theoretical analysis and design. The modelling includes two parts; one for simulation, and another for dynamic analysis. Based on the system stability and robustness in the presence of multiple PV systems. Finally, transient studies for transmission-level connected PV systems are presented. All analysis and simulation are conducted using function blocks in MATLAB\Simulink environment. After the tutorial, the audience shall be able to design a practical grid-tied PV power system, simulate its operation, and evaluate its performance via MATLAB\Simulink. The tutorial will be organized to facilitate smooth transitions from the fundamental and practical knowledge to more advanced subjects.

10AM1 | Emerging Bidirectional Switches and Their Impact on Future AC Power Converters and Applications

INSTRUCTORS: **Thomas M. Jahns¹**, **Bulent Sarlioglu¹**, **Johann W. Kolar²**, **Jonas Huber²**, **Victor Veliadis³** ¹University of Wisconsin – Madison, United States; ²ETH Zurich, Switzerland; ³PowerAmerica, United States

This tutorial will introduce participants to the emerging technology of monolithic bidirectional (M-BD) power switches and the exciting opportunities they will open for future ac power converter topologies and their applications. Wide-bandgap (WBG) power semiconductor technology has opened the door to the development of long-sought monolithic bidirectional switches that can block voltage and conduct current in both polarities under full gate control in all four quadrants. Prototype versions of these M-BD devices produced in industrial and academic laboratories have been reported with ratings as high as \pm 1400V and \pm 100A. A section of this tutorial will be devoted to exposing participants to the underlying semiconductor technology of these M-BD switches including their operating principles, achievable terminal characteristics, technical challenges, and promising M-BD devices reported to date. Following this introduction to state-of-the-art M-BD switch technology, the tutorial will focus attention on the strong potential this new class of switches holds for having a major disruptive impact on the future of power electronics. In particular, this tutorial will focus on the exciting opportunities that these new switches provide for dramatically improving key performance metrics of future dc-ac and ac-ac power converters, including their power density, efficiency, EMI suppression, and (eventually) cost. Two of the well-known power converter classes that will be among the biggest beneficiaries of the future availability of M-BD switches are matrix converters (MCs) and current-source inverters (CSIs). While the appealing advantages of matrix converters for direct ac-ac power conversion have long been recognized, the unavailability of M-BD switches has prevented MCs using the baseline 3x3 matrix of ac switches from achieving wide commercial success. After reviewing the basic concepts associated with matrix converters and their control, attention will be focused on the opportunities that M-BD switches open for realizing the full commercial potential of future MCs in applications such as motor drives. Similarly, the future potential of new M-BD switches to revive long-neglected CSI technology will also be explored. Recent work has revealed a variety of appealing properties of CSI-based motor drives in a wide variety of dimensions including high-temperature operation, EMI suppression, and enhanced fault protection in permanent magnet machine drives. After reviewing the basic concepts of CSI technology for both ac-dc and dc-ac power converters, special attention will be focused on the game-changing potential of M-BD switches in future CSI-based integrated motor drives that combine motors and drives into the same housing. Finally, opportunities to realize the full potential of M-BD switches in promising new power converter topologies

will be explored. One particularly exciting development is their application in a new T-Type switching cell (TT-SC) topology that provides the basis for designing high-performance WBG-based threelevel voltage-source inverters that can achieve appealingly high power density and efficiency performance metrics. Other promising power converter applications of M-BD switches will also be reviewed. Tutorial participants can expect to leave this tutorial with valuable insights into the emerging technology of M-BD switches and the opportunities they open for more fully exploiting wide-bandgap switch technology to revolutionize the power electronics field.

10AM2 | Interaction Among the Grid-connected Converters through Their Synchronization Mechanism

INSTRUCTORS: Marco Liserre¹, Grahame Holmes², Mario Paolone³, Rongwu Zhu⁴, Roberto Rosso⁵

¹Christian-Albrechts-Universität zu Kiel, Germany; ²RMIT University, Australia; ³Swiss Federal Institute of Technology, Switzerland; ⁴Harbin Institute of Technology, Shenzhen, China; ⁵ENERCON, Germany

Electrical power systems are currently transitioning from centralized structures, where most of the power generation comes from small numbers of large power rotating machines, to distributed structures, where much of the power generation comes from large numbers of small power-electronic-interfaced renewable resources. This increasing use of multi-functional power electronic converters (such as STATCOM, DVR, UPFC, UPS and Solid-state Transformer) is challenging the principles of electrical grid operation. One emerging area of concern is harmonic stability issues created by large numbers of grid-connected power converters, with converter synchronization to the grid emerging as a critical factor which can cause anomalous interactions between these converters. This tutorial considers this synchronization issue from the perspective of both the electrical power grid and the converter. The tutorial begins with the electrical grid perspective, looking at limitations of conventional grid modelling approaches in the presence of gridconnected converters, and then presenting advances that have been made in this area. Next, the tutorial reviews grid-synchronization from the converter perspective, looking at modelling issues, established gridsynchronization strategies and grid converter classification implications. The tutorial then presents power synchronization as an emerging alternative for Grid-Forming-Converters, and considers its benefits in comparison to a Phase-Locked-Loop approach. Finally, the tutorial presents the idea of selfsynchronization, where the converter synchronizes to internal control loop variables instead of measured voltages, to improve its stability and ride-through capability in the presence of grid harmonics and faults.

10AM3 | Wide Bandgap Power Electronics Based Electric Machine Drives

INSTRUCTORS: Jin Wang¹, Yousef Abdullah²

¹The Ohio State University, United States; ²Kuwait University

The demand on high performance high power density electric machine drive systems continues to grow as multiple industry sectors look to cut costs and improve power density and efficiency. For this reason, researchers and engineers have been working on wide bandgap (WBG) based power electronics circuits to meet the immediate needs of industry and satisfy future requirements. The following tutorial provides an in-depth look of challenges and status or WBG motor drives, covering topics on both circuit level and system level, which includes gate drive design, circuit layout, reflective wave, thermal design, EMI, leakage current, and insulation stress to motor windings with high dv/dt PWM. Two case studies, one on a 1.8 kVA integrated GaN based motor drive and the other on 7 kV 1 MVA SiC based motor drive, will be used as examples during the discussion.

10AM4 | Monitoring Power Module Degradation via Lifetime-Varying Parameters

INSTRUCTORS: Christoph H. van der Broeck¹, Timothy A. Polom²

¹FEV Europe GmbH, Germany; ²Silicon Austria Labs GmbH, Austria

This tutorial introduces and breaks down thermal response monitoring and degradation diagnosis techniques especially applicable to power electronic modules. Such monitoring technologies are essential in next-generation integrated power electronic systems that require reduced size, weight and cost while ensuring highly reliable operation over ever extending lifetimes. The introduced methodology ultimately enables realization of predictive maintenance strategies that utilize power converters fully until critical degradation thresholds are reached. They allow operating lifetimes of power conversion systems to be maximized or optimized according to engineering and availability constraints. Degradation mechanisms in power electronic modules occur at material interfaces in large part due to mismatches in thermal expansion coefficients. Resulting thermal cycles periodically induce strain at these material interfaces which, in turn, leads to fatigue, i.e., crack growth and delamination. In many cases, the growth of cracks and delamination occurs within the primary heat dissipation path of a power device, thus altering thermal response. The presented scheme of detection, localization, and overall guantification of different degradation mechanisms is based on systematically monitoring lifetime-varying electrothermal response properties and parameters. This tutorial has the objective to present and clarify details of the many promising research approaches that have been recently proposed to realize in situ health monitoring and diagnosis. After establishing motivation, this tutorial reviews electrothermal modeling approaches especially applicable to power modules and examines typical electrothermal response characteristics. Moving forward, it details thermal real-time monitoring systems that combine temperature data, extracted via sensors and temperature-sensitive electrical/optical parameters, with 3-D real-time models. It is demonstrated how the fusion of model and sensor data can detect abnormal thermal responses, which are linked to occurrences of degradation. Page 2 of 3 The tutorial provides an overview on thermal characterization technologies that measure thermal impedance in time and frequency domain. It is analyzed how thermal impedance reflects different degradation mechanisms and can serve as the focal point of a scheme to localize and quantify these mechanisms. Addressing the broad array of implementation options, the final part of the tutorial investigates real-time technologies that can extract life-time varying thermal parameters, in particular thermal impedance, during normal converter operation. It finally shows how extracted degradation sensitive data can be utilized for degradation diagnosis using artificial intelligence technologies.

11AM1 | Advances in Intelligent Solid-State DC Substations for Future Interconnected DC Grids

INSTRUCTORS: **Rik W. De Doncker, Jingxin Hu, Shenghui Cui, Johannes Voss, Philipp Joebges** *RWTH Aachen University, Aachen, Germany*

The change of the electrical supply system to more environmental-friendly energy sources require the development of a new grid infrastructure. Next to the increasing penetration of large-scale renewable energy sources such as offshore wind farms, the change of consumer behavior in the distribution grids from consumer into producer due to the installation of decentralized generations will result in a bottleneck in the distribution grids. Local or regional balancing between loads and generations is found to be a cost effective solution for the future electrical distribution grids, which can be realized with direct current (DC) technology more efficiently and flexibly. The tutorial will focus on the latest advances and best practices of intelligent solid-state DC substations for future flexible DC grids, which covers a selection of key enabling technologies from converter topologies, optimized control, hardware-in-the-loop simulation techniques, to the development of megawatt mediumvoltage demonstrators. The presented advances are collected from a number of recent and ongoing research projects in the Institute for Power Generation and Storage Systems, which includes the Flexible Electrical Networks (FEN) Research Campus funded by the German Federal Ministry of Education and Research. Following a general introduction and a technology roadmap of flexible DC grids, the tutorial will elaborate the technologies of bidirectional isolated DC-DC converters for intelligent solid-state DC substations for

interconnection of DC grids at different voltage levels. It will start with dual-active bridge (DAB) based DC-DC converter topologies for LVDC-MVDC applications, where advanced modulation and control of DAB converters will also be discussed. This includes the instantaneous flux and current control method as well as the advanced black start-up and fault ride-through strategies for a highly dynamic and robust operation under both normal and fault conditions. Then, the development and control of an IGCT-based 5 kV, 5 MW DAB DC-DC converter will be presented. This includes the employment of the modified auxiliary-resonant commutated-pole circuit to ensure zerovoltage soft-switching of IGCT devices with snubber capacitors, and a novel anti-saturation detection and compensation methods for mediumfrequency transformers. Considering the numerous benefits of the bipolar DC distribution, the tutorial will also present advances in power conversion technologies for bipolar LVDC and MVDC distribution systems. The concept of topological integration is adopted and demonstrated forstate-of-the-art AC-DC and DC-DC converterssuch as MMC and DAB, which enables a full bipolar operation capability on the DC side with a minimum count of additional components. The last section of the tutorial will deal with the real-time simulation and hardware-in-the-loop test for intelligent DC substations. Different modeling techniques will be discussed and compared with best practices in the real-time environment. A successful example of using the rapid-control-prototyping tool to develop a high-power medium-voltage modular DC-DC converter will be presented as well as the lessons learnt.

11AM3 | Optimised Electrical Machine Designs for E-Mobility Applications

INSTRUCTORS: Mircea Popescu¹, Philip Mellor², Nick Simpson², James Goss, Melanie Michon¹, Jonathan Godbehere¹

¹Motor Design Ltd., United Kingdom; ²University of Bristol, United Kingdom

Transport electrification is seen as one of main solutions to reduce global CO2 emissions and increased demand of mechanical energy can be provided by electrical energy. The best energy conversion systems are undoubtedly the combination: electrical machines + power electronics + batteries. The increasing demand of full electric vehicles arises specific challenges in terms of design for manufacturing, low weight, material costs and material supply chain. There is a strong interest to reduce the volume and cost of active materials in propulsion motor technologies beyond their current state-of-art, with a strong focus on industrial feasibility for mass production. Potential solutions include increased motor speeds and higher pole numbers and/or the adoption of rare earth free typologies such as reluctance (switched and synchronous) and induction machines. As there can be significantly different usage and performance requirements across e-mobility applications adopting a common standard of motor design is unlikely to yield the optimum in terms of overall system efficiency and electric vehicle range. These considerations will be discussed and compared. Advances in fast switching power semiconductor devices and digital control have enabled high frequency operation of electrical machine drives, with fundamental operating frequencies exceeding 1 kHz being proposed. High frequency operation allows for greater mechanical speeds and designs with a larger number of magnetic poles, leading to a more compact electrical machine package for a given output requirement. However, high frequency operation results in a higher volumetric loss in he active components of the electrical machine; primarily as a result of induced circulating eddy currents in the stator laminations, winding conductors and the rotor. The non-uniform heating and reduction in efficiency associated with these AC loss effects represent a major hurdle to the successful development of compact high frequency electrical machine drives. The benefits and challenges associated with high frequency operation of electrical machines for aerospace and automotive applications will be reviewed and the techniques and design choices available to the designer to reduce high frequency loss effects and extract heat will be surveyed. Cutting-edge sensitivity analysis and multi-objective optimisation techniques will be applied in the design of an electric motor for a PHEV traction application. Each candidate solution will be evaluated in terms of electromagnetic, thermal and mechanical behaviour across the full operating envelope. The optimisation will generate a pareto front which allows efficiency over a drive cycle to be traded off against motor cost. This approach utilises a high performance or cloud computing infrastructure to deliver a truly revolutionary design workflow.

11AM4 | Conducted, Near-Field and Radiated EMI Emission Mitigation for Wide Bandgap Converters: Fundamentals, Modeling and Solutions

INSTRUCTORS: Cong Li¹, Shuo Wang²

¹GE Research, United States; ²University of Florida, United States

This seminar is part of a series of education activities initiated by IEEE EMC Society Special Committee 5 (SC5) - Power Electronics EMC. The purposes are to raise broader power electronics audiences' awareness of EMC, and connect advanced EMC technologies with WBG power electronics systems to enable low noise, high efficiency, and high power density solutions for future power conversion systems. This seminar is a comprehensive quide to provide engineers with techniques to develop and construct electromagnetically compatible Wide Bandgap (WBG) power electronic converters. The seminar provides a good opportunity for the fundamental theory, measurement, and suppression of electromagnetic interference (EMI) for WBG power electronics. It will have full coverage on the conducted emission, near field, and radiated EMI. The first section provides EMC theory and fundamentals for WBG power conversion, comparison of commonly used industrial EMI standards, techniques for common-mode (CM) and differential mode (DM) current separation, and practical CM/DM measurement methods. The second section focuses on a comprehensive 5-step EMC design process for WBG power converters' conducted emission EMI challenges: "SOLVE". SOLVE design flow begins with considerations on Selecting proper architectures based upon system ratings and EMC specifications. The next steps develop techniques for Obtaining component parasitics and Layout for the system EMI model. Vetting of different filter design aspects, including magnetic material selection, structure, and practical filter performance. The last step presents techniques and principles for packaging Enhancement. The third section focuses on the near field EMI generated from components in WBG power converters. The near field EMI can be generated from WBG power modules, transformers, inductors, and PCB traces. It can be coupled to other components in the converter to deteriorate the WBG converter's conductive and radiated EMI. With the high switching speeds and high switching frequencies of WBG power electronics to improve power density, the components are very close to each other, therefore the importance of understanding, measurement, and reduction of near field EMI cannot be overemphasized. The seminar will focus on the advancement of the theory, identification, and reduction of the near field EMI for WBG power electronics. The fourth section focus on the radiated EMI for WBG power electronics. The WBG device powered power electronics systems can achieve higher power densities than those with the 2 conventional Si devices. However, higher switching speed and higher switching frequencies lead to more significant radiated EMI. The radiated EMI can be over the limits from several to hundreds of MHz, which poses a big barrier to high power density power electronics design in the areas such as consumer electronics, electric vehicles, and the aviation industry, etc. This is especially important for most power electronics engineers who lack knowledge on the radiated EMI in power electronics systems. The seminar will focus on the advancement of the theory, measurement, and reduction techniques developed in recent years for the radiated EMI in WBG power electronics systems.

12PM1 | Applying Artificial Intelligence to Battery State Estimation

INSTRUCTORS: Carlos Vidal¹, Phillip Kollmeyer¹, Javier Gazzarr²

¹McMaster University, Canada; ²MathWorks, United States

This tutorial will teach the entire process necessary to create, test, and deploy machine learning algorithms which estimate battery state of charge or other states and properties of interest. Traditional state estimation methods depend on battery models that cannot always capture the complex nonlinear, temperaturedependent characteristics inherent in battery electrochemistry. Machine learning simplifies the process by treating the battery as a black box. The relation between states of interest and measured battery parameters are fit to a neural network, which is a series of matrix calculations containing hundreds or thousands of learnable parameters. Machine learning has potential to achieve better accuracy than conventional battery modeling and state estimation techniques and is a promising solution for a wide range of commercial and industrial applications. Battery state estimation and machine learning theory will first be introduced, along with a discussion of different types of machine learning methods that can be

applied to battery applications. Then the steps to create a machine learning algorithm - an experimental collection of data, defining network configuration and hyperparameters, training, and testing - will each be discussed in detail. A case study comparing a non-recurrent feedforward neural network with a recurrent, LSTM-based neural network will be provided, demonstrating that both network types can perform very well for realistic vehicle drive cycles over a wide range of temperatures. The tutorial will also include an interactive session where the attendees will train and test neural networks for the stateof-charge estimation via example data and code executing in MATLAB Online, which can run in any web browser. Following the training and testing process, the next step is to deploy the networks in hardware and evaluate their real-time performance and computational load. The method of saving a neural network as a MATLAB object for direct use in Simulink, auto-generation of C-code, and deployment to a real-time target, such as a battery management system, will be demonstrated. Example results showing processor time as a function of algorithm type and several learnable parameters will be given. It will provide insights into machine learning algorithms' suitability for large battery packs with a hundred or more cells. The tutorial will also provide several other examples of how to apply machine learning to battery applications, including (1) use of machine learning in place of equivalent circuit models, (2) estimation of temperature to reduce the need for physical sensors in a battery pack, and (3) state of health estimation.

12PM2 | Resiliency-Oriented Grid-Interactive Converters: Concepts, Design, and Field Implementation

INSTRUCTORS: Xiaonan Lu¹, Jin Tan², Andy Hoke², Lisa Qi³

¹Temple University, United States; ²National Renewable Energy Laboratory, United States; " ³ABB Inc., United States

As the penetration level of inverter-based distributed energy resources (DERs) increases rapidly, distribution grids, as the most significant 'grid-edge' for DER integration, play a crucial role in bridging the grid backbone (i.e., transmission system) to the end-users. Resilient and stable distribution grids are urgently needed to modernize electric power grids with high penetration of inverter-based resources (IBRs) and ensure operational continuity. Conventional grid-interactive power electronic converter design mainly focuses on satisfying the design constraints of individual converter units and the operational requirements at the single point of interconnection (POI). However, given the increasing penetration level of IBRs in modern power grids, converter systems should also be taken into account to meet the grid needs in a wider area. Furthermore, the concept of converter design has been tremendously advanced, considering the cross-domain and multi-disciplinary objectives. Particularly, on top of the conventional and legacy converter design constraints on power density, energy conversion efficiency, among others, additional considerations on the interactions among multiple converters (i.e., converter systems) should be highlighted, with special emphases on the coupling operation between converter hardware implementation (physical layer) and information exchange through communication interconnections (cyber layer), control design respecting the tradeoff between local control constraints satisfaction and interactive operation with neighboring converters, and fault-tolerant design and converter system resiliency enhancement coordinated with conventional protection schemes in a multi-timescale context. All these emerging design constraints call for a paradigm shift into a resiliency-oriented converter design framework. In this tutorial, the diversified and multi-disciplinary instructor team from academia, government national laboratories, and leading industry companies will introduce the resiliency-oriented modeling and control of grid-interactive converter, and the topics will range from fundamental concepts covering the necessary background knowledge to advanced applications and field deployment. The topics will echo the cutting-edge technologies and applications of grid-interactive converters, including hybrid and networked AC and DC microgrids, inverter-based renewable energy (e.g., photovoltaics) integration, resiliency enhancement, and protection coordination in inverter-dominated power grids, among others.

12PM3 | Cryogenic Power Electronics Design for Electrified Aircraft Propulsion

INSTRUCTORS: Fei (Fred) Wang¹, Zheyu Zhang², Ruirui Chen¹, Shengyi Liu³

¹University of Tennessee, United States; ²Clemson University, United States; ³Boeing Company, United States

Cryogenic power electronics offer numerous game-changing benefits, including 1) improved performance of power semiconductor devices, such as silicon (Si)- and gallium nitride (GaN)- based, offering decreased specific on-state resistance and increased switching speed; 2) faster switching frequency operation at cryogenic temperature, greatly reducing the need for passive (e.g. EMI filtering); thereby reducing filter weight; 3) less cooling requirement at extremely low ambient temperatures, and 4) light and/or efficient busbar designs due to the low resistivity of conductors at cryogenic temperature. This seminar will provide several key perspectives for the cryogenic power electronics design from the component up to the converter level. First, the characteristics of critical components, including power semiconductors and magnetics, at cryogenic temperature are introduced. Second, special considerations, trade, and design studies of cryogenic power stage and filter are discussed. Then, two examples of a 40 kW Si-based and a 1 MW SiC-based cryogenically-cooled inverter system for electric aircraft propulsion are illustrated, with cooling design, safety considerations, and the protection scheme highlighted. Upon completion, seminar attendees will have a firm grasp on the cryogenic power electronics design and be provided with a range of possible options in order to better utilize the cryogenic cooling system in power converters.

12PM4 | Hybrid Semiconductor Switches based Power Modules, Converters, and Systems

INSTRUCTORS: Fang Luo¹, Jiangbiao He²

¹State University of New York at Stony Brook, United States; ²University of Kentucky, United States

Power semiconductor devices play a backbone role in the development of power electronics. Over the past decade, semiconductor devices have experienced rapid development, especially promoted by the emerging wide-bandgap device technologies. However, regardless of conventional Silicon (Si) devices or the new Gallium Nitride (GaN) and Silicon Carbide (SiC) devices, every type of semiconductor devices has its own pros and cons. To fully leverage their different characteristics, various hybrid power devices and modules have been proposed and developed in the past years, ranging from the device level to converter level, or even power electronics system level. As a matter of fact, many of the concepts of hybrid semiconductor switches have been successfully applied in industries, such as the monolithic integration of Si IGBTs and SiC anti-parallel diodes (i.e., co-pack), the Cascode JFET, and the "Si+SiC" hybrid three-level active neutral-point-clamped commercial modules. Numerous performance benefits have been achieved with such hybrid devices, modules, and converters, including efficiency and reliability improvement, EMI mitigation, cost reduction, etc. In this tutorial, we will start with a review of the development history of various hybrid semiconductor devices and the related successful commercial examples, followed by the new opportunities and challenges with the emerging wide bandgap devices. Afterwards, we will present "Si+SiC" hybrid switching devices at the power module level, review the operating principle, gate drivers, packaging, and performance evaluation. Furthermore, we will present various "Si+SiC" hybrid power converters, specifically including the hardware development, controls, and experimental verifications. Application examples include electric aircraft propulsions and interruptible power supplies for data center applications will be discussed. Finally, we will conclude the tutorial with a summary and Q&A session.

1PM1 | Design and Development of Scalable Battery Testers/Emulators and Their Applications for Future Transportation Electrification

INSTRUCTORS: Sheldon Williamson¹, Uday Deshpande²

¹Ontario Tech University, Canada; ²D&V Electronics Ltd., Canada

As electrified transport systems proliferate, batteries are increasingly becoming the critical element in the immediate and long-term technical and commercial success of these programs. Understanding of battery technology and its role in the applications is becoming crucial. While there have been many articles published on battery elements and systems, this tutorial approaches the problem from a user mindset. How do we use the various technology elements of battery models, calculations of charge and health to ensure a successful design outcome? Additionally, this tutorial will discuss how these elements apply to test and validation. Very few battery cell models are available in literature; most models are very generic or basic. Cell models are either based on equivalent circuit parameters, such as RC, R-RC, or based on SOC calculation - these are not enough to measure Ah-capacity fade, state-of-health (SOH), and/ or end-of-life (EOL). Thermal modeling is used minimally in related literature for testers and emulators. Cell degradation assessment due to varying temperature gradients is not feasible - this is particularly true for fast charging applications; 1C and above. Hence, testers/emulators today are unable to provide boundary testing (near EOL), specifically for applications such as fast chargers and controller validation or BMS validation. This tutorial will present more realistic and practical electro-chemical and electro-thermal models for emulation and testing purposes. Performance modeling will be presented in order to test advanced machine learning (ML)-based battery management systems (BMS) and charger controllers. Stochastic models of battery cells will also be presented in this tutorial. In addition, SOC/SOH estimation models specific to emulator/tester applications, which affect instantaneous battery performance, will also be presented. Advanced thermal/EOL degradation models, which can be used to test BMS with battery health estimation and energy management, will also be presented for testing applications. Finally, the tutorial will include emulation of custom cell models and health-conscious fast charging algorithms, keeping the effects of temperature gradients in mind. Keeping these aspects in mind, the following key practical aspects will be presented: • Emulation at cell-level, module level, and pack level (including development of advanced, higherorder thermal models); • Estimation of SOC and SOH using advanced ML techniques; • Validation of BMS developmental steps with respect to hardware, firmware, and software; • Testing of newly developed algorithms (balancing, SOC, SOH, EOL, etc.); • Development of a new constant-temperature-constant voltage (CT-CV) algorithm; • Testing of fault cases (over-temperature, over-voltage, etc.); • Programmable standard and user-owned battery models; • Bidirectional power supply design (regenerative design) for high-power discharge; Constant-Voltage (CV), Current (CC), Power (CP), Series Resistance (CR) loading; • Real-time HIL (Simulation of high-voltage batteries at cell/ module level; Real-time multi-cell battery simulations; Temperature simulations using isolated analog outputs and advanced models).

1PM2 | Printed Circuit Boards in Power Converter Applications: Design Considerations and Failure Mechanisms

INSTRUCTORS: Ashish Arora, Yike Hu

Exponent, United States

Printed Circuit Boards (PCBs) are the backbone of all electronic circuits and are ubiquitous in today's world in almost all applications. PCBs not only interconnect components through conductors routed through the board with traces and vias, but also provide electrical insulation between conductors of different potentials that are in different circuit nodes. Their use in power converter and energy storage applications gives rise to risks that do not necessarily exist in other lower power applications. While PCB failures are not very common, a propagating PCB failure in a power converter or energy storage application can trigger a cascading series of failures that spread to the system's energy storage component eventually resulting in a fire. Propagating PCB failures can occur due to a number of reasons such as contamination on the PCB, improper PCB layout or a failure of a component on the PCB itself. Design choices made during the development of a product, the cleanliness of the PCB manufacturing

process, the stresses applied to the PCB during a products assembly process etc. can all impact the probability of a PCB failure in the field. Understanding the causes of PCB failures and how these failures can propagate in an application allows for the design and manufacture of systems with more robust PCBs that have a lower probability of a catastrophic failure in the field. This tutorial will provide an overview of some of the requirements and challenges of designing and manufacturing PCBs specially for power converter and energy storage applications. The tutorial will also provide an overview of the types of PCBs, how PCBs are manufactured, how components get onto the PCBs and the standards that exist to evaluate the PCB manufacturing process. PCB failure mechanisms such as interconnect overheating, contamination, electrochemical migration, dendrite formation and conductive anodic filaments, tin whiskers and component over-heating will be reviewed. Case studies will provide examples of failures observed in the field and the means to mitigate them.

1PM3 | Defining, Modeling, and Optimizing for Energy Efficiency in 5G

INSTRUCTOR: Brian Zahnstecher

PowerRox, United States

With so much hype and news around the deployment of the next-generation broadband network (5G), it is quite alarming to find out much of the "promise" of 5G assumes the energy infrastructure exists to power all this new HW. More fundamentally, the payback estimates for these massive investments all assume the network can be fully utilized, while neglecting network bottlenecks because they relate to energy and not data throughput. The 5G Energy Gap and potential electrical grid destabilization is a risk to the entire deployment and all that is attached to it. This risk is broken down into the concepts of the Power Value Chain, Power Cost Factor, 5G Derate Factor, and other technical/business and even socioeconomic factors. This entry/intermediate-level seminar introduces these concepts in a simple, yet realistic way to break the complicated network down into manageable pieces for all stakeholders, then translate the unique inputs/requirements of each into the normalized, "universal currency" of energy. From there, both static and dynamic analyses can be performed to assess end-to-end network configurations and optimize each piece through the lens of energy efficiency.

Technical Program

The following Sessions cover all areas of technical interest to the practicing energy conversion professional.



Topic A: Renewable and Sustainable Energy Applications

A01: Photovoltaic Systems

1772 | Comparison of Modulation Techniques for a Single-Phase Full-Bridge Photovoltaic Micro-Inverter considering Reactive Power Capability

Tobias Brinker, Lennart Hoffmann, Jens Friebe Leibniz Universität Hannover, Germany

1294 | Experimental Analysis of Laminated Bus Bars for Building-Integrated Photovoltaic Applications

S. Ravyts¹, P. Nivelle², J. Carlous², R. Sabariego³, M. Daenen², J. Driesen³, J. Cappelle¹ ¹KU Leuven - Gent, Belgium; ²Hasselt University, Belgium; ³KU Leuven- Leuven, Belgium

1779 Influence of DC/DC Stage on the Design of the Output Filter of the Inverter Stage in Two-Stage Grid-Connected PV Systems

Branislav Stevanović¹, Santiago Cóbreces², Emanuel Serban³, Pedro Alou¹, Martin Ordonez³, Miroslav Vasić¹

¹Universidad Politécnica de Madrid, Spain; ²Universidad de Alcalá, Spain; ³The University of British Columbia, Canada

1362 | Sizing Approach for a Single-Phase Grid-Connected Photovoltaic Converter with Active and Reactive Power Management

Rosa Iris Viera-Díaz, Mario González-García, Ricardo Álvarez-Salas, Homero Miranda, Yuniel León-Ruiz Universidad Autónoma de San Luis Potosí, Mexico

A02: Renewable and Sustainable Energy Systems

2422 | Economic Analysis for Hourly Dispatching Wind Energy Power Using Battery and Supercapacitor Hybrid Energy Storage System

Pranoy Roy, JiangBiao He University of Kentucky, United States

1819 | A Single-Phase Enhanced Grid-Forming Controller with Converter Current Limiting

Masoud Karimi-Ghartemani¹, Ali Zakerian¹, Sayed Ali Khajehoddin² ¹Mississippi State University, United States; ²University of Alberta, Canada

1226 Comparative Study of Transverse Flux Permanent Magnet Machines for Wind Power Applications

R. Kumar¹, Z.Q. Zhu¹, A. Duke², A. Thomas², R. Clark², Z. Azar² ¹The University of Sheffield, United Kingdom; ²Sheffield Siemens Gamesa Renewable Energy Research Centre, United Kingdom

2346 | Review of DC Offshore Wind Farm Topologies

Kareem A. Noor Al-Deen, Hussain A. Hussain Kuwait University, Kuwait

1990 | Control Strategies for Variable Speed Operation of Pumped Storage Plants with Full-Size Converter Fed Synchronous Machines

Raghbendra Tiwari¹, Roy Nilsen¹, Olve Mo² ¹Norwegian University of Science and Technology, Norway; ²SINTEF Energy Research, Norway

A03: Power Converters for Renewable and Sustainable Energy Systems

1328 | Flexible AC Phase Configurable NPC-Based Converter Topology

Emanuel Serban^{1,2}, Jan Hammer¹, Cosmin Pondiche², Martin Ordonez¹ ¹The University of British Columbia, Canada; ²EnerSys, Canada

2144 | Harmonics Compensation of the LCC in a Parallel LCC-VSCs Configuration for a Hybrid AC/DC Network

Rouzbeh Reza Ahrabi, Yunwei Li University of Alberta, Canada

1192 A Dual-Input Single-Output DC-DC Converter Topology for Renewable Energy Applications

Pasan Gunawardena, Nie Hou, Dulika Nayanasiri, Yunwei Li University of Alberta, Canada

2016 | PWM Control of n-Phase Interleaved Current Fed Topology

Sonam Acharya¹, Santanu Mishra¹, Arvind Tiwari² ¹Indian Institute of Technology Kanpur, India; ²GE Research, United States

A04: Control of Photovoltaic Systems

1563 | Analysis of Maximum Power Point Tracking in Four Different Modes for Multioutput Hybrid Bipolar Converter

Nidhi Malhotra, Pawan Kumar, R.K. Singh Indian Institute of Technology (BHU), Varanasi, India

1904 | Discontinuous Modulation for Improved Thermal Balance of Three-Level **1500-V** Photovoltaic Inverters under Low-Voltage Ride-Through

Jinkui He¹, Ariya Sangwongwanich¹, Yongheng Yang², Zhongyi Quan³, Yunwei Li³, Francesco lannuzzo¹ ¹Aalborg University, Denmark; ²Zhejiang University, China; ³University of Alberta, Canada

1482 | A Semi Discontinuous PWM Method for Mitigating Oscillation in a Three-Level Grid-Tied PV Inverter

Zhaoxia Yang¹, Jianwu Zeng¹, Qixing Ren², Liangcai Wu², Zhengjun Liao² ¹Minnesota State University, United States; ²Growatt New Energy Technology Co., Ltd., China

1864 | Hybrid MPPT Technique Based on MPC and PSO for PV Systems Subject to Partial Shading

Angelo G. Santos, Filipe A.C. Bahia, Fabiano F. Costa, André P.N. Tahim, Leandro L.O. Carralero Federal University of Bahia, Brazil

1502 | A Reactive Power Control Optimization Scheme for the Power Imbalance of Cascaded Photovoltaic Converter

Chu Wang, Min Chen, Yufei Jie Zhejiang University, China

1690 An Improved PV to Isolated Port Differential Power Processing Architecture for Solar PV Applications

Aqsa Rouf, Soumya Shubhra Nag Indian Institute of Technology Delhi, India

1389 A Decentralized Adaptive Voltage Regulation Control Strategy Based on a Novel Modular Three-Phase Integrated PV Inverter

Xinghua Dang, Shangzhi Pan, Xicai Pan, Jinwu Gong, Xiaolu Ge, Jingxiang Shi, Minglong Wang, Lidong Hao, Pengxin Jin *Wuhan University, China*

Session A05: Energy Storage Systems

2053 Cell Balancing of Li-Ion Battery Pack with Adaptive Generalised Extended State Observers for Electric Vehicle Applications

Utkal Ranjan Muduli¹, Khaled Al Jaafari¹, Khalifa Al Hosani¹, Ranjan Kumar Behera², Rustem R. Khusnutdinov³, Alfred R. Safin³ ¹Khalifa University, United Arab Emirates; ²Indian Institute of Technology Patna, India; ³Kazan State Power Engineering University, Russia

1666 | Passivity Control in Modular Battery Energy Storage Systems

Ezequiel Rodriguez¹, Ramon Leyva², Gaowen Liang¹, Glen G. Farivar³, Josep Pou¹, Christopher D. Townsend⁴, Naga Brahmendra Yadav Gorla³ ¹Nanyang Technological University, Singapore; ²Universitat Rovira i Virgili, Spain; ³University of Western Australia, Australia

1299 A Comparison of the Battery Fault Tolerance of Modular Multilevel Converters with Half-Bridge and Full-Bridge Submodules

Gaowen Liang¹, Glen G. Farivar¹, Gorla Naga Brahmendra Yadav¹, Christopher D. Townsend², Salvador Ceballos³, Hossein Dehghani Tafti², Josep Pou¹ ¹Nanyang Technological University, Singapore; ²University of Western Australia, Australia; ³Ikerlan Technology Research Centre (BRTA), Spain

1565 | Design, Control and Prototyping of a Bidirectional Dual Active Bridge Converter for Integrating a Sodium Metal Halide Battery into a Telecom Station

Mario Porru^{1,2}, Alessandro Serpi^{1,2}, Alessandro Soldati³, Luca Tassi³, Alfonso Damiano² ¹NEPSY srl, Italy; ²University of Cagliari, Italy; ³University of Parma, Italy

1794 | Design of a 1500V Si IGBT/SiC MOSFET Hybrid Switch-Based Three-Level Active NPC Inverter

Haichen Liu, Tiefu Zhao, Jim Gafford, Somasundaram Essakiappan, Madhav Manjrekar University of North Carolina Charlotte, United States

1894 A Novel ZCS Bidirectional CUK Equalizer for Energy Balance of Battery Cells Connected in Series

Xinchi He¹, Rui Ling¹, Dongxue Li² ¹Chongqing University, China; ²Vicor Corporation, United States

1604 Novel Battery Equalizer-Charger Symbiosis Structure Based on Three-Port DC-DC Converters

Nguyen-Anh Nguyen, Phuong-Ha La, Ngoc-Thao Pham, Sung-Jin Choi University of Ulsan, Korea

1089 | Solar Water Pumping System with Captive Energy Storage Functionality

Hina Parveen, Utkarsh Sharma, Bhim Singh Indian Institute of Technology Delhi, India

Session A06: Microgrids and Grid Integration of Renewables

1373 | Mode Transition in DC Microgrids with Non-Dispatchable Sources

S. Jaya, A.S. Vijay, Imran Khan, Anshuman Shukla, Suryanarayana Doolla Indian Institute of Technology Bombay, India

2215 | Subsynchronous Control Interaction Study Framework and Applications to Southern California Edison System

Chaoyang Jing, Patricia Arons Southern California Edison, United States

1550 | A Simulation Platform for Testing the Monitoring Techniques of a Microgrid

Mohd Aquib, Suryanarayana Doolla, Mukul C. Chandorkar Indian Institute of Technology Bombay, India

2248 | Design and Optimization Strategy to Size Resilient Stand-Alone Hybrid Microgrids in Various Climatic Conditions

Norma Anglani¹, Giovanna Oriti², Ruth Fish², Douglas L. Van Bossuyt² ¹University of Pavia, Italy; ²Naval Postgraduate School, United States

1807 | Dual Converter Operating with Floating Capacitors Connecting Open-End Winding Doubly-Fed Induction Generator to a DC Microgrid

Emerson L. Soares¹, Cursino B. Jacobina¹, Nady Rocha², Victor Felipe M.B. Melo² ¹Federal University of Campina Grande, Brazil; ²Federal University of Paraíba, Brazil

1246 A New General Multi-Layout Energy Hub Management Model for Industrial and Commercial Multi-Energy Systems with Complex Configurations

Mehrdad Aghamohamadi¹, Clement Chuah¹, Amin Mahmoudi¹, John K. Ward², Mohammed H. Haque³ ¹Flinders University, Australia; ²CSIRO, Australia; ³University of South Australia, Australia

1859 | Sizing of Hybrid Supercapacitors for Off-Grid PV Applications

Tarek Ibrahim¹, Tamas Kerekes¹, Dezso Sera², Sergiu Spataru³, Daniel-Ioan Stroe¹ ¹Aalborg University, Denmark; ²Queensland University of Technology, Australia; ³Technical University of Denmark, Denmark

1841 | Dynamic Analysis of AC Microgrids with Constant Power Loads or Sources

Mohammad Mahdavyfakhr, Navid Amiri, Hanqing Lin, Juri Jatskevich The University of British Columbia, Canada

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2307 | Soft Switched High Gain Boost Converter for Low Voltage Applications

Manikant Kumar, Kirti Mathuria, Vinod Kumar Yadav, Arun Kumar Verma Malaviya National Institute of Technology Jaipur, India

2132 | A Fully Symmetrical Three-Port Hybrid Converter for PV Systems

Zhongting Tang¹, Yongheng Yang², Frede Blaabjerg¹ ¹Aalborg University, Denmark; ²Zhejiang University, China

1098 | Experimental Verification of Three-Phase PV Inverter Using Multiple Bidirectional Choppers for Utility-Scale PV Systems

Linyue Qiao, Yoshifumi Shimizu, Makoto Hagiwara Tokyo Institute of Technology, Japan

2471 | Optimal Design of Multi-Port DC/DC Converters for Low Power and High Frequency Applications

Marzieh Karami¹, Guangqi Zhu¹, Rohit Baranwal¹, Vijay Bhavaraju¹, David W. Ganger¹, Cheng Luo² ¹Eaton, United States; ²Eaton, China

2567 | Design and Testing of a Modular Back-to-Back Power Electronics Converter for Wave Energy Harvesting

Mattia Mantellini¹, Riccardo Morici¹, Marcos Blanco², Marcos Lafoz², Gustavo Navarro², Luca Zarri³ ¹OCEM Power Electronics, Italy; ²CIEMAT, Spain; ³University of Bologna, Italy

2447 | Design Considerations of 6.5kV Enabled Three-Level and 10kV Enabled Two-Level Medium Voltage SST

Apoorv Agarwal, Anup Anurag, Nithin Kolli, Ashish Kumar, Subhashish Bhattacharya North Carolina State University, United States

1060 Investigation of a New Alternate Arm Modular Multilevel Converter Topology for HVDC Applications

Dereje Woldegiorgis, Alan Mantooth University of Arkansas, United States

1980 | A Hybrid GaN + Si Based Cascaded H-Bridge Multi-Level Inverter and PWM Scheme for Improved Efficiency

Prince Kumar¹, D. Venkatramanan¹, Abhijit Kshirsagar², Ned Mohan¹ ¹University of Minnesota Twin Cities, United States; ²Indian Institute of Technology Dharwad, India

Session A08: Control of Renewable Energy Systems

1472 | Sliding Mode Control Based Energy Harvesting System for Low Power Applications

Honorio Martinez Sarmiento¹, Maen Marji¹, Cheaheng Lim¹, Jonghoon Kim², Nan Wang¹, Woonki Na¹ ¹California State University Fresno, United States; ²Chungnam National University, Korea

1998 | MPPT Novel Controller Based on Passivity for the PV Solar Panel-Boost Power Converter Combination

J. Linares-Flores, A. Hernández-Méndez, J.A. Juárez-Abad, M.A. Contreras-Ordaz, C. García-Rodriguez Universidad Tecnológica de la Mixteca, Mexico

1200 A New Kalman-Filter-Based Harmonic Current Suppression Method for the Virtual Oscillator Controlled Voltage Source Converters with LCL

Siyi Luo¹, Weimin Wu¹, Koutroulis Eftychios², Frede Blaabjerg³, Henry Shu-Hung Chung⁴ ¹Shanghai Maritime University, China; ²Technical University of Crete, Greece; ³Aalborg University, Denmark; ⁴City University of Hong Kong, China

1300 | Transient Stability Enhancement for Virtual Synchronous Generator by Combining Direct Power Control

Xuejiao Zhong¹, Yutao Lou², Tiliang Wen¹, Donghai Zhu¹, Xudong Zou¹, Xiang Guo¹ ¹Huazhong University of Science and Technology, China; ²Shanghai Institute of Satellite Engineering, China

2334 Power-Synchronized Current Control for Grid-Connected Converters

Xiao Wang, Xiongfei Wang Aalborg University, Denmark

1587 A New Control Strategy Based on PLL to Enhance System Stability under Varying Output Power in Weak Grids

Junliang Liu¹, Xiong Du¹, Yuming Liu², Dengfeng Li², Bo Zhang¹, Chenghui Tong¹ ¹Chongqing University, China; ²State Grid Chongqing Electric Power Company, China

1323 240°-Clamped PWM in Three Phase Grid-Connected PV Converter Application

Hafsa Qamar, Haleema Qamar, Rajapandian Ayyanar Arizona State University, United States

Session A09: Grid Integration of Renewables

1656 An Enhanced Double Quasi-PR Controller for Grid-Side Inverter with Long Transmission Cable

Weibiao Wu¹, Ke Hu², Ming Zhang¹, Gujing Han¹ ¹Wuhan Textile University, China; ²Huazhong University of Science and Technology, China

1066 | Circulating Current Analysis of Paralleled Grid-Connected Inverters Based on the Multi-Frequency Model

Liguo Wu, Xinbo Ruan, Zhiheng Lin, Hao Zhang Nanjing University of Aeronautics and Astronautics, China

1647 | Comparison of Grid-Forming Converter Control Strategies

Anant Narula, Massimo Bongiorno, Mebtu Beza Chalmers University of Technology, Sweden

2252 | Dynamic Impact of Voltage-Dependent Current Injection on Fault-Ride-Through of Grid-Following Converters

Xinshuo Wang¹, Heng Wu¹, Xiongfei Wang¹, Laurids Dall², Jun Bum Kwon³ ¹Aalborg University, Denmark; ²Energinet, Denmark; ³Ørsted, Denmark

1199 | A New Type of Three-Phase Asymmetric LCL Power Filter for Grid-Tied Voltage Source Inverter

Weimin Wu¹, Yaozhong Zhang¹, Henry Shu-Hung Chung², Frede Blaabjerg³ ¹Shanghai Maritime University, China; ²City University of Hong Kong, China; ³Aalborg University, Denmark

1709 | Analysis of Overmodulation in Power Synchronization-Based Voltage Source Converters

Federico Cecati¹, Sante Pugliese¹, Marco Liserre¹, Xiongfei Wang², Frede Blaabjerg² ¹Christian-Albrechts-Universität zu Kiel, Germany; ²Aalborg University, Denmark

1428 | Empirical Evaluation of GPS Clock Accuracy for Isochronous Droop-Based Inverters

Toby Meyers, Barry Mather National Renewable Energy Laboratory, United States

Session A10: Wind Enegy Systems

1536 | Permanent Magnet Generators for Wind Application: An Analytical Investigation

Seyed Payam Emami¹, Emad Roshandel², Amin Mahmoudi², Samad Taghipour Boroujeni¹, Solmaz Kahourzade³

¹Shahrekord University, Iran; ²Flinders University, Australia; ³University of South Australia, Australia

2298 | Aggregation of Wind Turbine Grid-Side Inverters by Voltage Angle and Cable Resonance Compensation

Zichao Zhou¹, Xiongfei Wang¹, Yin Sun² ¹Aalborg University, Denmark; ²Shell Global Solutions International B.V., The Netherlands

1393 | Research on Dynamic Reactive Power Coordinated Control Strategy of Doubly-Fed Wind Turbine Based on Improved Genetic Algorithm

Sen Cui¹, Xiangwu Yan¹, Ruibo Li¹, Wenfei Chang¹, Waseem Aslam² ¹North China Electric Power University, China; ²University of Sargodha, Pakistan

1485 | Power-Electronics-Based Mission Profile Emulator for DFIG-Based Wind Power Generation System

Huichao Ge, Ke Ma Shanghai Jiao Tong University, China

1707 | Electromagnetic Study of Direct-Driven Wind Turbine Generators by Coupled Field- Circuit Simulations and Full-Scale Bench Tests

Christoph Mülder¹, Fabian Müller¹, Andreas Thul¹, Kay Hameyer¹, Christoph Meier² ¹RWTH Aachen University, Germany; ²Wobben Research and Development GmbH, Germany

2173 | Comparison of Active and Passive 9-Phase Wind Turbine Conversion System for an all DC Grid

Omid Beik¹, Ahmad S. Al-Adsani² ¹McMasters University, Canada; ²Public Authority for Applied Education and Training, Kuwait

2299 | Dynamic Model Validation and Harmonic Stability Analysis of Offshore Wind Power Plants

Zichao Zhou¹, Xiongfei Wang¹, Fangzhou Zhao¹, Jan R. Svensson², Lukasz Kocewiak³, Mikkel Peter Sidoroff Gryning³, Aravind Mohanaveeramani²

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1139 An Amplitude-Modulated Pseudo-Random Binary Sequence Approach to Broadband Impedance Spectroscopy for Photovoltaic Module System Identification

Linda Shelembe, Paul Barendse University of Cape Town, South Africa

1140 A Quantitative Feedback Theory Approach to Converter-Based Broadband Impedance Spectroscopy for Online Condition Monitoring of Photovoltaic Modules

Linda Shelembe, Paul Barendse University of Cape Town, South Africa

1368 | Light Intensity Modulation and Two-Port Network Analysis of Dynamic Response of Photovoltaic Module

Thomas Link, Sean Youngblood, Lauren Boulay, S.M. Rakiul Islam, Eric Donkor, Sung-Yeul Park University of Connecticut, United States

1281 | A Traction Inverter Design for Increasing the DC Link Voltage in Electric Vehicles Hui Zhang

State University of New York at Oswego, United States

1088 | HVDC Transmission of Offshore Wind Farm Using Current-Source Actively Commutated Converter with Very-Low-Capacity AC Network

Zixin Li^{1,2}, Kedong Luan^{1,2}, Fei Xu^{1,2}, Fanqiang Gao^{1,2}, Cong Zhao^{1,2}, Ping Wang^{1,2}, Yaohua Li^{1,2} ¹Chinese Academy of Sciences, China; ²University of Chinese Academy of Sciences, China

1254 Online Condition Monitoring of Fuel Cells (FC) by Implementing Electrical Impedance Spectroscopy Using a Switch-Mode DC-DC Converter

Surprise Mahlangu, Paul Barendse University of Cape Town, South Africa

2294 Power Switch Open-Circuit Fault-Diagnosis Based on a Shallow Long-Short Term Memory Neural Network: Investigation of an Interleaved Buck Converter for Electrolyser Applications

Rahul Kumar¹, Shanal Kumar¹, Giansalvo Cirrincione², Maurizio Cirrincione¹, Damien Guilbert³, Krishnil Ram¹, Ali Mohammadi¹

¹The University of the South Pacific, Fiji; ²University of Picardy Jules Verne, France; ³University of Lorraine, France

Session A12: Architectures for Renewable and Hybrid Renewable Energy Systems

2170 | Three-Port Multilevel Converter for Hourly Dispatching Solar PV Power with Battery Energy Storage System

Pranoy Roy, JiangBiao He, Aaron Cramer University of Kentucky, United States

2513 | Synchronizing Control of Wind Turbine Driven Doubly Fed Induction Generator System with DG in Remote Area Involving Solar PV-Battery Energy Storage

Sambasivaiah Puchalapalli, Bhim Singh Indian Institute of Technology Delhi, India

2459 | Smoothing of PV Output Power in Grid-Tied Energy Storage System with Model Predictive Control and Battery Lifetime Consideration

Md Safayatullah, Qun Zhou, Issa Batarseh University of Central Florida, United States

1973 | A Direct AC/AC Modular Multilevel Cascade Converter Based on Bridge Cells with Distributed Energy Resources

Bruno E. de O.B. Luna¹, Cursino B. Jacobina², Alexandre C. Oliveira², Nustenil S.M.L. Marinus³ ¹Federal Rural University of the Semi-arid Region, Brazil; ²Federal University of Campina Grande, Brazil; ³Federal Institute of Education, Science and Technology of Ceará, Brazil

2188 | Optimization of Reactive Power Distribution in Series PV-Battery-Hybrid Systems

Yiwei Pan¹, Ariya Sangwongwanich¹, Yongheng Yang², Frede Blaabjerg¹ ¹Aalborg University, Denmark; ²Zhejiang University, China

1287 | Modular Differential Power Processing Architecture Utilizing Isolated Bus to Virtually Unify Photovoltaic Panel Characteristics in Large-Scale Systems

Takumi Suzuki, Masatoshi Uno Ibaraki University, Japan

Session A13: Renewable Energy and Storage Systems

1695 | An Efficient and Compact Single-Stage High-Frequency-Link Medium Voltage AC to DC Converter

Harisyam P.V., Dibakar Das, Kaushik Basu Indian Institute of Science, India

1663 | Impact of Partial Power Processing Dual-Active Bridge Converter on Li-Ion Battery Storage Systems

Hamzeh Beiranvand, Felix Hoffmann, Frederik Hahn, Marco Liserre Christian-Albrechts-Universität zu Kiel, Germany

2523 Modular Wireless Power Transmission for Photovoltaic Subpanel System

Yue Zheng, Zeyu Cheng, Chang Liu, Hongling Liu, Mahshid Amirabadi, Brad Lehman Northeastern University, United States

1664 | Design of an Isolated DC-DC Converter for PV Micro-Inverters with Planar Transformer and PCB Integrated Winding

Tobias Manthey, Tobias Brinker, Jens Friebe Leibniz Universität Hannover, Germany

1803 | Hardware and Control Design Considerations for a Mobile 1 MW Input-Series Output-Parallel (ISOP) DC-DC Converter in Medium Voltage Range

David Tatusch¹, Jens Friebe¹, Anton Gorodnichev², Daniel Haake², Fabian Schnabel², Marco Jung³ ¹Leibniz Universität Hannover, Germany; ²Fraunhofer Institute for Energy Economics and Energy System Technology, Germany; ³Bonn-Rhein-Sieg University of Applied Sciences, Germany

2437 Optimized AC/DC Dual Active Bridge Converter Using Monolithic SiC Bidirectional FET (BiDFET) for Solar PV Applications

Suyash Sushilkumar Shah, Ramandeep Narwal, Subhashish Bhattacharya, Ajit Kanale, Tzu-Hsuan Cheng, Utkarsh Mehrotra, Aditi Agarwal, B. Jayant Baliga, Douglas C. Hopkins North Carolina State University, United States

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2233 | Reliable Method for the Measurement of Diffusion Capacitance in Solar Photovoltaic Cells

Alireza Ramyar, Yasir Altheyabi, Al-Thaddeus Avestruz University of Michigan, United States

1593 A Lead-Lag Filter for Virtual Synchronous Machines with Improved Electromechanical Damping Fabio Mandrile, Vincenzo Mallemaci, Enrico Carpaneto, Radu Bojoi *Politecnico di Torino, Italy*

2026 | Multisampling Based Grid Impedance Estimation for Two-Cell Interleaved Three-Phase Inverters

Shan He, Dao Zhou, Xiongfei Wang, Frede Blaabjerg Aalborg University, Denmark

2424 | Levelized Cost of Energy Optimization in Hybrid PV Plants by Energy Storage for Ramp-Rate Control Operation

Irene Peláez, Cristian Blanco, Andrés Suarez, Ángel Navarro, Pablo García University of Oviedo, Spain

1363 | Control Strategy to Attenuate Voltage Oscillations under Unbalanced Power Distribution in Large Scale Photovoltaic Cascaded Multilevel Converters

Yuniel León-Ruiz, Mario González-García, Ricardo Álvarez-Salas, Víctor Cárdenas, Rosa Iris Viera-Díaz Universidad Autónoma de San Luis Potosí, Mexico

Topic B: Smart Grid and Utility Applications

Session B01: Power Converters for Distributed Resources and Microgrids

1924 An Isolated Voltage Injection Based Hybrid Circuit Breaker for MVDC Applications

Abdul Basit Mirza, Yalda Azadeh, Hongwu Peng, Fang Luo Stony Brook University, United States

2227 | Solid State Circuit Breaker Design with Discrete SiC MOSFETs for Aircraft Electrification Application

Piranavan Suntharalingam, Armen Baronian *Eaton, United States*

2134 | Modeling of Solid-State Circuit Breaker during Current Interruption Phase

Dehao Qin¹, Di Zhang², Chuanyang Li³, Dong Dong⁴, Yang Cao³, Zheyu Zhang¹ ¹Clemson University, United States; ²Naval Postgraduate School, United States; ³University of Connecticut, United States; ⁴Virginia Polytechnic Institute and State University, United States

1671 | Control of a Three-Phase Four-Wire Modular Multilevel Converter as a Grid Emulator in Fault Scenarios

Ming Jia, Shenghui Cui, Katharina Hetzenecker, Jingxin Hu, Rik W. De Doncker *RWTH Aachen University, Germany*

2011 | A New Fully Soft-Switched, Single-Stage Bidirectional LLC Resonant Based AC/DC Converter for Hybrid Micro-Grid with Active Ripple Energy Storage

Parham Mohamadi, John Lam York University, Canada

1975 | 3-Phase Back to Back Active Power Filter for a Multi-Generator Power System with Reduced DC-Link Capacitor

Jongwan Kim¹, Jih-Sheng Lai² ¹Texas Instruments, United States; ²Virginia Polytechnic Institute and State University, United States

2301 | Residual Power Transfer Capability Analysis of an MMC-SST under Submodule IGBT Open-Circuit Fault

Jiajie Zang¹, Jiacheng Wang¹, Jianwen Zhang², Jianqiao Zhou², Jiahu Guo², Dongmin Xi³ ¹Simon Fraser University, Canada; ²Shanghai Jiao Tong University, China; ³Inner Mongolia University of Technology, China

Session B02: V2G and G2V

1181 Distributed Control Design for V2G in DC Fast Charging Stations

Asal Zabetian-Hosseini, Geza Joos, Benoit Boulet *McGill University, Canada*

2500 | A New Modular Level-2 PEV Charger for Plug-In Electric Vehicle: Design and Implementation

Laith Alkhawaldeh, Lingli Gong, Mohamed Youssef Ontario Tech University, Canada

2098 | lectric Vehicle Battery as Energy Storage Unit Consider Renewable Power Uncertainty

Qiyun Dang, Di Wu, Benoit Boulet *McGill Univesity, Canada*

1339 Passenger Weight Detection by Air Suspension Pressure Monitoring for Smart Grid Integration of Electric Buses

Utz Spaeth, Heiko Fechtner, Michele Weisbach, Alexander Popp, Benedikt Schmuelling University of Wuppertal, Germany

Session B03: Control of DC Microgrids

1950 | A Plug-and-Play Capable Multi-Agent Network for Distributed Consensus-Based Operation in DC Power Systems

Anas Alseyat, Md Habib Ullah, Jae-Do Park University of Colorado Denver, United States

1777 | A Power Electronics-Based Power HIL Real Time Simulation Platform for Evaluating PV-BES Converters on DC Microgrids

Isuru Jayawardana, Carl Ngai Man Ho University of Manitoba, Canada

1853 | Tertiary Control Method for Droop Controlled DC-DC Converters to Ensure Bounded Voltages in DC Microgrids

Shrivatsal Sharma¹, Vishnu Mahadeva Iyer², Subhashish Bhattacharya¹, Jun Kikuchi³, Ke Zou³ ¹North Carolina State University, United States; ²Indian Institute of Science, India; ³Ford Motor Company, United States

2025 Weighted Dynamic Aggregation Modeling of DC Microgrid Converters with Droop Control

Aida Afshar Nia, Navid Shabanikia, S. Ali Khajehoddin University of Alberta, Canada

2495 | MAS-Based Distributed Load Restoration in Resilient Networked DC Microgids Systems

Md Habib Ullah, Jae-Do Park University of Colorado Denver, United States

Session B04: Grid Intelligence for Unique Loading Scenarios

1149 | Digital Twin for Self-Security of Smart Inverter

Tareq Hossen, Mehmetcan Gursoy, Behrooz Mirafzal Kansas State University, United States

1348 Comparative Investigation of System-Level Optimized Power Conversion System Architectures to Reduce LCOE for Large-Scale PV-Plus-Storage Farms

Zheng An, Rajendra Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

2076 | A Model-Based Short-Term Load Forecast Methodology for Aggregated Power Consumption of Thermostatically Controlled Appliances in DSM

Pegah Yazdkhasti, Chris P. Diduch University of New Brunswickick, Canada

1245 | Review on the State-of-the-Art Operation and Planning of Electric Vehicle Charging Stations in Electricity Distribution Systems

Mehrdad Aghamohamadi¹, Amin Mahmoudi¹, John K. Ward², Mohammed H. Haque³ ¹Flinders University, Australia; ²CSIRO, Australia; ³University of South Australia, Australia

1243 | Recourse-Based BCD Robust Integrated Bidding Strategy for Multi-Energy Systems under Uncertainties of Load and Energy Prices

Mehrdad Aghamohamadi¹, Amin Mahmoudi¹, John K. Ward², Megan Sleep¹, Mohammed H. Haque³ ¹Flinders University, Australia; ²CSIRO, Australia; ³University of South Australia, Australia

1069 | Multi-Terminal Soft Open Point with Anti-Islanding and Over-Current Protection Capability

Han Deng¹, Yang Qi², Jingyang Fang³, Vincent Debusschere⁴, Yi Tang¹ ¹Nanyang Technological University, Singapore; ²Northwestern Polytechnical University; ³University of Kaiserslautern, Germany; ⁴Grenoble Institute of Technology, France

1221 | Fault-Tolerant Distribution Network Enabled by Series Soft Open Point

Yang Qi¹, Han Deng², Yi Tang²

¹Northwestern Polytechnical University, China; ²Nanyang Technological University, Singapore

Session B05: Power Converter Utilization in Microgrids

1489 | Reactive Power Allocation of PV Inverters for Voltage Support in Power Systems Based on Transactive Energy Approach

Paychuda Kritprajun¹, Joshua C. Hambrick², Leon M. Tolbert¹, Yunting Liu¹, Jiaojiao Dong¹, Lin Zhu¹, Qihuan Dong¹, Kevin Schneider³

¹The The University of Tennessee Knoxville, United States; ²Oak Ridge National Laboratory, United States; ³Pacific Northwest National Laboratory, United States

1892 | Development of a Power Electronics-Based Testbed for a Flexible Combined Heat and Power System

Haiguo Li¹, Dingrui Li¹, Zihan Gao¹, Yiwei Ma¹, Zhe Yang¹, Jingxin Wang¹, Fred Wang^{1,2} ¹University of Tennessee Knoxville, United States; ²Oak Ridge National Laboratory, United States

1292 | Optimal Sizing of Grid-Tied Residential Microgrids under Real-Time Pricing

Rahmat Khezri¹, Amin Mahmoudi¹, Mohammad Hassan Khooban², Nesimi Ertugrul³ ¹Flinders University, Australia; ²Aarhus University, Denmark; ³University of Adelaide, Australia

1742 | Active and Reactive Power Distribution for Cascaded-H-Bridge Microinverters under Island Microgrid

Maohang Qiu, Mengxuan Wei, Shuai Yang, Xiaoyan Liu, Dong Cao University of Dayton, United States

2007 | Microgrid Light-Load Efficiency Improvement Based on Online-Inverter Detection

Ali Sheykhi, Nima Amouzegar Ashtiani, S. Ali Khajehoddin University of Alberta, Canada

2267 | Reliability/Cost-Based Power Routing in Power Electronic-Based Power Systems Saeed Peyghami, Frede Blaabjerg

Aalborg University, Denmark

1835 Quickest Detection of Series Arc Faults on DC Microgrids

Kaushik Gajula, Vu Le, Xiu Yao, Shaofeng Zou, Luis Herrera University at Buffalo, United States

Session B06: Smart Buildings and Energy Management Strategies

1051 A Novel Solar Harvesting Modular Wireless Sensor Mote for Green House Applications: Design & Implementation

Lingli Gong, Anshuman Sharma, Jordan Henry, Mohamed Youssef Ontario Tech University, Canada

1326 | Smart Microgrid Architecture for Home Energy Management System

Majed Shakir, Yevgen Biletskiy University of New Brunswick, Canada

1902 | Generalized Energy Storage Model-in-the-Loop Suitable for Energy Star and CTA-2045 Control Types

Huangjie Gong¹, Evan S. Jones¹, A.H.M. Jakaria², Aminul Huque², Ajit Renjit², Dan M. Ionel² ¹University of Kentucky, United States; ²Electric Power Research Institute, United States

2017 | A Dynamic Load Control Strategy for an Efficient Building Demand Response

Konrad Erich Kork Schmitt, Ilham Osman, Rabindra Bhatta, Mahtab Murshed, Manohar Chamana, Stephen Bayne *Texas Tech University, United States*

Texas Teen Oniversity, Onited States

2460 Control Architectures of Solar-Powered HVAC Systems: A DC-DC Converter's Perspective

Niraja Swaminathan, Bailey Sauter, Yue Cao Oregon State University, United States

2478 Distributed Optimal Scheduling in Community-Scale Microgrids

Maitreyee Marathe, Giri Venkataramanan University of Wisconsin Madison, United States

1401 | Energy Management and Optimal Planning of a Residential Microgrid with Time-of-Use Electricity Tariffs

Rahmat Khezri¹, Amin Mahmoudi¹, Mohammed H. Haque², Kaveh Khalilpour³ ¹Flinders University, Australia; ²University of South Australia, Australia; ³University of Technology Sydney, Australia

1714 Capacity Optimization and Optimal Placement of Battery Energy Storage System for Solar PV Integrated Power Network

Hassan I. Alhammad, Khalid A. Khan, Fahad Alismail, Muhammad Khalid King Fahd University of Petroleum and Minerals, Saudi Arabia

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1374 | Impedance Modeling and Analysis of Grid Side Sampling Modular Multilevel Converter

Bo Zhang¹, Xiong Du¹, Jingbo Zhao², Jiapei Zhou³, Cheng Qian¹, Chengmao Du¹ ¹Chongqing University, China; ²State Grid Jiangsu Electric Power Co., Ltd., China; ³Global Energy Interconnection Research Institute, China

1398 | Transient Modeling of Phase-Locked Loop and its Applications in a Multi-VSCs Grid-Connected System

Han Yan, Meng Huang, Xikun Fu, Yingjie Tang, Ju Sheng, Xiaoming Zha Wuhan University, China

1486 A New Impedance-Based Modeling and Stability Analysis Approach for Power Oscillations between Grid-Forming Inverters

Hanchao Liu, Zhe Chen, Maozhong Gong, Philip Hart, Yichao Zhang, Yukai Wang *GE Research, United States*

1142 Utilization of Local Phasor Measurements for Interarea-Oscillation Damping with Utility-Scale PV Plant

Mayur Basu, Jinho Kim, Robert M. Nelms, Eduard Muljadi Auburn University, United States

2336 | Frequency Selective Damping of Sub-Synchronous Oscillations for Grid-Forming Power Converters

Ngoc Bao Lai¹, Leonardo Marin², Andrés Tarrasó¹, Gregory N. Baltas¹, Pedro Rodriguez¹ ¹Luxembourg Institute of Science and Technology, Luxembourg; ²Universitat Politècnica de Catalunya, Spain

1228 | Extremum Seeking Control Based Resonant Frequency Estimation for a Grid-Tied Inverter with LCL Filter

Yuheng Wu¹, Mohammad Mahmud¹, Yue Zhao¹, Radha Krishna Moorthy², Madhu Sudhan Chinthavali² ¹University of Arkansas, United States; ²Oak Ridge National Laboratory, United States

2250 | Impedance Analysis of Voltage Source Converter Based on Voltage Modulated Matrix

Chao Wu¹, Xiaoling Xiong², Frede Blaabjerg¹ ¹Aalborg University, Denmark; ²North China Electric Power University, China

Session B08: Control of Distributed Resources and Microgrids

1249 Variable Step Size Modified Clipped Least Mean Square Adaptive Control for Power Quality Improvement for a Solar PV-BS Based Microgrid with Seamless Mode Transfer Capability Vivek Naravanan, Bhim Singh

Indian Institute of Technology Delhi, India

1909 | Secondary Voltage and Frequency Regulation for Grid Re-Synchronization in Microgrid with Unified Virtual Oscillator Controlled Multi-Port Converters

Md Rashed Hassan Bipu, M.A. Awal, Siye Cen, Salina Zabin, Mehnaz Akhter Khan, David Lubkeman, Iqbal Husain

North Carolina State University, United States

2184 Asymmetrical Voltage Support Control of Three-Phase Four-Wire Inverters with Zero Active Power Oscillation during Grid Faults

Jun Ge¹, Zhikang Shuai¹, Xia Shen¹, Yu Feng¹, Huimin Zhao¹, Yang Shen¹, Z. John Shen² ¹Hunan University, China; ²Illinois Institute of Technology, United States

2043 | Enhanced DC-Link Voltage Control in a Virtual Synchronous Generator-Based Buildingto-Building Grid considering Islanded Mode Operation

Mhret Berhe Gebremariam, Pablo Garcia Fernandez, Cristian Blanco Charro, Angel Navarro Rodríguez University of Oviedo, Spain

2190 | Control Strategy for Multiple Residential Solar PV Systems in Distribution Network with Improved Power Quality

Yashi Singh, Bhim Singh, Sukumar Mishra Indian Institute of Technology Delhi, India

1968 | Secant-Based Flexible Power Point Tracking Algorithm for Degraded Photovoltaic Systems

Anusha Kumaresan¹, Hossein Dehghani Tafti², Glen G. Farivar¹, Nandha Kumar Kandasamy³, Josep Pou¹ ¹Nanyang Technological University, Singapore; ²University of Western Australia, Australia; ³Singapore Institute of Technology, Singapore

2106 | Parameters Stability Region Analysis of Diesel Generation Forming Hybrid Islanded Microgrid with High Penetration of Renewable Energy

Xun Jiang¹, Meiqin Mao¹, Liuchen Chang¹, Peng Li², Yong Shi¹ ¹Hefei University of Technology, China; ²North China Electric Power University, China

Session B09: Control of Renewable Energy Resources

1404 An Improved Proportional Resonant Controller for Current Harmonics Reduction and Power Ripples Mitigation of Self-Synchronized Grid-Tied PV System under Distorted Grid Voltages

Manash Kumar Mishra, V.N. Lal Indian Institute of Technology (BHU), Varanasi, India

1653 Control of Solar PV-Battery System to Limit in PCC Voltage Rise and for Power Quality Improvement

Gaurav Modi, Bhim Singh, Yashi Singh Indian Institute of Technology Delhi, India

1978 Review of Control Methods in Grid-Connected PV and Energy Storage System

Md Safayatullah, Reza Rezaii, Mohamed Tamasas Elrais, Issa Batarseh University of Central Florida, United States

1219 A Virtual SVPWM Based Power Control Scheme for Multi-Port DC-AC Converters in PV-Battery Hybrid Systems

Jiangfeng Wang¹, Kai Sun², Yunwei Li¹ ¹University of Alberta, Canada; ²Tsinghua University, China

2145 Active Disturbance Rejection Control of Doubly-Fed Induction Generators Driven by Wind Turbines

Matthew Penne¹, Wei Qiao¹, Liyan Qu¹, Lizhi Qu¹, Renke Huang², Qiuhua Huang² ¹University of Nebraska Lincoln, United States; ²Pacific Northwest National Laboratory, United States

1257 A Per-Phase Power Controller allowing Smooth Transitions to Islanded Operation

Hossein Abedini, Tommaso Caldognetto, Paolo Mattavelli University of Padova, Italy

1605 An Improved Energy Hub Model for Physical Layer in Energy Router

Zilong Wang, Tong Liu, Wei Wang, Qicai Ren, Alian Chen Shandong University, China

Session B10: Control of Grid-Tied Inverters

1037 | Complex Power Control Method for Grid-Forming Inverter in $\alpha\beta$ -Domain

Ko Oue, Shunya Sano, Toshiji Kato, Kaoru Inoue Doshisha University, Japan

2417 | Lyapunov Energy Function Based Direct Power Control of Synchronverters under Unbalanced Grid Voltage Conditions

Vikram Roy Chowdhury, Deepak Divan Georgia Institute of Technology, United States

2361 | Resynchronization Strategy for a 200kVA Grid-Forming Power Converter

Andres Tarraso¹, Ngoc Bao Lai², Pedro Rodriguez² ¹Universitat Politècnica de Catalunya, Spain; ²Luxembourg Institute of Science and Technology, Luxembourg

1455 | Angle Droop Design for Grid-Forming Inverters considering Impacts of Virtual Impedance Control

Le Kong¹, Yaosuo Xue², Liang Qiao¹, Fred Wang^{1,2} ¹University of Tennessee Knoxville, United States; ²Oak Ridge National Laboratory, United States

2115 | Switched-Boost Common-Ground Five-Level (SBCG5L) Grid-Connected Inverter with Single-Stage Dynamic Voltage Boosting Concept

Reza Barzegarkhoo¹, Majid Farhangi¹, Ricardo P. Aguilera¹, Yam P. Siwakoti¹, Sze Sing Lee² ¹University of Technology Sydney, Australia; ²Newcastle University in Singapore, Singapore

1194 | An Enhanced Single-Phase Self-Tuning Filter Based Open-Loop Frequency Estimator for Weak Grid

Anant Kumar Vema¹, Hafiz Ahmed², Pedro Roncero-Sánchez³, Pradyumn Chaturvedi⁴ ¹National Institue of Technology Hamirpur, India; ²Bangor University, United Kingdom; ³Universidad de Castilla-La Mancha, Spain; ⁴Visvesvaraya National Institute of Technology, India

1410 | Direct Charge Control Method for Mixed Conduction Mode (DCM and TPCM) Grid-Connected Inverter

Pu Zhao, Qingxin Guan, Yu Zhang Huazhong University of Science and Technology, China

Session B11: Control of DC Microgrids

1939 Comparative Study of Coordinated Photovoltaic and Battery Control Strategies on the Battery Lifetime in Stand-Alone DC Microgrids

Hein Wai Yan¹, Glen G. Farivar¹, Neha Beniwal¹, Naga Brahmendra Yadav Gorla¹, Hossein Dehghani Tafti², Salvador Ceballos³, Josep Pou¹, Georgios Konstantinou⁴

¹Nanyang Technological University, Singapore; ²University of Western Australia, Australia; ³Basque Research and Technology Alliance, Spain; ⁴University of New South Wales, Australia

2029 | Model Predictive Control for Current Sharing and Voltage Balancing in DC Microgrids

Lalit Kishore Marepalli, Kaushik Gajula, Luis Herrera University at Buffalo, United States

1913 | Control Strategy for Effective Battery Utilization in a Stand-Alone DC Microgrid with Solar Energy

Hein Wai Yan¹, Glen G. Farivar¹, Neha Beniwal¹, Naga Brahmendra Yadav Gorla¹, Hossein Dehghani Tafti², Salvador Ceballos³, Josep Pou¹, Georgios Konstantinou⁴

¹Nanyang Technological University, Singapore; ²University of Western Australia, Australia; ³Basque Research and Technology Alliance, Spain; ⁴University of New South Wales, Australia

1026 | Distributed Linear State Observer (DLSO)-Based Distributed Secondary Control for DC Microgrids under False Signal Attacks

Yajie Jiang¹, Yun Yang², Siew-Chong Tan³, Shu-Yuen Ron Hui⁴ ¹The University of Hong Kong, China; ²The Hong Kong Polytechnic University, China; ³Nanyang Technological University, Singapore; ⁴Imperial College London, United Kingdom

1439 | The Impact of PV Arrays Disturbances on the Performance of Droop Controllers in a DC Microgrid

Niloofar Ghanbari, Subhashish Bhattacharya North Carolina State University, United States

2488 | Enhancing Distribution Grid Flexibility Using Active Power Distribution Node Converter Interfaces

Alvaro Cardoza, Alexis Kwasinski University of Pittsburgh, United States

2415 | Feedback Linearization Based Direct Power Control of a Three-Phase Grid-Connected Inverter with Online Parameter Update

Vikram Roy Chowdhury, Deepak Divan Georgia Institute of Technology, United States

Session B12: Microgrid Control

1919 Design Power Control Strategies of Grid-Forming Inverters for Microgrid Application

Jing Wang National Renewable Energy Laboratory, United States

2283 An Enhanced Control Strategy of Bidirectional Interlinking Converters in a Hybrid AC/DC Microgrid

Qipeng Zheng, Fei Gao Shanghai Jiao Tong University, China

2555 Coordination of Protection and Ride-Through Settings for Islanded Facility Microgrids

Mark Vygoder¹, Farzad Banihashemi¹, Jacob Gudex¹, Robert M. Cuzner¹, Giovanna Oriti² ¹University of Wisconsin Milwaukee, United States; ²Naval Postgraduate School, United States

1966 | Event-Triggered Self-Learning Control Scheme for Power Electronics Dominated Grid

Mohsen Hosseinzadehtaher, Amin Y. Fard, Mohammad B. Shadmand University of Illinois Chicago, United States

1795 Optimal Separation Method of Dynamic Microgrid Operation

Xuefei Zhu, Jinho Kim, Eduard Muljadi, R. Mark Nelms Auburn University, United States

2049 | Improved Delay Compensation in Communication-Based Hierarchical Control of a Low Voltage 3-Phase AC Microgrid Using a Secondary Control Based on Smith Predictor

Ángel Navarro-Rodríguez, Cristian Blanco, Pablo García, Mohammad Irfan Yousuf University of Oviedo, Spain

1789 Analysis of a Complex-Valued Droop Method in AC Microgrids with Complete Steady-State Frequency Compensation Using dq-Decomposition

Carlos Gómez-Aleixandre, Cristian Blanco, Andrés Suárez-González, Ángel Navarro-Rodríguez, Pablo García

University of Oviedo, Spain

Session B13: Solid State Transformers

1325 | Doubly-Fed Solid State Auto-Transformer (SSAT) Concept for Multi-Pulse Rectifiers

Farhana Islam, Harish S. Krishnamoorthy University of Houston, United States

2004 500kVA Hybrid Solid State Transformer (HSST): Modelling and Control

Sanjay Rajendran, Soumik Sen, Zhicheng Guo, Alex Q. Huang The University of Texas at Austin, United States

2397 | Design of Nanocrystalline Medium-Voltage Medium-Frequency Three-Phase Transformers for Grid-Connected Applications

Roderick Amir Gomez Jimenez¹, Germán G. Oggier², Roberto A. Fantino¹, Juan Carlos Balda¹, Yue Zhao¹ ¹Unviersity of Arkansas, United States; ²Universidad Nacional de Río Cuarto, Argentina

2556 | Insulation Design on High-Frequency Transformer for Solid-State Transformer

Zheqing Li, Yi-Hsun Hsieh, Qiang Li, Fred C. Lee, Chunyang Zhao Virginia Polytechnic Institute and State University, United States

2569 Virtual Prototyping Process for Assessment of Medium Voltage Grid-Connected Solid State Transformer Implementations

Rounak Siddaiah¹, Mark Vygoder¹, Robert M. Cuzner¹, Juan C. Ordonez², Mauricio B. Chagas² ¹University of Wisconsin Milwaukee, United States; ²Florida State University, United States

1721 | Design Considerations for a 50 kW Dual Bridge Series Resonant DC/DC Converter with Wide-Input Voltage Range for Solid-State Transformers

Pramod Apte¹, Siqi Lin¹, Lukas Fraeger², Jens Friebe¹ ¹Leibniz Universität Hannover, Germany; ²BLOCK Transformatoren-Elektronik GmbH, Germany

1574 | Enhanced CurrenT-Type P-HIL Interface Algorithm for Smart Transformers Testing

Sante Pugliese¹, Marco Liserre¹, Giovanni De Carne² ¹Christian-Albrechts-Universität zu Kiel, Germany; ²Karlsruhe Institute of Technology, Germany

Session B14: Power Converters for Distributed Resources and Microgrids

2086 | A New Common-Ground Switched-Boost Five-Level Inverter Suitable for Both Single and Three-Phase Grid-Tied Applications

Reza Barzegarkhoo, Yam P. Siwakoti, Ricardo P. Aguilera University of Technology Sydney, Australia

1971 | Design and Development of a Multi-Port Converter for Marine Microgrid Applications

Md Rifat Kaisar Rachi, Siye Cen, Md Rashed Hassan Bipu, Mehnaz Akhter Khan, Iqbal Husain North Carolina State University, United States

1387 | Multi-Port DC-DC Converter for Interconnecting Bipolar DC Buses of Bipolar DC Distribution System

Jun-Young Lee, Jee-Hoon Jung Ulsan National Institute of Science and Technology, Korea

2438 A Multiport DC Transformer to Enable Flexible Scalable DC as a Service

Mickael J. Mauger, Vikram Roy Chowdhury, Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

1518 | A Transformerless Bidirectional Charger for Light Electric Vehicles

Jitendra Gupta, Bhim Singh, Muhammad Zarkab Farooqi Indian Institue of Technology Delhi, India

2452 | Design Considerations of Three Phase Active Front End Converter for 13.8 kV Asynchronous Microgrid Power Conditioning System enabled by Series Connection of Gen-3 10 kV SiC MOSFETs

Nithin Kolli, Sanket Parashar, Raj Kumar Kokkonda, Anup Anurag, Ashish Kumar, Subhashish Bhattacharya, Victor Veliadis North Carolina State University, United States

1016 | Design of the Hybrid Flexible Power Supply System for AC Electric Arc Furnace

Chongbin Zhao, Qirong Jiang Tsinghua University, China

1624 An Ultra-Low Weight Bidirectional Back end PFC Topology

Alex Sanchez, Asier Garcia-Bediaga, Itziar Alzuguren, Iñigo Zubitur, Alejandro Rujas Ikerlan Technology Research Centre (BRTA), Spain

Session B15: High Power, Power Electronic Systems for Utility Applications

1911 | Solid State Transformers as Enhanced Smart Inverters for Power Quality Improvement in Active Distribution Networks

Javad Khodabakhsh, Gerry Moschopoulos Western University, Canada

1044 | Continuous Operation of Wind Power Plants under DC Line Faults in Multi-Circuit HVDC Transmission System

Mitsuyoshi Enomoto¹, Kenichiro Sano¹, Junya Kanno², Junichi Fukushima² ¹Tokyo Institute of Technology, Japan; ²Tokyo Electric Power Company Holdings, Japan

2090 | A New Delta Hybrid Series STATCOM and DC Capacitor Voltage Balance Using Zero-Sequence Current

Ibhan Chand Rath, Anshuman Shukla Indian Institute of Technology Bombay, India

2291 Inductive Operation of the Low-Capacitance StatCom Using Modular Filter Inductor

Glen G. Farivar¹, Christopher D. Townsend², Hossein Dehghani Tafti², Ezequiel Rodriguez¹, Josep Pou¹, Branislav Hredzak³ ¹Nanyang Technological University, Singapore; ²University of Western Australia, Australia; ³University of New South Wales, Australia

1083 | A Bipolar Hybrid Circuit Breaker for Low-Voltage DC Circuits

Sudipta Sen¹, Shahab Mehraeen¹, Keyue Smedley² ¹Louisiana State University, United States; ²University of California Irvine, United States

1090 | Symmetries in Power Electronics

Jingyang Fang, Stefan M. Goetz Duke University, United States

Session B16: Hybrid Transformers

1121 | Magnetic Integration and Modeling of Hybrid Distribution Transformer

Yibin Liu, Deliang Liang, Yhheng Wang, Lishi Zhang, Dawei Li, Yachen Gao, Zihao Wu, Chenxi Wang, Lutian Tang

Xian Jiaotong University, China

1255 | Multiple Protection Strategies for Hybrid Distribution Transformer Based on DC-Link Voltage Fault-Tolerant Control

Lishi Zhang, Deliang Liang, Qidong Wen, Hua Liu, Yibin Liu, Yachen Gao, Zihao Wu, Chenxi Wang, Lutian Tang

¹Xi'an Jiaotong University, China; ²State Grid Shaanxi Electric Power Research Institute, China

2287 Autonomous Fail-Normal Switch for Hybrid Transformers

Emre Durna, Joseph Benzaquen, Rajendra Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

1619 | Active Transformer Functionalities including an Energy Storage System

Jose David Vidal Leon¹, Andres Tarraso¹, Jose Ignacio Candela¹, Pedro Rodriguez² ¹Polytechnic University of Catalonia, Spain; ²Luxembourg Institute of Science and Technology, Luxembourg

1118 | Hybrid Smart Transformer for Enhanced Power System Protection Against DC with Advanced Grid Support

Moazzam Nazir¹, Johan H. Enslin¹, Klaehn Burkes² ¹Clemson University, United States; ²Savannah River National Laboratory, United States

Topic C: Big Data, Machine Learning, Cyber Security and Design Automation

Session C01: Big Data, Machine Learning, Cyber Security

2480 | Intelligent Anomaly Mitigation in Cyber-Physical Inverter-Based Systems

Asad Ali Khan¹, Sara Ahmed¹, Omar A. Beg² ¹University of Texas San Antonio, United States; ²University of Texas Permian Basin, United States

2084 | Blockchain-Enabled Security Module for Transforming Conventional Inverters toward Firmware Security-Enhanced Smart Inverters

Bohyun Ahn, Gomanth Bere, Seerin Ahmad, Jinchun Choi, Taesic Kim, Sung-won Park Texas A&M University Kingsville, United States

1150 | Load Power Estimation Using a Recurrent Neural Network for the Purpose of Computer Power Energy Efficiency Improvement

Shinichi Kawaguchi Kanagawa Institute of Technology, Japan

2095 | Real-Time Implementation of GPU-Accelerated Neural Network Learning for Dynamic System Identification

Nicholas Autobee, Amanda Rowsell, Patrick Bales-Parks, Jae-Do Park University of Colorado Denver, United States

Session C02: Artificial Intelligence and Machine Learning

1371 Efficient-ArcNet: Series AC Arc Fault Detection Using Lightweight Convolutional Neural Network

Kamal Chandra Paul¹, Tiefu Zhao¹, Chen Chen², Yunsheng Ban³, Yao Wang³ ¹University of North Carolina Charlotte, United States; ²University of Central Florida, United States; ³Hebei University of Technology, China

1940 | Real-Time DC Pulsed Power Load Monitoring Using Simplified k-NN Algorithm

Yue Ma¹, Atif Maqsood², Damian Oslebo³, Keith Corzine¹ ¹University of California Santa Cruz, United States; ²Dynapower Company, LLC, United States; ³Naval Sea Systems Command, United States

2224 | Intelligent Prediction of States in Multi-Port Autonomous Reconfigurable Solar Power Plant (MARS)

Suman Debnath, Shruti Kulkarni, Catherine Schuman Oak Ridge National Laboratory, United States

2474 | Detection of Stator Fault in Synchronous Reluctance Machines Using Shallow Neural Network

Siwan Shachin Narayan¹, Rahul R. Kumar¹, Giansalvo Cirrincione², Maurizio Cirrincione¹ ¹The University of the South Pacific, Fiji; ²University of Picardy Jule Verne, France

1683 A Machine Learning Based Method to Efficiently Analyze the Cogging Torque under Manufacturing Tolerances

Andrea Reales¹, Werner Jara¹, Gabriel Hermosilla¹, Carlos Madariaga², Juan Tapia², Gerd Bramerdorfer³ ¹Pontificia Universidad Católica de Valparaiso, Chile; ²Universidad de Concepcion, Chile; ³Johannes Kepler University Linz, Austria

Session C03: Other Topics in Big Data, Machine Learning, Cyber Security and Design Automation

1702 | Fast and Accurate Inductance Extraction for Power Module Layout Optimization Using Loop-Based Method

Quang Le, Imam Al Razi, Yarui Peng, H. Alan Mantooth University of Arkansas, United States

2554 On the Explainability of Black Box Data-Driven Controllers for Power Electronic Converters

Subham Sahoo, Huai Wang, Frede Blaabjerg Aalborg University, Denmark

1346 Using Machine Learning Technology to Online Predict the Maximum Common Mode Current of Three-Phase Motor Drive Inverter

Ximu Zhang¹, Yang Huang¹, Jared Walden¹, Hua Bai¹, Fanning Jin², Xiaodong Shi², Bing Cheng² ¹University of Tennessee Knoxville, United States; ²Mercedes-Benz R&D North America, Inc., United States

Session C04: Data Analysis for Batteries and Energy Storage

1528 Comparative Analysis on the Electrical State-of-Health Degradation of 21700 LiNiCoAlO2 Based on Alternating and Direct Currents

Bongwoo Kwak¹, Myungbok Kim¹, Jonghoon Kim² ¹Korea Institute of Industrial Technology, Korea; ²Chungnam National University, Korea

2292 Artificial Intelligence-Based Hardware Fault Detection for Battery Balancing Circuits

Kyoung-Tak Kim¹, Hyun-Jun Lee¹, Joung-hu Park¹, Gomanth Bere², Justin J. Ochoa², Taesic Kim² ¹Soongsil University, Korea; ²Texas A&M University Kingsville, United States

1882 | Fast and Robust Estimation of Lithium-Ion Batteries State of Health Using Ensemble Learning

Xin Sui, Shan He, Soren Byg Vilsen, Remus Teodorescu, Daniel-Ioan Stroe Aalborg University, Denmark

2396 | Lifetime Modeling and Analysis of Aqueous Organic Redox-Flow Batteries for Renewable Energy Application

Zhongting Tang¹, Ariya Sangwongwanich¹, Yongheng Yang², Charlotte Overgaard Wilhelmsen¹, Sebastian Birkedal Kristensen¹, Jens Laurids Sørensen¹, Jens Muff¹, Frede Blaabjerg¹ ¹Aalborg University, Denmark; ²Zhejiang University, China

1513 | A Bidirectional Cell-to-Buffer Battery Equalizer at Boundary Conduction Mode with Constant On-Time Control

Yiqing Lu, Zhengqi Wei, Haoyu Wang ShanghaiTech University, China

Session C05: Cyber Security and Cyber Attacks

1356 Model-Based Cyber-Attack Detection for Voltage Source Converters in Island Microgrids

Jinan Zhang, Jin Ye, Lulu Guo University of Georgia, United States

1865 | Detection and Mitigation of Cyber-Attacks against Power Measurement Channels Using LSTM Neural Networks

Mitchell Wilson, Hisham Mahmood, Joseph Giordano Florida Polytechnic University, United States

1737 | Stability Investigation of Cooperative Controlled DC Microgrid under Stealth Cyber Attacks

Minrui Leng¹, Subham Sahoo², Frede Blaabjerg² ¹Sichuan University, China; ²Aalborg University, Denmark

1917 | An Active Detection Scheme for Sensor Spoofing in Grid-Tied PV Systems

Hasan Ibrahim, Jorge Ramos-Ruiz, Jaewon Kim, Woo Hyun Ko, Tong Huang, Prasad Enjeti, P.R. Kumar, Le Xie

Texas A&M University, United States

1286 | A Resilient Scheme for Mitigating False Data Injection Attacks in Distributed DC Microgrids

Jingqiu Zhang¹, Gurupraanesh Raman¹, Gururaghav Raman¹, Jimmy Chih-Hsien Peng¹, Weidong Xiao² ¹National University of Singapore, Singapore; ²The University of Sydney, Australia

Topic D: Transportation Electrification Applications

Session D01: Electric Drivetrains

1195 | Rule-Based Energy Management Strategy of a Power-Split Hybrid Electric Vehicle with LSTM Network Prediction Model

Helia Jamali, Yue Wang, Yuhang Yang, Saeid Habibi, Ali Emadi McMaster University, Canada

2171 | Reconfigurable Cascaded Multilevel Converter: A New Topology for EV Powertrain

Giulia Tresca¹, Riccardo Leuzzi¹, Andrea Formentini², Luca Rovere³, Norma Anglani¹, Pericle Zanchetta^{1,3} ¹Università di Pavia, Italy; ²University of Genoa, Italy; ³University of Nottingham, United Kingdom

1239 | Electromagnetic and Direct-Cooling Analysis of a Traction Motor

John Wanjiku¹, Lan Ge², Zhiyuan Zhang², Kang Chang², Chengtao Wu², Fuliang Zhan² ¹Siemens Digital Industries Software, Canada; ²Siemens Digital Industries Software, China

1297 | A Composite Converter with Reduced Power Electronics for Electric Powertrain Applications

Xiaokang Zhang, Jean-Yves Gauthier, Xuefang Lin-Shi INSA-Lyon, France

2322 | Impact of Current Profiling for NVH Mitigation on Switched Reluctance Machine Drive Accessories

Shuvajit Das¹, Anik Chowdhury¹, Md Ehsanul Haque¹, Md Tawhid Bin Tarek¹, Yilmaz Sozer¹, David Colavincenzo², Fernando Venegas², Jeffrey Geither² ¹The University of Akron, United States; ²Bendix Commercial Vehicle Systems, United States

Session D02: Battery Management Systems for Transportation

1174 | Model-Based Design Methodology for Capacitor-Based Equalization Circuits

Francesco Porpora¹, Mauro Di Monaco¹, Giuseppe Tomasso¹, Matilde D'Arpino² ¹University of Cassino and Southern Lazio, Italy; ²The Ohio State University, United States

2389 | Predictive Battery SoC Control for Dual Propulsion Differential Four Wheel Drive Electric Vehicle

Utkal Ranjan Muduli¹, Khaled Al Jaafari¹, Ranjan Kumar Behera², Abdul R. Beig¹, Khalifa Al Hosani¹, Jamal Y. Alsawalhi¹

¹Khalifa University, United Arab Emirates; ²Indian Institute of Technology Patna, India

1768 | A New Design Optimization Method for Dynamic Inductive Power Transfer Systems utilizing a Neural Network

Shuntaro Inoue, Reebal Nimri, Abhilash Kamineni, Regan Zane Utah State University, United States

1498 | A High-Density 5kW 800V to 48V DC/DC Converter for Vehicle Applications

Xinyuan Du¹, Fei Diao¹, Yue Zhao¹, Kevin Uvodich², Nenad Miljkovic² ¹University of Arkansas, United States; ²University of Illinois at Urbana-Champaign, United States

Session D03: Charging Techniques for Transportation

2028 | A Lightweight Multilevel Power Converter for Electric Aircraft Drivetrain

Samantha Coday, Nathan Ellis, Zitao Liao, Robert C.N. Pilawa-Podgurski University of California Berkeley, United States

2507 | Electrical Insulation Design and Qualification of a SiC-Based Generator-Rectifier Unit (GRU) for High-Altitude Operation

Lakshmi Ravi¹, Jiewen Hu¹, Xingchen Zhao¹, Dong Dong¹, Rolando Burgos¹, Sriram Chandrasekaran², Saeed Alipour², Richard Eddins³

¹Virginia Polytechnic Institute and State University, United States; ²Raytheon Technologies, United States; ³GE Aviation, United States

1049 A New Multilevel Inverter under Distributed Unbalance DC Voltage for Electric Vehicle Applications

Mohammad Bhuiya, Lingli Gong, Mohamed Z. Youssef Ontario Tech University, Canada

2021 | Open Device Fault Detection and Fail Safe Action Strategy for a Premium Class Electric Vehicle with a Dual Inverter fed Open Winding Motor

Hiroaki Matsumori¹, Yuto Maeda¹, Takashi Kosaka¹, Nobuyuki Matsui¹, Hiroki Iwai², Teppei Tsuda², Subrata Saha²

¹Nagoya Institute of Technology, Japan; ²Aisin Corporation, Japan

Session D04: Transportation Electrification – 1

2501 A Novel Buck-Boost Type DC-DC Converter Topology for Electric Vehicle Applications

Mohammad Saleh Khan¹, Soumya Shubhra Nag¹, Anandarup Das¹, Changwoo Yoon² ¹Indian Institute of Technology Delhi, India; ²Seoul National University of Science and Technology, Korea

1614 Development of an Engine Starter Generator and Implementation of a Power Efficient Starting Procedure

Lukas Killingseder¹, Wolfgang Gruber², Alexander Burgstaller¹, Martin Freudenthaler¹ ¹BRP-Rotax GmbH & Co. KG, Austria; ²Johannes Kepler University Linz, Austria

1170 Influence of the HV DC Bus Impedance on the Current Ripple Distribution in Electric Vehicles

Michael Schlüter, Marius Gentejohann, Sibylle Dieckerhoff Technische Universität Berlin, Germany

1568 | A Real-Time Operational Cost Minimization Strategy for Energy Management of Fuel Cell Electric Vehicles

Chao Jia, Junwei Cui, Wei Qiao, Liyan Qu University of Nebraska Lincoln, United States

1509 Design and Analysis of a Flexible Multi-Output Wireless Power Transfer System with Variable Inductor

Jin Zhao, Yonglin Zhang, Liang Qi Jiangsu University of Science and Technology, China

1352 Analysis and Mitigation of Oscillations in Inductive Power Transfer Systems with Constant Voltage Load and Pulse Density Modulation

Jiayu Zhou¹, Giuseppe Guidi², Kjell Ljokelsoy², Jon Are Suul^{1,2} ¹Norwegian University of Science and Technology, Norway; ²SINTEF Energy Research, Norway

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2311 | Low-Frequency Oscillations Analysis in AC Railway Networks Using Eigenmode Identification

Paul Frutos¹, Juan Manuel Guerrero¹, Iker Muniategui², Iban Vicente², Aitor Endemano², Fernando Briz¹ ¹University of Oviedo, Spain; ²Ingeteam SA, Spain

1303 | Impedance Based Design Method for Interoperable Wireless Power Transfer Systems

Denis Kraus¹, Marius Hassler¹, Grant Covic², Hans-Georg Herzog¹ ¹Technical University of Munich, Germany; ²The University of Auckland, New Zealand

Session D05: Transportation Electrification – 2

1738 | Development of a Fuel Cell Hybrid Electric Vertical Takeoff and Landing Aircraft Power Train

Mengxuan Wei¹, Maohang Qiu¹, Shuai Yang¹, Xiaoyan Liu¹, Jeff Taylor², Dong Cao¹ ¹University of Dayton, United States; ²Event 38 Unmanned Systems, United States

2352 | Phase Collaborative Interleaving Method to Reduce DC-Link Current Ripple in Switched Reluctance Machine Drive

Md Ehsanul Haque¹, Anik Chowdhury¹, Shuvajit Das¹, Yilmaz Sozer¹, Fernando Venegas², David Colavincenzo²

¹The University of Akron, United States; ²Bendix Commercial Vehicle Systems, United States

2509 Comparison of Medium-Voltage High-Frequency Power Inverters for Aircraft Propulsion Drives

Majid T. Fard, JiangBiao He University of Kentucky, United States

2314 | Mechanical Performance of Transverse Flux Machines at High Speeds of Operation

Shuvajit Das¹, Anik Chowdhury¹, Teppei Tsuda², Naoto Saito², Subrata Saha², Yilmaz Sozer¹ ¹The University of Akron, United States; ²Aisin Corporation, Japan

1972 | Multilevel Traction Converter Topology with Medium Frequency Isolation

Bishwajyoti Purkayastha, Tanmoy Bhattacharya Indian Institute of Technology Kharagpur, India

Session D06: Transportation Electrification – 3

1501 | Load Management Strategy for DC Fast Charging Stations

Sony Susan Varghese¹, Geza Joos¹, Syed Qaseem Ali² ¹McGill University, Canada; ²OPAL-RT Technologies, Inc., Canada

2328 | Position Fault Detection and Failover Method for UAM PMSM Control

Taeyoen Lee¹, Heekwang Lee², Bonkil Koo¹, Kwanghee Nam¹ ¹Pohang University of Science and Technology, Korea; ²Hyundai Motor Company, Korea

2430 | Fleet Speed Profile Optimization for Autonomous and Connected Vehicles

Mohammad Arifur Rahman, Md Ehsanul Haque, Yilmaz Sozer, Ali Riza Ozdemir The University of Akron, United States

1247 Design Methodology for a Transformerless Multilevel Inductive Power Transfer System

Jaehong Lee¹, Myung-Yong Kim², Seung-Hwan Lee¹ ¹University of Seoul, Korea; ²Korea Railroad Research Institute, Korea

1013 Current Balancing of a Multi-Phase Inverter for Wireless Power Transfer Systems Based on Mutually Negatively Coupled Inductors

Yiming Zhang¹, Yuanchao Wu¹, Shuxin Chen², Xin Li², Yi Tang² ¹Fuzhou University, China; ²Nanyang Technological University, Singapore

Session D07: Electric Vehicle Charging

2344 | Efficiency of Motor and Inverter Reconfigured as a Boost-Buck Connected Integrated BEV Charger

Erik Hoevenaars¹, Marc Hiller² ¹Robert Bosch GmbH, Germany; ²Karlsruhe Institute of Technology, Germany

1716 | Analysis and Design of a Multiport Converter Based Integrated On-Board Charger for Electric Vehicle Powertrains

Arka Basu, Subhajyoti Mukherjee Indian Institute of Technology Bhubaneswar, India

1730 Input Power Quality Control of Integrated On-Board Charger with Reduced DC-Link Capacitance

Muhammad Zarkab, Bhim Singh, B.K. Panigrahi Indian Institute of Technology Delhi, India

1347 A Flexible Resonant Converter Based Battery Charger with Power Relays

Yuqi Wei, Alan Mantooth University of Arkansas, United States

1725 A Two-Stage Standard On-Board Electric Vehicle Charger with Minimum Switch Count

Soumya Ranjan Meher, Rajeev Kumar Singh Indian Institute of Technology (BHU), Varanasi, India

Session D08: EV Battery Management - 1

1107 | A Battery Capacity Estimation Method Using Surface Temperature Change under Constant-Current Charge Scenario

Jufeng Yang¹, Yingfeng Cai¹, Chris Mi² ¹Jiangsu University, China; ²San Diego State University, United States

1288 | DAB Converter with Trapezoidal Wave Heating Capability for Lithium-Ion Battery of Electric Vehicles

Yuta Sasama, Masatoshi Uno Ibaraki University, Japan

1632 | Stress-Constrained Fast Charging of Lithium-Ion Battery with Predictive Control

Hao Zhong, Hongwen He, Zhongbao Wei Beijing Institute of Technology, China

1108 | State-of-Health Estimation for Lithium Iron Phosphate Batteries Based on Constant-Voltage Charge Data Using a Resistor-Inductor Network Based Equivalent Circuit Model

Jufeng Yang¹, Yingfeng Cai¹, Chris Mi² ¹Jiangsu University, China; ²San Diego State University, United States

Session D09: EV Battery Management – 2

1554 | Multi-State Fusion Based Internal Short Circuit Fault Diagnostic for Lithium-Ion Battery Jian Hu, Zhongbao Wei, Hongwen He

Beijing Institute of Technology, China

1039 | Parameter Identification of Lithium Battery Thermal Model Based on Two-Stage Forgetting Factor Least Square Method

Marui Li¹, Chaoyu Dong^{1,2}, Yunfei Mu¹, Xiaohong Dong³, Jingming Cao¹, Hongjie Jia¹ ¹Tianjin University, China; ²Imperial College London, United Kingdom; ³Hebei University, China

1727 | The Effect of Pulsed Current on the Lifetime of Lithium-Ion Batteries

Xinrong Huang¹, Siyu Jin¹, Jinhao Meng², Remus Teodorescu¹, Daniel-Ioan Stroe¹ ¹Aalborg University, Denmark; ²University of Electronic Science and Technology of China, China

2175 | Sorting Selection Balancing Control for the Modular Multilevel DC/DC Converter in Battery Swapping Stations

Zhan Ma¹, Xiuqing Yi², Wei Li¹, Feng Gao¹, Fujia Yu³ ¹Shandong University, China; ²Shandong University of Traditional Chinese Medicine, China; ³State Grid Binzhou Power Supply Company, China

Topic E: Power Converter Topologies

Session E01: DC-DC Non-Isolated -1

2033 | Modified Split-Phase Switching with Improved Fly Capacitor Utilization in a 48V-to-POL Dual Inductor Hybrid-Dickson Converter

Nathan M. Ellis, Robert C.N. Pilawa-Podgurski University of California Berkeley, United States

2504 | A Comparative Study of SiC JFET Super-Cascode Topologies

Lee Gill, Luciano A. Garcia Rodriguez, Jacob Mueller, Jason Neely Sandia National Laboratories, United States

1692 Non-Isolated DC-DC Converter Implementations Based on Piezoelectric Transformers

Elaine Ng, Jessica D. Boles, Jeffrey H. Lang, David J. Perreault Massachusetts Institute of Technology, United States

1134 | A Single-Switch Capacitor Clamped Non-Resonant Linear Soft-Switching DC-DC Converter

Yangbin Zeng, Hong Li, Haitao Du, Zhidong Qiu, Ziqi Chen Beijing Jiaotong University, China

1433 Voltage Gain Control of a Switched-Resonator Converter Based on the 2:1 Switched-Capacitor Cell

Dulika Nayanasiri, Yunwei Li University of Alberta, Canada

Session E02: DC-DC Isolated -1

2321 | Current Reduction by Tuning Split Ratio for a Three-Phase LLC Resonant Converter with Split Resonant Capacitors

Kazuto Takagi, Yuuki Aoyagi, Akiteru Chiba GS Yuasa Infrastructure Systems Co., Ltd., Japan

1761 | Design Optimization of PCB-Winding Matrix Transformer for 400V/12V Unregulated LLC Converter

Pranav Raj Prakash, Ahmed Nabih, Qiang Li Virginia Polytechnic Institute and State University, United States

1129 | Analytical Model of the Current Stress in Active-Bridge Active-Clamp Converter for More Electric Aircraft

Alejandro Fernandez-Hernandez¹, Asier Garcia-Bediaga¹, Irma Villar¹, Gonzalo Abad² ¹Ikerlan Technology Research Centre (BRTA), Spain; ²Mondragon Unibertsitatea, Spain

1765 | Bidirectional Resonant Frequency Tracking for CLLC Converters Based on Voltage Falling Edges

Jun Min, Martin Ordonez The University of British Columbia, Canada

1163 | Controller-in-the-Loop of a Transformer Saturation Control for High-Power Three-Phase Dual-Active Bridge DC-DC Converters

Johannes Voss, Raphael Mencher, Philipp Joebges, Jan Mathé, Rik W. De Doncker *RWTH Aachen University, Germany*

Session E03: DC-DC Isolated – 2

1711 A Modified Soft-Switched Push-Pull Topology with Phase-Shift Modulation

Mandeep Singh Rana, Santanu K. Mishra, Hitesh Kumar Indian Institute of Technology Kanpur, India

1474 | Low-Profile and High-Efficiency 3 kW 400 V-48 V LLC Converter with a Matrix

of Four Transformers and Inductors for 48V Power Architecture for Data Centers Ahmed Nabih, Qiang Li

Virginia Polytechnic Institute and State University, United States

2442 | Time-Domain Analysis of a Low Q Three-Phase Series Resonant Converter Abirami Kalathy, Majid Pahlevani, Praveen Jain

Queen's University, Canada

1849 | Optimized Synchronous Operation of Active-Clamp Bidirectional Flyback Based on GaN Devices for a Multi-Cell Multi-Port Structure

Asier Garcia-Bediaga, Ander Avila, Itziar Alzuguren, Alejandro Rujas Ikerlan Technology Research Centre (BRTA), Spain

1984 | Control Strategies for Complete Soft-Switching of ICN Converters Mausamjeet Khatua, Khurram K. Afridi

Cornell University, United States

Session E04: AC-DC Single Phase Converters – 1

1241 A Four-Phase 5 kW Interleaved Totem-Pole PFC Platform Based on SiC FETs and Controlled by SA4041 Digital Power Processor

Gabriel Scarlatescu, Tanya Kirilova Gachovska, Tudor Lipan Solantro Semiconductors Corp., Canada

2008 | A CCM Bridgeless Single-Stage Soft-Switching AC-DC Converter for EV Charging Application

Peyman Amiri¹, Wilson Eberle¹, Deepak Gautam², Chris Botting² ¹The University of British Columbia, Canada; ²Delta-Q Technologies Inc., Canada

1970 An Interleaved Bridgeless AC/DC Stacked SiC Switches Based LLC Converter with Semi-Active Rectifiers for EV High Voltage Battery Systems

Mehdi Abbasi, John Lam York University, Canada

1126 Power Decoupling Method Using Input Filters in a Matrix Converter for Isolated AC-DC Converters Fed by Single- or Three-Phase Supply

Wataru Kodaka, Satoshi Ogasawara, Koji Orikawa Hokkaido University, Japan

Session E05: AC-DC and DC-AC Topologies and Control

2014 A Truly Universal Bridgeless Single-Stage Soft-Switching AC/DC Converter for EV On-Board Charging Application

Peyman Amiri¹, Wilson Eberle¹, Deepak Gautam², Chris Botting² ¹The University of British Columbia, Canada; ²Delta-Q Technologies Inc., Canada

2401 A Multiport Converter for More Electric Aircraft with Hybrid AC-DC Electric Power System

Javad Khodabakhsh, Gerry Moschopoulos Western University, Canada

2557 A MHz LLC Converter Based Single-Stage Soft-Switching Isolated Inverter with Hybrid Modulation Method

Hao Wen¹, Dong Jiao¹, Jih-Sheng Lai¹, Johan Strydom², Bing Lu² ¹Virginia Polytechnic Institute and State University, United States; ²Texas Instrument, United States

1959 | RF Band PWM Generator with High Efficiency and Wide-B and Control

Tomohiro Yoneyama, Yu Hosoyamada, Shohei Kobayashi, Itsuo Yuzurihara *Kyosan Electric Mfg. Co., Ltd., Japan*

Session E06: DC-AC Multiphase Converters

2528 | Model Predictive Control of a Double Stage AC-DC Converter for Grid-Interface of Vanadium Flow Batteries

Savatore Riccardo Di Salvo¹, Matteo Bulzi¹, Jacopo Riccio², Riccardo Leuzzi¹, Pericle Zanchetta¹, Norma Anglani¹ ¹University of Pavia, Italy; ²University of Nottingham, United Kingdom

1555 Volume Comparison of Passive Components for Hard-Switching Current- and Voltage-Source-Inverters

Benedikt Riegler, Annette Mütze Graz University of Technology, Austria

1740 | Bidirectional DC-AC Converter Using a High-Frequency Transformer with Multi-Frequency Decoupled Power Control

Juan Zuniga, Marius Takongmo, Chatumal Perera, Vishwa Perera, John Salmon University of Alberta, Canada

1728 A Hybrid Active Neutral Point Clamped Converter Consisting of Si IGBTs and GaN HEMTs for Auxiliary Systems of Electric Aircraft

Leon Fauth^{1,2}, Christian Beckemeier^{1,2}, Jens Friebe^{1,2} ¹Technische Universität Braunschweig, Germany; ²Leibniz Universität Hannover, Germany

Session E07: Multilevel Converters – In Memory of Prof. Akira Nabae

2123 Adaptive High-Frequency Injection and Control Loops Design for Flying Capacitor Passive Cross-Connected Modular Multilevel Converter Based Drive Systems

Massimiliano Biason, Riccardo Breda, Mattia Iurich, Simone Mazzer, Roberto Petrella University of Udine, Italy

1359 | Capacitor Voltage Ripple Suppression of the Switched Capacitor Modular Multilevel Converter

Qichen Yang¹, Robson Bauwelz Gonzatti^{1,2}, Hamed Pourgharibshahi¹, Fang Peng¹ ¹Florida State University, United States; ²Federal University of Itajuba, Brazil

2475 | A Hybrid Binary Multilevel Cascaded Inverter for Medium-Voltage Applications

Jih-Sheng Lai¹, Bryan Gutierrez¹, Moonhyun Lee², Chih-Shen Yeh³, Hao Wen¹, Dong Jiao¹, Zhengming Hou¹, Hsinche Hsieh¹

¹Virginia Polytechnic Institute and State University, United States; ²Rivian, United States; ³Transphorm, United States

1875 | Enhanced Interleaved PWM Scheme with Flux Compensation for Three-Parallel Connected Inverters

Chenhui Zhang, Marius Takongmo, John Salmon University of Alberta, Canada

1828 | A Multi-Level Active Power Filter for Common-Mode Voltage Attenuation in Multi-Level Inverters

Dongwoo Han¹, Fang Z. Peng¹, Suman Dwari² ¹Florida State University, United States; ²Raytheon Technologies Research Center, United States

Session E08: DC-DC Non-Isolated – 2

2374 | A 48-to-12 V Cascaded Multi-Resonant Switched Capacitor Converter with 4700 W/in3 Power Density and 98.9% Efficiency

Ting Ge, Zichao Ye, Robert C.N. Pilawa-Podgurski University of California Berkeley, United States

2286 | A Transformerless Composite Step-Down DC-DC Converter with Wide Input Voltage Range

Satyaki Mukherjee, Dragan Maksimović University of Colorado Boulder, United States

1330 A Multi-Phase Cascaded Series-Parallel (CaSP) Hybrid Converter for Direct 48 V to Point-of-Load Applications

Yicheng Zhu, Zichao Ye, Ting Ge, Rose Abramson, Robert C.N. Pilawa-Podgurski University of California Berkeley, United States

2218 | High-Efficiency Operation of a Bidirectional Non-Isolated DC-DC Converter Based on Flying-Capacitor Converters

Kazuaki Tesaki, Makoto Hagiwara Tokyo Institute of Technology, Japan

1747 A 92.7%-Efficiency 30A 48V-to-1V Dual-Path Hybrid Dickson Converter for PoL Applications

Chen Chen, Jin Liu, Hoi Lee The University of Texas at Dallas, United States

1868 A Merged H-Bridge Based Switched Tank Converter for Front-End Voltage Regulator Modules

Jiawei Liang, Haoyu Wang, Hengzhao Yang ShanghaiTech University, China

Session E09: DC-DC Non-Isolated - 3

1641 A Hybrid Si/SiC Interleaved Bidirectional DC-DC Converter to Optimal Power Quality, Efficiency, and Cost Tradeoff

Kun Qu, Chao Zhang, Weibin Chen, Bo Hu, Jing Chen, Jun Wang Hunan University, China

2023 Analytic Model and Design Procedure of the Single-Secondary Trans-Inductor Voltage Regulator

Hang Shao, Tao Zhao, Dianbo Fu, Daocheng Huang, Jinghai Zhou Monolithic Power Systems, Inc., United States

1405 | An Ultrahigh Step-Down DC-DC Converter Based on Switched-Capacitor and Coupled Inductor Techniques

Longyang Yu¹, Chengzi Yang¹, Wei Mu¹, Fengtao Yang¹, Huaqing Li¹, Laili Wang¹, Yuquan Su², Chi Zhang² ¹Xi'an Jiaotong University, China; ²MiSiliconn Semiconductor Technologies Co., Ltd., China

1493 | Input-Parallel-Output-Series Two-Stage Interleaved DC-DC Converter Using Coupled Inductors

Yasuhiro Kodama, Hirotaka Koizumi Tokyo University of Science, Japan

1651 | Model-Free Predictive Control of Interleaved DC-DC Converters, Based on Ultra-Local Model, with Constant Switching Frequency

Fernando Bento, Imed Jlassi, Antonio J. Marques Cardoso University of Beira Interior, Portugal

1621 An Efficient and Compact Multi-Port Power Supply for Nano-Satellites

Arnab Sarkar¹, Nachiketa Deshmukh¹, Pankaj Kumar¹, Sandeep Anand² ¹Indian Institute of Technology Kanpur, India; ²Indian Institute of Technology Bombay, India

Session E10: DC-DC Isolated – 3

1561 Exact Analysis of Parallel Resonant DC-DC Converter Using Phase Shift Modulation

Vishal Anand A.G.¹, Anirban Pal², Ranganathan Gurunathan¹, Kaushik Basu² ¹Bloom Energy (I) Pvt Ltd., India; ²Indian Institute of Science, India

2010 | Single-Stage Saturable Inductive-Link Half-Bridge Point of Load Converter

Tuhin Subhra Sasmal, Kalyan Yenduri, Pritam Das Binghamton University, United States

1436 | Multiplexing-Based Flyback Converter for Multi-Port USB Power Delivery with True Power-Sharing

Xingyue Tian¹, Han Cui¹, Lingxiao Xue² ¹University of Tennessee Knoxville, United States; ²Oak Ridge National Laboratory, United States

1045 | Transient Model and Elimination Method for DC Bias Current in Dual Active Bridge Converter

Yangfan Chen, Yu Zhang Huazhong University of Science and Technology, China

1220 Analysis of Synchronous-Rectification Switch Control for Active Class-E Rectifier

Gwangyol Noh^{1,2}, Gyu Cheol Lim³, Jung-Ik Ha¹ ¹Seoul National University, Korea; ²Samsun Electronics, Korea; ³Seoul National University Electric Power Research Institute, Korea

1426 A Modified Three-Port Bidirectional LLC Resonant Converter for Renewable Power Systems Xi Chen, Issa Batarseh

University of Central Florida, United States

Session E11: DC-DC Isolated – 4

1603 Startup Strategy for ISOP Hybrid DC Transformer Featuring Low Current and Voltage Stress Wei Wang, Zhiwei Chen, Tong Liu, Jie Chen, Zilong Wang, Qicai Ren, Alian Chen Shandong University, China

1549 | Regenerative Snubber Based Bootstrapped Gate Driver Power Supply for Multiple Input Flyback Converter

Arnab Sarkar¹, Aditya Aman², Sandeep Anand² ¹Indian Institute of Technology Kanpur, India; ²Indian Institute of Technology Bombay, India

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1120 A Constant Current Control Method with Improved Dynamic Performance for CLLC Converters

Huan Chen, Kai Sun, Languang Lu, Shuoqi Wang, Hongsheng Chong, Yudi Qin *Tsinghua University, China*

1876 A Switchable Rectifier-Based LLC Resonant Converter for Photovoltaic Applications

Fahad Alaql, Reza Rezaii, Sahin Gullu, Mohamed Tamasas Elrais, Issa Batarseh University of Central Florida, United States

1349 | Multiple Operation Modes Based Stacked Structure LLC Converter for Very Wide Range Operation

Yuqi Wei, Alan Mantooth University of Arkansas, United States

1718 | Five-Level T-Type Converter Based Fault-Tolerant Isolated DC-DC Topology Using WBG Devices

Amin Ashraf Gandomi¹, Leila Parsa¹, Keith Corzine¹, Vahid Dargahi² ¹University of California Santa Cruz, United States; ²University of Washington Tacoma, United States

Session E12: DC-DC Isolated – 5

1829 A Novel Structure of Fully Soft-Switched DC-DC Converter with Frequency Doubling Feature for High-Density Power Conversion

Saikat Dey, Ashwin Chandwani, Ayan Mallik Arizona State University, United States

2362 A Boost and LLC Resonant-Based Three-Port DC-DC Converter

Fahad Alaql, Issa Batarseh University of Central Florida, United States

2479 | Characteristics of Buck/Boost Operation in an Isolated DC-DC Converter Based on a Phase-Shift Controlled High-Frequency Inverter

Shohei Komeda, Masato Yamashita Tokyo University of Marine Science and Technology, Japan

2074 400V-to-48V GaN Modular LLC Resonant Converter with Planar Transformer

Qingyun Huang¹, Qingxuan Ma¹, Alex Q. Huang¹, Michael de Rooij² ¹The University of Texas at Austin, United States; ²Efficient Power Conversion Corporation, United States

1470 A Dual-Transformer-Based DC-DC Converter for Wide Voltage Gain and Wide ZVS Range by Utilizing a Sub-Optimal Simplified Control

Deliang Chen, Junjun Deng, Mingyang Li, Zhenpo Wang, Yang Li Beijing Institute of Technology, China

1152 Unidirectional Active-Passive Bridge (APB) DC-DC Converter Based on Resonant Control: FSM, PMW Operation with Soft-Switching Range and Step Power Control Method

Cao Anh Tuan, Takaharu Takeshita Nagoya Institute of Technology, Japan

1122 | Boost Assist Control of LLC Resonant Converter for Wide Voltage Range by Use of Secondary-Side MOSFETs with ZVS Using Reverse Recovery Current of Body Diodes

Takae Shimada¹, Mizuki Nakahara¹, Takuya Ishigaki² ¹Hitachi, Ltd., Japan; ²Hitachi Industrial Equipment Systems Co., Ltd., Japan

Session E13: DC-DC Isolated - 6

2439 Novel Transformer with Variable Leakage and Magnetizing Inductances

Angshuman Sharma, Jonathan W. Kimball Missouri University of Science and Technology, United States

1148 | Effects of Parasitics on an Active Clamp Assisted Phase Shifted Full Bridge Converter Operation

Manmohan Mahapatra, Anirban Pal, Kaushik Basu Indian Institute of Science, India

1390 Dual Range Forward Topology for High Efficiency at Universal Mains

Noam Ezra, Teng Long University of Cambridge, United Kingdom

1290 Automatic Current Balancing Multi-Phase Reconfigurable LLC Converter with Wide Voltage Gain Range for On-Board Battery Charger

Kakeru Koyama, Masatoshi Uno Ibaraki University, Japan

1594 | A Two-Stage DC-DC Converter with Wide Input Voltage Range Based on Magnetic Isolation Feedback Control

Renxi Dong, Xinbo Ruan, Ye Xu, Jinyang Yu Nanjing University of Aeronautics and Astronautics, China

2482 Current Harmonics Dead Time Design Method to Achieve ZVS with Non-Linear Output Capacitance

Matthew Hansen, Abhilash Kamineni, Regan Zane Utah State University, United States

1944 Variable Resonant and Switching Frequency Charging Control Strategy of LCC Converter with Wide Range Load

Mengjie Qin, Wenjie Chen, Fan Zhang, Ye Aizhen, Yang Xu, Houran Mohamad Abou *Xi'an Jiaotong University, China*

Session E14: AC-DC Single Phase Converters – 2

1598 A New Hybrid Si/SiC CCM Totem Pole Bridgeless PFC Design Towards Optimal Performance and Cost Tradeoff

Weibin Chen, Chao Zhang, Kun Qu, Bo Hu, Jing Chen, Jun Wang Hunan University, China

2323 | A Single-Stage Four-Phase Totem-Pole AC-DC Converter with Wide Voltage Range and Compact Integrated Magnetic Component

Tat-Thang Le, Ramadhan Muhammad Hakim, Junyeong Park, Sewan Choi Seoul National University of Science and Technology, Korea

1879 | Paralleled Two-Stage Single-Phase AC-DC Converter Modules Utilizing a Second-Stage Input-Current Based Droop Control Strategy

Danish Shahzad, Khurram K. Afridi Cornell University, United States

2111 | Modular Hybrid Step-Down PFC Converter for Direct AC/DC Conversion with Differential Power Processing in Data Centers

Ratul Das, Hanh-Phuc Le University of California San Diego, United States

1424 A Bulk-Capacitance Reduction Method Using Self-Driven Thyristor for AC-DC Converters Niu Jia¹, Han Cui¹, Lingxiao Xue²

¹University of Tennessee Knoxville, United States; ²Oak Ridge National Laboratory, United States

Session E15: AC-DC Single Phase Converters – 3

1095 | A Novel Transformerless Common-Ground AC/DC Switching Converter with Integral Fault Protection utilizing Active Isolation Techniques

Clint Halsted, Madhav Manjrekar, Babak Parkhideh University of North Carolina Charlotte, United States

1801 | A Discretized Sampling Based Current Sensorless Control of Single-Phase Totem-Pole Power Factor Corrector

Ashwin Chandwani¹, Saikat Dey¹, Ayan Mallik¹, Arun Sankar² ¹Arizona State University, United States; ²Mercedes-Benz R&D North America, Inc., United States

1988 | Design and Implementation of 50V/400A Single-Stage Full-Bridge Synchronous Rectifier for Data Center Application

Isaac Wong¹, Guangqi Zhu², Birger Pahl², Subhashish Bhattacharya¹ ¹North Carolina State University, United States; ²Eaton, United States

2038 | Control Techniques for a Current-Mode-Controlled Merged-Energy-Buffer-Based Two-Stage Electrolytic-Free Offline LED Driver

Maida Farooq¹, Firehiwot Gurara¹, Mausamjeet Khatua¹, Danish Shahzad¹, Saad Pervaiz², Khurram K. Afridi¹ ¹Cornell University, United States; ²Texas Instruments, United States

1862 Asymmetric Cascaded Transformer Multilevel AC-DC Converter

Bruna S. Gehrke¹, Cursino B. Jacobina¹, Nayara B. de Freitas², Italo R.F.M.P. da Silva³, Reuben P.R. Sousa¹ ¹Federal University of Campina Grande, Brazil; ²INESC TEC, Portugal; ³Federal University of Paraíba, Brazil

Session E16: AC-DC MultiPhase Converters – 1

1273 Implementation of an Isolated Phase-Modular-Designed Three-Phase PFC Rectifier Based on Single-Stage LLC Converter

Mojtaba Forouzesh, Yan-Fei Liu, Paresh C. Sen Queen's University, Canada

1644 | Three-Phase PFC Converter with Reconfigurable LCL Filter

Jalal Dadkhah¹, Carl N.M. Ho¹, Ken K.M. Siu², River Tin Ho Li³ ¹University of Manitoba, Canada; ²University of North Texas, United States; ³Hong Kong Applied Science and Technology Research Institute Company Limited, Hong Kong

1583 Isolated Three-Phase AC to DC Converter with Matrix Converter Applying Compensation for Voltage Error by Voltage-Based Commutation

Satoshi Nakamura, Hiroki Watanabe, Shunsuke Takuma, Kashin Kiri, Jun-ichi Itoh Nagaoka University of Techonology, Japan

1843 Unidirectional Five-Level Rectifiers for WECS Applications

Amanda P. Monteiro¹, Cursino B. Jacobina¹, Filipe A.C. Bahia², Reuben P.R. Sousa¹ ¹Federal University of Campina Grande, Brazil; ²Federal University of Bahia, Brazil

1215 A Three-Phase Voltage Doubler Topology Consisted of Small Number of Switching Devices with Low Switching Frequency

Mizuki Nakahara¹, Hirooki Tokoi¹, Hideto Takada², Hironori Oohashi² ¹Hitachi, Ltd., Japan; ²Hitachi Industrial Equipment Systems Co., Ltd., Japan

1873 | Surge Voltage Reduction Method for DAB Matrix Converter Using Circulating Current in Whole Load Condition

Shunsuke Takuma, Kashin Kiri, Hiroki Watanabe, Jun-ichi Itoh Nagaoka University of Technology, Japan

1976 | Ultra-Light Load Performance Enhancement of a 1 MVA SiC Medium Voltage Three Phase Rectifier

Hanning Tang^{1,2}, Alex Huang¹ ¹The University of Texas at Austin, United States; ²SharkNinja Operating LLC, United States

2070 | A Modular Three-Phase Diode Rectifier with High-Frequency Isolation and Sinusoidal Input Currents

Erick I. Pool-Mazun, Jose Sandoval, Prasad Enjeti Texas A&M University, United States

Session E17: DC-AC Single Phase Converter - 1

2436 | Improved Off-Time Discrete Control for DCM Grid-Tied Inverter with Accurate Average Current Model and considering Nonlinear Parasitic Capacitance

Cheng Huang, Tomoyuki Mannen, Takanori Isobe University of Tsukuba, Japan

1137 | A High Performance High Frequency Inverter Architecture with Wide Load Range

Chang Liu, Yueshi Guan, Yijie Wang, Dianguo Xu Harbin Institute of Technology, China

1589 | Design and Analysis of Resonant Inverter for a Wide Range of Input Voltage

Junhyeong Lee, Jung-Ik Ha Seoul National University, Korea

1065 | A Wide Load Range ZVS Inverter for Radio Frequency Capacitively Coupled Plasma

Si Chen¹, Xinbo Ruan¹, Ying Li² ¹Nanjing University of Aeronautics and Astronautics, China; ²University of Nottingham, United Kingdom

Session E18: DC-AC Single Phase Converter – 2

1954 | Improved Lifetime of GaN-Based Single Phase PV Inverter Using Dynamic Hardware Allocation

Kamal Sabi, Daniel Costinett The University of Tennessee Knoxville, United States

2137 | Single-Stage Isolated Half-Bridge/Full-Bridge Converter for DC/AC Applications

Laysa L. Souza¹, Diego Acevedo-Bueno¹, Montiê A. Vitorino¹, Edison R.C. da Silva¹, Jens Friebe², Antonio M.N. Lima¹

¹Federal University of Campina Grande, Brazil; ²Leibniz Universität Hannover, Germany

1705 | Multilevel Converter Based on Series and Parallel Connections Using High-Frequency Transformer

Filipe V. Rocha¹, Cursino B. Jacobina¹, Nady Rocha² ¹Federal University of Campina Grande, Brazil; ²Federal University of Paraíba, Brazil

1717 | Multilevel Converter Based on Series and Parallel Connections Using Floating Capacitor

Filipe V. Rocha¹, Cursino B. Jacobina¹, Nady Rocha², Antonio de Paula Dias Queiroz³ ¹Federal University of Campina Grande, Brazil; ²Federal University of Paraíba, Brazil; ³Federal Institute of Paraíba, Brazil

1059 Accurate Power Loss Model of a Three Level ANPC Inverter Utilizing Hybrid Si/SiC Switching Devices

Dereje Woldegiorgis, Alan Mantooth University of Arkansas, United States

Session E19: AC-AC Isolated

2512 | Parallel Capacitive-Link Universal Converters with Low Current Stress and High Efficiency

Junhao Luo¹, Khalegh Mozaffari², Brad Lehman¹, Mahshid Amirabadi¹ ¹Northeastern University, United States; ²Enphase Energy, United States

1820 | PUC Converter Based on AC-DC-AC Multilevel Topologies with a Shared Leg

Jean T. Cardoso, Cursino B. Jacobina, Phelipe L.S. Rodrigues, Antonio M.N. Lima Federal University of Campina Grande, Brazil

1087 | Investigation on Operational Range and Suitable Control for Single Phase to Three Phase Matrix Converter

Tabish Nazir Mir¹, Bhim Singh¹, Abdul Hamid Bhat² ¹Indian Institute of Technology Delhi, India; ²National Institute of Technology Srinagar, India

2103 AC-DC-AC Converter with Shared Legs Based on Cascaded Six-Leg and Three-Leg Cells

Alan S. Felinto, Cursino B. Jacobina Federal University of Campina Grande, Brazil

1457 | A Single-Phase AC-DC-AC Three-Leg Converter Hybrid with Two and Three Level Legs

Nustenil S.M.L. Marinus¹, Reuben P.R. Jacobina², Nady Rocha³, Alexandre C. Oliveira², Cursino B. Jacobina², Leonardo C. Pontes¹

¹Federal Institute of Education, Science and Technology of Ceará, Brazil; ²Federal University of Campina Grande, Brazil; ³Federal University of Paraíba, Brazil

1676 | Three-Phase AC-AC X-Type Indirect Matrix Converters with Open-End Rectifier Stage

André Wild S. Ramalho, Montiê A. Vitorino, Maurício B.R. Corrêa, Edgar R. Braga-Filho Federal University of Campina Grande, Brazil

2065 | Novel Comprehensive Control of Matrix Converters

Galina Mirzaeva, Maria Seron, Graham Goodwin The University of Newcastle, Australia

Session E20: Multilevel Converters – Topologies – 1

2119 Modular Isolated Vertically Symmetric Dual Inductor Hybrid Converter for Differential Power Processing

Ratul Das, Hanh-Phuc Le University of California San Diego, United States

1633 Optimized Circulating Current Injection Control Scheme for Modular Multilevel Converters

Govind Avinash Reddy, Anshuman Shukla Indian Institute of Technology Bombay, India

2105 | Three-Phase AC-DC-AC Converter with Shared Legs and High-Frequency Link

Alan S. Felinto, Cursino B. Jacobina Federal University of Campina Grande, Brazil

1145 | Comprehensive Analysis of the Control Structures for MMC Applications

Semih Isik, Mohammed Alharbi, Subhashish Bhattacharya North Carolina State University, United States

1677 A Single-Phase 35-Levels Cascaded PUC Multilevel Inverter Fed by a Single DC-Source

Samuel C.S. Júnior¹, Cursino Jacobina¹, Edgard L.L. Fabricio² ¹Federal University of Campina Grande, Brazil; ²Federal Institute of Paraíba, Brazil

2100 | A Compact Design Using GaN Semiconductor Devices for a Flying Capacitor Five-Level Inverter

Majid Farhangi¹, Yam P. Siwakoti¹, Reza Barzegarkhoo¹, Saad Ul Hasan¹, Dylan Lu¹, Dan Rogers² ¹University of Technology Sydney, Australia; ²University of Oxford, United Kingdom

1488 | A GaN Based Four-Port Flying Capacitor Multilevel Converter

Mohamed Tamasas Elrais, Issa Batarseh University of Central Florida, United States

Session E21: Multilevel Converters – Topologies – 2

1648 | Transformer-Based Single-Phase AC-DC-AC Multilevel Converter for Voltage Step-Up Applications

Rodrigo P. de Lacerda¹, Cursino B. Jacobina¹, Edgard L.L. Fabricio², Jean Torelli Cardoso¹ ¹Federal University of Campina Grande, Brazil; ²Federal Institute of Paraíba, Brazil

1870 A Seven-Level Inverter with Natural Balance and Boosting Capability

Ronnan de B. Cardoso¹, Edison Roberto C. da Silva^{2,3}, Leonardo R. Limongi¹, André Elias L. da Costa² ¹Federal University of Pernambuco, Brazil; ²Federal University of Campina Grande, Brazil; ³Federal University of Paraíba, Brazil

1815 | Single-Phase AC-DC-AC Multilevel Five-Leg Converter Based on a High-Frequency Transformer

Jean T. Cardoso, Cursino B. Jacobina, Phelipe L.S. Rodrigues, Antonio M.N. Lima Federal University of Campina Grande, Brazil

1464 | Hybrid Flying Capacitor Inverter Based on Array Bootstrap Driver for High Power Density Application

Jingxiang Shi, Shangzhi Pan, Jinwu Gong, Zhipeng Yin, Xinghua Dang, Minglong Wang Wuhan University, China

1263 | Performance Assessment of a 13-Levels Self-Balanced Inverter Based on a Dual T-Type Topology

S. Foti¹, A. Testa¹, S. De Caro¹, G. Scelba², A. Cusumano² ¹University of Messina, Italy; ²University of Catania, Italy

2237 AC-DC Single-Phase Multilevel Converters with Floating DC-Link and Reduced Controlled Switches

Ulisses G. Lima¹, Cursino B. Jacobina², Reuben P.R. Sousa¹, Rodrigo P. de Lacerda¹ Federal University of Campina Grande, Brazil

Session E22: Multilevel Converters – Topologies – 3

1355 A Single-Phase Five-Level Grid-Connected Inverter for Photovoltaic Applications

Jadyson J. Silva¹, Filipe A.C. Bahia¹, Andre P.N. Tahim¹, Darlan A. Fernandes², Fabiano F. Costa¹ ¹Federal University of Bahia, Brazil; ²Federal University of Paraíba, Brazil

1496 A Three-Level Neutral-Point Clamped Dual-Output Converter

Ahmed S. Hussein, Amer Ghias Nanyang Technological University, Singapore

2113 A Novel Seven Level Hybrid Fault Tolerant Converter

Rajat Shahane, Satish Belkhode, Anshuman Shukla Indian Institute of Technology Bombay, India

1620 A Six-Switch Five-Level Transformer-Less Inverter without Leakage Current for Grid-Tied PV System

Jaber Fallah Ardashir¹, Mahdi Gasemi¹, Behrouz Rozmeh¹, Saeed Peyghami², Frede Blaabjerg² ¹Islamic Azad University, Iran; ²Aalborg University, Denmark

2097 | A Novel Single-Source Single-Stage Switched-Boost Five-Level (S5B5L) Inverter with Dynamic Voltage Boosting Feature

Majid Farhangi¹, Reza Barzegarkhoo¹, Yam P. Siwakoti¹, Dylan Lu¹, Sze Sing Lee² ¹University of Technology Sydney, Australia; ²Newcastle University in Singapore, Singapore

1334 | A DAB Converter Constructed by Nine-Switch Five-Level Active-Neutral-Point-Clamped Bridges

Na Gao, Yu Zhang, Zengguang Qiu, Qingxin Guan Huazhong University of Science and Technology, China

1106 | Comparison of an Interleaved Multi-Branch Inverter and a Four-Level Inverter with Variable Voltage Levels for Emulation of Three-Phase Machines

Manuel Fischer, Yang Hu, Johannes Ruthardt, Philipp Ziegler, Jörg Roth-Stielow University of Stuttgart, Germany

Session E23: Multilevel Converters – Control – 1

1958 | Open-Switch Fault Diagnosis in Four-Level Active Neutral-Point-Clamped Inverters

Jonathan Pribadi, Dong-Choon Lee Yeungnam University, Korea

1443 | Model-Free Second-Order Sliding Mode Control for Grid-Connected Voltage Source Compact Multilevel Converters

Mohammad Babaie, Kamal Al-Haddad École de technologie supérieure, Canada

1406 | Self-Balancing 3-Phase 5-Level Flying E-Type Inverter for Photovoltaic Applications

M. di Benedetto¹, A. Lidozzi¹, L. Solero¹, F. Crescimbini¹, P.J. Grbović² ¹Roma Tre University, Italy; ²University of Innsbruck, Austria

1629 | Constant Overlap-Time Based SMs Capacitor Voltage Balancing Scheme for Alternate Arm Converter

Govind Avinash Reddy, Nageswara Rao Karaka, Anshuman Shukla Indian Institute of Technology Bombay, India

1469 A Robust Ultra-Local Model Control with DC Capacitor Voltage-Balancing for PEC9 Inverter

Meysam Gheisarnejad¹, Mohammad Sharifzadeh², Mohammad-Hassan Khooban¹, Kamal Al-Haddad² ¹Aarhus University, Denmark; ²École de technologie supérieure, Canada

1467 | Convex Optimization-Based Vector Current Control Design for Grid-Connected Packed E-Cell Inverters

Mahdieh S. Sadabadi¹, Mohammad Sharifzadeh², Majid Mehrasa³, Seddik Bacha³, Kamal Al-Haddad² ¹The University of Sheffield, United Kingdom; ²École de Technologie Supérieure, Canada; ³Université Grenoble Alpes, France

2253 | Hybrid Multilevel T-Type Inverter Exploiting a Nearest Level Modulation Technique

S. Foti¹, A. Testa¹, S. De Caro¹, T. Scimone¹, G. Scelba², G. Scarcella² ¹University of Messina, Italy; ²University of Catania, Italy

Session E24: Multilevel Converters – Control – 2

2089 | Statcom Operation of Hybrid Series Converter and DC Capacitor Voltage Balance Technique

Ibhan Chand Rath, Anshuman Shukla Indian Institute of Technology Bombay, India

1092 | Multiplexing the Level Provider of Multilevel Converters in Series-Parallel-Form Switch-Linear Hybrid Envelope Tracking Power Supply

Peng Zhou, Xinbo Ruan, Ning Liu, Yazhou Wang Nanjing University of Aeronautics and Astronautics, China

1782 A Novel Inter-Modulated Floating Carrier Level Shifted PWM Method for PUC9 Converter

Kiavash Askari Noghani¹, Mostafa Abarzadeh², Alireza Javadi³, Kamal Al-Haddad¹ ¹École de technologie supérieure, Canada; ²SmartD Technologies Inc., Canada; ³SUEZ Water Technologies & Solutions, Canada

2009 | Splitting of Voltage Reference between Half-Bridge and Full-Bridge Sub-Modules in Hybrid MMC

Risabh Sarangi¹, Tanmoy Bhattacharya², Dheeman Chatterjee² ¹Indian Institute of Technology Kanpur, India; ²Indian Institute of Technology Kharagpur, India

1462 | Circulating Current Control in Arm Link Enhanced Modular Multilevel Converter for Low-Voltage and Variable Frequency Applications

Rodrigo Aguilar¹, Luca Tarisciotti², Javier Pereda¹ ¹Pontificia Universidad Católica de Chile, Chile; ²Universidad Andrés Bello, Chile

2088 Common-Mode Voltages Reduction Space Vector Modulation for Active Neutral-Point-Clamped Converter

Jalal Amini, Mehrdad Moallem Simon Fraser University, Canada

1284 Analysis and Implementation of a 5-Level Hybrid Inverter with Reduced Switching Devices Using Phase-Shifted PWM

Almachius Kahwa, Hidemine Obara, Yasutaka Fujimoto Yokohama National University, Japan

Session E25: DC-AC Multi-Phase Converters – 2

2148 | Overvoltage Mitigation Techniques for SiC-MOSFET Based High-Speed Drives: Comparison of Active Gate Driver and Output dv/dt Filter

Jelena Loncarski¹, Francesca Maiullari², Rinaldo Consoletti², Vito Giuseppe Monopoli², Francesco Cupertino² ¹University of Bologna, Italy; ²Politecnico di Bari, Italy

2413 | Discontinuous Space Vector Pulse Width Modulation for Six Switch Converter with Independent Control of Phase Voltages and Switching Device Stress Alleviation

Josiah O. Haruna, Olorunfemi Ojo Tennessee Tech University, United States

1454 | Three-Phase Buck-Boost Inverter with Reduced Current Ripple

Ashraf Ali Khan¹, Usman Ali Khan², Shehab Ahmed¹ ¹King Abdullah University of Science and Technology, Saudi Arabia; ²Yonsei University, Korea

2238 Optimum Injection of Second Harmonic Circulating Current for Reduction in SubModule Capacitor Voltage Ripple in Overmodulated MMC

G. Veera Bharath, Poras T. Balsara The University of Texas at Dallas, United States

2581 | QCM-Enabled SiC Three-Phase Traction Inverter

Yanfeng Shen, Yunlei Jiang, Luke Shillaber, Hui Zhao, Teng Long University of Cambridge, United Kingdom

1335 Assessment of a Multi-Functional Converter System for Traction Electric Drives

C. Alosa, F. Immovilli, E. Lorenzani University of Modena and Reggio Emilia, Italy

1756 | Role of Active Clamp Circuit in a DC/AC Isolated Converter Based on the Principle of Pulsating DC Link

Daniele Marciano, Simone Palazzo, Giovanni Busatto, Annunziata Sanseverino, Francesco Velardi University of Cassino and Southern Lazio, Italy

Topic F: Control, Modeling and Optimization of Power Converters

Session F01: Dynamic Modeling of Power Converters

1967 An Accurate Dynamic Characteristic Design Method for Boost Converter with PI Control Based on Motion Decomposition and Eigenvalue Configuration

Hong Li¹, Zexi Zhou¹, Zhipeng Zhang¹, Guoen Cao², Yajing Zhang³ ¹Beijing Jiaotong University, China; ²Chinese Academy of Science, China; ³Beijing Information Science and Technology University, China

2359 | Dynamic Phasor Model of Multi-Converter Systems

Arash Nazari¹, Yaosuo Xue², Jayesh Kumar Motwani¹, Igor Cvetkovic¹, Dong Dong¹, Dushan Boroyevich¹ ¹Virginia Polytechnic Institute and State University, United States; ²Oak Ridge National Laboratory, United States

1775 | Frequency Domain Modelling of an LCLC Resonant Converter with Capacitive Output Filter under Hybrid Modulation

Shahbaj Dhillon, Abhishek Awasthi, Praveen Jain Queen's University, Canada

1285 | Reduced-Order Equivalent Circuit Model of Series Resonant Converter considering the Interaction between Resonant Elements

Xin Li¹, Shuxin Chen¹, Yi Tang¹, Yiming Zhang², Xin Zhang³ ¹Nanyang Technological University, Singapore; ²Fuzhou University, China; ³Zhejiang University, China

2290 | Frequency Domain Modelling of an LCC Resonant Converter with Capacitive Output Filter Shahbaj Dhillon, Abhishek Awasthi, Praveen Jain

Queen's University, Canada

Session F02: Reliability, Diagnostics and Fault Analysis of Power Converters

1686 | Online Junction Temperature Monitoring of Power Semiconductor Devices Based on a Wheatstone Bridge

Niklas Fritz¹, Maximilian Friedel¹, Rik W. De Doncker¹, Timothy A. Polom² ¹RWTH Aachen University, Germany; ²Silicon Austria Labs GmbH, Austria

2337 | Junction Temperature Estimation of SiC MOSFETs During Inverter Operation Using Switching Times and On-State Voltages

Daniel Herwig, Axel Mertens Leibniz Universität Hannover, Germany

1308 | "Plug-and-Play" Tiny AI-Empowered Output Filter Parameter Extraction Framework with Single RNN Cell for Digital Power

Kelvin Yi-wen Hong¹, Henry Shu-hung Chung¹, Alan Wai-Lun Lo², Huai Wang³ ¹City University of Hong Kong, China; ²Chu Hai College of Higher Education, China; ³Aalborg University, Denmark

1872 | Mode Analysis and Identification Scheme of Open-Circuit Fault in a Three-Phase DAB Converter

Sagar Kumar Rastogi¹, Suyash Sushilkumar Shah¹, Brij N. Singh², Subhashish Bhattacharya¹ ¹North Carolina State University, United States; ²John Deere, United States

2041 On-State Voltage Measurement of High-Side Power Transistors in Three-Phase Four-Leg Inverter for In-Situ Prognostics

Chondon Roy, Namwon Kim, James Gafford, Babak Parkhideh University of North Carolina Charlotte, United States

Session F03: Control of DC-DC Converters

1338 Current Sharing Control Strategy for Parallel-Connected H-Bridges DC-DC Converter: Modelling, Analysis and HIL Test

Cristina Terlizzi¹, Stefano Bifaretti¹, Alessandro Lampasi² ¹University of Rome "Tor Vergata", Italy; ²ENEA, DTT S.c.a.r.l., Italy

2055 | Improved Instantaneous Flux and Current Control for Three-Phase Dual-Active Bridge DC-DC Converters

Rafael Goldbeck, Jingxin Hu, Rik W. De Doncker RWTH Aachen University, Germany

1430 A Power Sharing Control Scheme with Fast-Dynamic Response for Input-Series Output-Parallel DAB DC-DC Converter

Nie Hou, Pasan Gunawardena, Xuesong Wu, Li Ding, Yue Zhang, Yun Wei Li University of Alberta, Canada

2477 | A Decentralized Nonlinear Control Scheme for Modular Power Sharing in DC-DC Converters

Soham Roy¹, Mansi Joisher², Alex J. Hanson¹ ¹The University of Texas at Austin, United States; ²National Institute of Technology Karnataka, India

Session F04: Power Converter Modeling and Control

2064 | Grid-Connected Self-Synchronizing Cascaded H-Bridge Inverters with Autonomous Power Sharing

Soham Dutta¹, Minghui Lu¹, Branko Majmunovic², Rahul Mallik¹, Gab-Su Seo³, Dragan Maksimović², Brian Johnson¹

¹University of Washington, United States; ²University of Colorado, United States; ³National Renewable Energy Laboratory, United States

1982 Input AC Voltage Sensorless Control Method for Single-Phase PFC Converter Using Frequency Estimator

Seunghoon Baek¹, Chun-Gi Yun², Younghoon Cho³ ¹Virginia Polytechnic Institute and State University, United States; ²Korea Electrical Manufacturers Association, Korea; ³Konkuk University, Korea

1609 Optimized PWM Scheme with Minimized Common-Mode Voltage Amplitude and Frequency in VSI-Fed Motor Drives

Zhe Zhang, Ali M. Bazzi University of Connecticut, United States

2391 | Proximate Time-Optimal Control of Flying-Capacitor Multi-Level Converters Using a Fixed Frequency PID Framework

Chandan Suthar¹, V. Inder Kumar¹, Faleh Alskran², Dragan Maksimović¹ ¹University of Colorado Boulder, United States; ²Advanced Energy Industries, Inc., United States

Session F05: Power Converter Stability

1735 | An Approach for Modeling and Stability Analysis of Single-Phase Microgrids

Nima Amouzegar Ashtiani¹, S. Ali Khajehoddin¹, Masoud Karimi-Ghartemani² ¹University of Alberta, Canada; ²Mississippi State University, United States

1962 | A Floquet Theory-Based Stability Analysis Method for Cascaded DC-DC Converters by Combining with the Describing Function of PWM Link

Hong Li, Zhipeng Zhang, Zexi Zhou, Zhaoyi Chu, Yangbin Zeng, Zhidong Qiu Beijing Jiaotong University, China

1063 | Evaluating Small-Signal Synchronization Stability of Grid-Forming Converter through Complex Impedance Plane

Jiale Yu¹, Han Deng¹, Yi Tang¹, Yang Qi², Xiong Liu³ ¹Nanyang Technological University, Singapore; ²Northwestern Polytechnical University, China; ³Jinan University, China

1077 | Stability Analysis and Improvement of Three-Phase Grid-Tied Power Converters through the Generalized Phase Portraits Method

Jiale Yu¹, Yi Tang¹, Jingyang Fang², Hongchang Li³ ¹Nanyang Technological University, Singapore; ²Duke University, United States; ³Xinjiang University, China

Session F06: Power Converter EMI

2522 | Identification and Validation of a Non Symmetrical System Level EMC Model for Power Electronics Converter

Blazej Czerniewski^{1,2}, Jean-Luc Schanen¹, Herve Chazal¹, Pericle Zanchetta^{2,3}, Caio Fronseca de Freitas⁴ ¹Université Grenoble Alpes, France; ²University of Nottingham, United Kingdom; ³University of Pavia, Italy; ⁴Centrale Lille, France

1991 | PCB Winding Coupled Inductor Design for SiC-Based Soft-Switching Three-Phase C-DC Converter with Balance Technique

Gibong Son, Zhengrong Huang, Qiang Li, Fred C. Lee Virginia Polytechnic Institute and State University, United States

2366 Novel Common Mode Voltage Elimination Methods in Three-Phase Four-Wire Grid-Connected Inverters

Alexander L. Julian¹, Giovanna Oriti² ¹Consultant, United States; ²Naval Postgraduate School, United States

1856 | Electric Near Field Emission from a 1Mhz Power Converter for Electric Vehicles

Yanwen Lai¹, Juntao Yao¹, Shuo Wang¹, Zheng Luo², Yiming Li² ¹University of Florida, United States; ²Monolithic Power Systems, Inc., United States

Session F07: Converter Power Quality

2296 | Parallel Differential Evolution Algorithm Accelerated by Graphics Processing Unit for Harmonic Minimization in Power Converters

Kaiqi Ren, Fei He, Zhaoyuan Li, Kehu Yang China University of Mining and Technology, China

2473 | Decentralized PWM Interleaving for Ripple Minimization in Both Symmetric and Asymmetric Parallel-Connected DC-DC Converters

Soham Dutta, Minghui Lu, Brian Johnson University of Washington, United States

1798 | Linear-System-Based Selective Harmonic Elimination Solution for Multilevel Inverters

Concettina Buccella, Maria Gabriella Cimoroni, Carlo Cecati University of L'Aquila, Italy

1231 Enhanced Modulation Technique for Power Quality Improvement of LED Drivers

Huan Li¹, Weidong Xiao¹, Sinan Li¹, Jimmy Chih-Hsien Peng² ¹The University of Sydney, Australia; ²National University of Singapore, Singapore

Session F08: Design and Control of Power Converters

2199 Switching Losses Minimized Harmonic Elimination for Two-Level Inverters

Kehu Yang¹, Suna Pan¹, Huawei Li² ¹China University of Mining and Technology, China; ²Beijing Institute of Aerospace Test Technology, China

1786 | Modeling and ZVS Constraints of the Hybrid-Bridge LLC Resonant Converter for MHz Level Operation

Lingeshwaren Sobrayen^{1,2}, Patrick Dehem², Charif Karimi¹, Tanguy Phulpin¹, Daniel Sadarnac¹ ¹CentraleSupélec, France, France; ²EnerSys, France

1437 | Splitting Inductance Tuning Method to Eliminate High Frequency Oscillation in Dual Active Bridge Converter

Chang Wang, Jiasheng Huang, Gabriel Zsurzsan, Zhe Zhang Technical University of Denmark, Denmark

1916 | Minimizing Switching-On Current Spike through GaN in Low Power Applications

Yajie Qiu, Jinseng Vanderkloot, Lucas Lu GaN Systems, Canada

Session F09: Power Converter Stability and Control

1703 System-Level Mapping of Modeling Methods for Stability Characterization in Microgrids Yubo Song¹, Subham Sahoo¹, Yongheng Yang², Frede Blaabjerg¹ ¹Aalborg University, Denmark; ²Zhejiang University, China

1674 A Modular Multilevel Converter as a Grid Emulator in Balanced and Unbalanced Scenarios Using a Delta-Wye Transformer

Ming Jia, Shenghui Cui, Philipp Joebges, Rik W. De Doncker RWTH Aachen University, Germany

2271 | Transient Performance Evaluation of Grid-Forming Control for Railway Traction Converters considering Inter-Phase Operation

Liang Zhao¹, Zheming Jin², Xiongfei Wang¹ ¹Aalborg University, Denmark; ²Beijing Jiaotong University, China

2268 Valley Current Control for the Flying Capacitor Voltage Balancing in the Three-Level Boost Converter with Variable Switching Frequency

Branislav Stevanović, Pedro Alou, Miroslav Vasić Universidad Politécnica de Madrid, Spain

1634 | A State Trajectory Control Method for Switched-Capacitor-Based Resonant Converter with the Finite State Machine Controller

Pan Wang¹, Rui Ling¹, Dongxue Li² ¹Chongging University, China; ²Vicor Corporation, United States

Session F10: Control Aspects of Grid-Connected Converters

1070 | Dynamic Performance Limitation and Enhancement of Grid-Forming Converters

Han Deng¹, Jingyang Fang², Yang Qi³, Vincent Debusschere⁴, Yi Tang¹ ¹Nanyang Technological University, Singapore; ²University of Kaiserslautern, Germany; ³Northwestern Polytechnical University; ⁴Grenoble Institute of Technology, France

1823 | A Data-Driven Approach for Grid Synchronization Based on Deep Learning

Mohammadreza Miranbeigi, Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

1253 Operational Flexibility of the Modular Multilevel Converter under Unbalanced Grid Conditions

Yu-chen Su, Hsuan-ming Li, Po-lin Chen, Po-tai Cheng National Tsing Hua University, Taiwan

2260 Unified Control (UniCon) Strategies for Grid-Connected Inverters

Mohammadreza Miranbeigi, Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

1745 | Grid-Tied Two PV LLC Converter with Dual MPPT Algorithm Based on the Adaptive Neuro Fuzzy Interface System (ANFIS)

Sumana Ghosh, Issa Batarseh University of Central Florida, United States

Session F11: Power Converter Control

2281 New Predictive Current Control for Modular Multilevel Converters with Revised Prediction Model considering Common-Mode Voltage

Yafei Yin, Zhenbin Zhang, Yuanxiang Sun, Zhen Li Shandong University, China

1880 | Direct Active-Balancing Control of Flying-Capacitor Voltages in an ANPC-Based Multilevel Inverter

Vahid Dargahi¹, Arash Khoshkbar Sadigh² ¹University of Washington, United States; ²The Pennsylvania State University, United States

1956 Modelling and Controller Design for Three-Phase Four-Leg Three-Level T-Type Inverter

Haoxin Yang, Li Zhang, Pengfei Tu, Yi Tang Nanyang Technological University, Singapore

1989 | Phase Control Using Network Node Voltage Feedback for Capacitor-Coupled Dual Active Bridge DC-DC Converters

Sunghyuk Choi, Jin-Su Hong, Jung-Ik Ha Seoul National University, Korea

2370 Inverter-Dominated Networked Microgrids with Marine Energy Resources and Energy Storage Systems for Coastal Community Resiliency Enhancement

Yuxi Men¹, Yuhua Du¹, Xiaonan Lu¹, Jianzhe Liu², Feng Qiu² ¹Temple University, United States; ²Argonne National Laboratory, United States

2162 | Shipboard Power Conversion System to Meet MIL-STD-1399 Limits for Pulsed Power Loads

Giovanna Oriti¹, Alexander L. Julian², Daniel P. DeToma³ ¹Naval Postgraduate School, United States; ²Consultant, United States; ³US Navy, United States

Session F12: Dynamic Modeling of Power Converters

1997 Accurate Small-Signal Modeling for Charge-Controlled LLC Resonant Converter

Yi-Hsun Hsieh, Fred C. Lee Virginia Polytechnic Institute and State University, United States

2405 An Improved Frequency Domain Based Analytical Model of Voltage-Fed Series LC-Parallel LC Resonant Converter with Capacitive Output Filter

Aiswarya Mathew¹, Abhishek Awasthi¹, Praveen Jain¹, Shahbaj S. Dhillon², Majid Pahlevani¹ ¹Queen's University, Canada; ²Voltsafe Inc., Canada

1027 | A Two-Stage Pulsed Power Supply with Ultra-Fast Dynamic Response and Low Input Current Ripple for Low-Frequency Pulsed Loads

Ye Xu, Xinbo Ruan, Xinze Huang, Jinyang Yu, Hao Zhang Nanjing University of Aeronautics and Astronautics, China

1860 | Small-Signal Modeling and Output Impedance Analysis of Three Stage Synchronous Generator for More Electric Aircraft

Chengxiang Zhang¹, Shuang Wang¹, Xinbo Ruan¹, Ming Yan², Donghua Wu² ¹Nanjing University of Aeronautics and Astronautics, China; ²Shaanxi Aero Electric Co. Ltd., China

1601 | A Simplified Time-Domain Gain Model for CLLC Resonant Converter

Yuliang Cao, Minh Ngo, Dong Dong, Rolando Burgos Virginia Polytechnic Institute and State University, United States

Session F13: Modulation of Power Converters

1949 | Discontinuous Modulation of Cascaded H-Bridge StatComs considering Capacitor Voltage Oscillations

Qingxiang Liu¹, Ezequiel Rodriguez¹, Glen G. Farivar¹, Josep Pou¹, Salvador Ceballos², Christopher D. Townsend³, Ramon Leyva⁴

¹Nanyang Technological University, Singapore; ²Basque Research and Technology Alliance, Spain; ³University of Western Australia, Australia; ⁴Universitat Rovira i Virgili, Spain

1209 Quasi-Reference PWM for 3-Level Voltage Source Inverters

Anatolii Tcai¹, Thiwanka Wijekoon¹, Jun-Hyung Jung², Marco Liserre² ¹Huawei Technologies Düsseldorf GmbH, Germany; ²Christian-Albrechts-Universität zu Kiel, Germany

2515 A Fault Tolerant Modulation Scheme to Eliminate DC Offset and Harmonic Fault Currents in the Balanced Inverter under Switch Short-Circuits Faults

Zhouzhou Wang, Hao Zeng, Thomas M. Jahns, Bulent Sarlioglu University of Wisconsin Madison, United States

1397 Common Mode Suppression Method of Current Source Back-to-Back Converter Based on Five-Segment Space Vector Modulation

Kang Liu, Dong Jiang, Zicheng Liu, Ruodong Wang Huazhong University of Science and Technology, China

1627 Novel Static Carrier Based Low Frequency Multilevel Modulations with Long Conduction Time: Analysis of Capacitor Voltage Balancing

Corentin Darbas¹, Jean-Christophe Olivier², Nicolas Ginot¹, Frédéric Poitiers¹ ¹IETR, France; ²IREENA, France

Session F14: Design and Control of Power Converters I

2062 | A Framework for High Density Converter Electrical-Thermal-Mechanical Co-Design and Co-Optimization for MEA Application

Mustafeez ul Hassan, Zhao Yuan, Asif Imran Emon, Fang Luo Stony Brook University, United States

2411 | The ZVS Transition Analysis and Optimization for CLLC-Type Resonant DC Transformer

Yuliang Cao, Minh Ngo, Dong Dong, Rolando Burgos Virginia Polytechnic Institute and State University, United States

1915 | Harmonic Compensation Control of Grid Interactive Inverters Based on Data-Driven Harmonic State Space Modeling

Dongsen Sun, Shengyi Wang, Liang Du, Xiaonan Lu Temple University, United States

1309 | Preliminary Testing and Implementation of a Peak Current Mode Control Scheme for a Two-Phase, Dual Interleaved Buck-Boost Converter

Kevin Cano-Pulido, Ismael Araujo-Vargas, Nancy Mondragón-Escamilla, Enrique Velázquez-Elizondo Instituto Politécnico Nacional, Mexico

Session F15: Utility Applications of Power Electronics

1208 DC Fault Current Estimation in a Multi-Terminal Hybrid MMC-HVDC System considering Fault Ride through Control

Yi Xu¹, Liang Qin¹, Yi Zhang², Kaipei Liu¹, Frede Blaabjerg² ¹Wuhan University, China; ²Aalborg University, Denmark

2341 Power Device Losses in Two-Level Converters with Direct Current Controllers for Grid Connected Applications

Jose Ortiz Gonzalez¹, Diego Pérez-Estévez², Ruizhu Wu¹, Jesús Doval-Gandoy², Phil Mawby¹, Olayiwola Alatise¹ ¹University of Warwick, United Kingdom; ²University of Vigo, Spain

2194 | Real-Time Simulation Framework for Hardware-in-the-Loop Testing of Multi-Port Autonomous Reconfigurable Solar power plant (MARS)

Zerui Dong¹, Suman Debnath², Wei Li³, Qianxue Xia⁴, Phani R.V. Marthi², Sudipta Chakraborty¹ ¹OPAL-RT Corporation, United States; ²Oak Ridge National Laboratory, United States; ³OPAL-RT Technologies, Inc., Canada; ⁴Georgia Institute of Technology, United States

1109 Design and Analysis of a High-Efficiency All-SiC Dynamic Voltage Restorer for Wide-Range Sag/Swell Mitigation

Lorenzo Ceccarelli, Xinwei Xu, Gabriel Tibola, Jorge L. Duarte Eindhoven University of Technology, The Netherlands

1818 | Transformer-Less Alternative Topologies of a Unified Power Quality Conditioner with Embedded Hybrid Energy Storage

Jose M. Piedra¹, Pablo García², Ramy Georgious¹, Geber Villa², Mhret Berhe Gebremariam² ¹ENFASYS, Spain; ²University of Oviedo, Spain

Session F16: Other Topics in Design, Control, Modelling and Optimization of Power Converters

1606 | A Remote Development Process and Platform for Power Electronic Systems

Michael Starke, Bailu Xiao, Mitch Smith, Pankaj Bhowmik, Steven Campbell, Radha K. Moorthy, Benjamin Dean, Madhu Chinthavali *Oak Ridge National Laboratory, United States*

1920 An Improved Low Speed Control Strategy for Permanent Magnet Synchronous Motor with Low Resolution Encoder

Qiushi Zhang, Yin Fan Southeast University, China

2448 | A Novel Trapezoidal Slope Compensation Technique with Peak Current Mode Control for Power Converters Switching at MHz Frequencies

Gnana Sambandam K.¹, Yu Yao¹, Harish S. Krishnamoorthy¹, Harshit Soni², Amitava Das² ¹University of Houston, United States; ²Tagore Technology, United States

1753 | Performance Analysis of an Input-Series-Output-Parallel LLC Resonant Converter with Parameters Mismatch

Qingxuan Ma, Qingyun Huang, Alex Q. Huang The University of Texas at Austin, United States

1179 DC-Link Inductor Investigation for Series-Connected Current Source Converter

Zijian Wang, Bowen Jiang, Qiang Wei Lakehead University, Canada

1499 | Toroidal Inductor Design and Comparison between Interleaved and Non-Interleaved 300 kW High Efficiency SiC Inverter

Harish Suryanarayana¹, Maziar Mobarrez¹, Jacob Miscio¹, Xiaoqing Song¹, Arun Kadavelugu¹, Silvio Colombi² ¹ABB, United States; ²ABB, Switzerland

2481 | Minimization of DC-Link Capacitance for a DC-Link Based Variable Speed Constant Frequency Aircraft Power System

Goutham Selvaraj¹, Kaushik Rajashekara¹, Krishna Raj Ramachandran Potti² ¹University of Houston, United States; ²Indian Institute of Technology Delhi, India

Session F17: Power Converter Modeling and Control - 1

1130 | A Simple Common-Mode Voltage Reduction Method Based on Zero-Sequence Voltage Injection for a Back-to-Back Three-Level NPC Converter

Xiaona Xu, Kui Wang, Zedong Zheng, Yongdong Li Tsinghua University, China

1157 | Design and Implementation of Bidirectional Voltage-Multiplier Front-End Converter for Switched Reluctance Motor Drive

Hung-Chi Chen, Yu-Jen Lin National Yang Ming Chiao Tung University, Taiwan

2355 | Efficient Predictive Control Scheme for Optimal Operation of Five Level Four Switch Inverter

Zhanfan Yu, Sally Sajadian Lafayette College, United States

1662 | A Carried-Based Space Vector Modulation Scheme for Si and SiC Based Enhanced Hybrid-ANPC Converter

Satish Belkhode, Anshuman Shukla, Suryanarayana Doolla Indian Institute of Technology Bombay, India

1613 A Commutation Method Free from Inrush Current for the Carrier-Based PWM Controlled Direct Matrix Converter

Sahel Solemanifard, Yan-Xing Chen, Mohammadreza Lak, Tzung-Lin Lee National Sun Yat-sen University, Taiwan

Session F18: Power Converter Modeling and Control – 2

1128 | Reactive Power Control to Minimize Inductor Current for Single Phase Dual Active Bridge DC/DC Converters

Hamid Naseem, Jul-Ki Seok Yeungnam University, Korea

1630 | Predictive Control for an Active Magnetic Bearing System with Sensorless Position Control

Luca Tarisciotti¹, Luca Papini², Constanza Ahumada³, Paolo Bolognesi² ¹University Andres Bello, Chile; ²University of Pisa, Italy; ³University of Chile, Chile

1946 | Analysis and Control of Synchronous Rectification for MHz Class-E Resonant Rectifier with Load Variation

Gyu Cheol Lim, Gwangyol Noh, Jung-Ik Ha Seoul National Univeristy, Korea

1723 | Design Oriented Analysis of Control Loops Interaction in Power Synchronization-Based Voltage Source Converter

Federico Cecati¹, Marco Liserre¹, Yicheng Liao², Xiongfei Wang², Frede Blaabjerg² ¹Christian-Albrechts-Universität zu Kiel, Germany; ²Aalborg University, Denmark

2379 | A Novel Modulation Technique for Pulsating DC Link Multistage Converter with Zero Voltage Transition Based on Different and Unrelated Switching Frequencies

Daniele Marciano, Simone Palazzo, Carmine Abbate, Giovanni Busatto, Annunziata Sanseverino, Davide Tedesco, Francesco Velardi

University of Cassino and Southern Lazio, Italy

Session F19: Power Converter Modeling and Control – 3

1266 A Novel Closed-Form Analytical Model for Zero-Voltage Switching (ZVS) Operation of a Totem Pole PFC with Hysteresis Current Control

Marco Torrisi¹, Sebastiano Messina¹, Mario Cacciato² ¹STMicroelectronics, Italy; ²University of Catania, Italy

1036 | Finite Control Set Model Predictive Control of a DC-DC Boost Converter Ensuring Time-Optimal Regulation and Controlled Output Voltage Deviation

Thibaut Harzig, Brandon Grainger University of Pittsburgh, United States

1912 | A PWM Control Method for Reducing dv/dt in Cascaded Power Converters

Mahima Gupta Portland State University, United States

2404 | Dispatchable Virtual-Oscillator-Controlled Inverters with Current-Limiting and MPPT Capabilities

Minghui Lu¹, Rahul Mallik¹, Brian Johnson¹, Sairaj Dhople² ¹University of Washington, United States; ²University of Minnesota, United States

2304 | Small Signal Stability Analysis of Paralleled Grid-Forming Islanded Voltage Regulated Inverters Using Self Synchronization

Peishuo Mu, Brendan McGrath, Donald Grahame Holmes, Carlos Teixeira RMIT University, Australia

Session F20: Power Converter Modeling and Control – 4

1780 A Carrier-Based PWM to Achieve Minimum Flux of Coupled Inductor for Interleaved Three-Level Inverters

Ruirui Chen¹, Fred Wang^{1,2} ¹The University of Tennessee Knoxville, United States; ²Oak Ridge National Laboratory, United States

2305 | Discrete Time Analysis of Dual Loop Stationary Frame Integral Dominant Voltage Regulated Inverters

Haris Siraj, Brendan McGrath, Inam Ullah Nutkani RMIT University, Australia

1289 | Deep Reinforcement Learning Based Input Voltage Sharing Method for Input-Series Output-Parallel Dual Active Bridge Converter in DC Microgrids

Yu Zeng¹, Ali Maswood¹, Josep Pou¹, Xin Zhang², Changjiang Sun¹, Zhan Li¹, Suvajit Mukherjee², Amit Kumar Gupta², Jiaxin Dong¹

¹Nanyang Technology University, Singapore; ²Zhejiang University, China; ³Rolls-Royce@NTU Corporate Lab, Singapore

1343 An LLC-Resonant Power Decoupling Strategy for a Quad-Active-Bridge Power Channel Based AC/DC Power Electronics Transformer

Xiaohui Li¹, Linqian Cheng¹, Liqun He¹, Chudi Lin¹, Cheng Wang², Zhongkui Zhu¹ ¹Soochow University, China; ²Nanjing University of Science and Technology, China

1595 Zero-Sequence Circulating Current Suppression with Stand-Alone Feedforward Control for Power Hardware-in-the-Loop System

Jun-Hyung Jung, Marius Langwasser, Sante Pugliese, Marco Liserre Christian-Albrechts-Universität zu Kiel, Germany

1353 Variable Frequency Repetitive-Resonant Combined Control for Grid-Tied and Intentional Islanding Operations

Marco di Benedetto, Alessandro Faro, Luca Bigarelli, Alessandro Lidozzi, Luca Solero Roma Tre University, C-PED, Italy

Session F21: Power Converter Stability I

2563 Improved Bilinear Discrete-Time Modeling of the Single-Phase Dual Active Bridge DC-DC Converter

Mohammad Tauquir Iqbal, Ali Iftekhar Maswood, Md Shafquat Ullah Khan, Yu Zeng Nanyang Technological University, Singapore

1596 Interaction Analysis of Current Control Loops in MMC under Asymmetrical Grid Faults

Jianglong Che, Meng Huang, Xiaoming Zha, Ju Sheng, Xikun Fu Wuhan University, China

1184 | Transient Angle Stability Prediction of Virtual Synchronous Generator Using LSTM Neural Network

Yang Shen, Zhikang Shuai, Chao Shen, Xia Shen, Jun Ge Hunan University, China

1155 | Modeling and Rekasius Substitution Stability Analysis of the Multi-Terminal MMC-HVDC Cyber-Physical System

Jingming Cao¹, Chaoyu Dong^{1,2}, Xiaodan Yu¹, Yunfei Mu¹, Qian Xiao¹, Hongjie Jia¹ ¹Tianjin University, China; ²Imperial College London, United Kingdom

1275 | Region-Based Stability Analysis on DC MGs with Consensus-Based Secondary Control and Communication Delay

Yuhua Du¹, Yuxi Men¹, Lizhi Ding¹, Xiaonan Lu¹, Bo Chen², Jianzhe Liu² ¹Temple University, United States; ²Argonne National Laboratory, United States

Session F22: Control Aspects in Power Electronic Systems – 1

2216 | Distributed Control for Modular Multilevel Converters Operated in Switching-Cycle Balancing Mode

Boran Fan¹, Jun Wang², Yu Rong¹, Vladimir Mitrovic¹, Jianghui Yu¹, Slavko Mocevic¹, Rolando Burgos¹, Dushan Boroyevich¹

¹Virginia Polytechnic Institute and State University, United States; ²University of Nebraska Lincoln, United States

1523 | Decoupled Modulation Scheme for Three-Phase Four-Leg Four-Wire Three-Level T-Type Inverter

Li Zhang, Haoxin Yang, Pengfei Tu, Yi Tang Nanyang Technological University, Singapore

1631 | Second-Order Sliding-Mode Controller for Boost Converters with Parameter Estimation

Celiang Deng¹, Rui Ling¹, Dongxue Li² ¹Chongqing University, China; ²Vicor Corporation, United States

2369 | Adaptive Pre-Synchronization and Discrete-Time Implementation for Unified Virtual Oscillator Control

M.A. Awal, Md Rifat Kaisar Rachi, Md Rashed Hassan Bipu, Hui Yu, Iqbal Husain North Carolina State University, United States

2502 An Improved Model-Free Finite Control Set Predictive Power Control for PWM Rectifiers

Haitao Yang¹, Zeyu Min¹, Yongchang Zhang¹, Zeting Wang¹, Dong Jiang² ¹North China University of Technology, China; ²Huazhong University of Science and Technology, China

1345 | Feed-Forward Compensation for Model Predictive Control in Tri-Port Current-Source Medium-Voltage String Inverters for PV-Plus-Storage Farms

Zheng An, Rajendra Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

Session F23: Control Aspects in Power Electronic Systems – 2

1884 A Control Method Based on Power Factor for Improving Output Voltage Stability and Efficiency of LLC Converter in Wide Range of Output Voltage and Load Impedance

Kazuhiro Umetani¹, Kota Shimomura¹, Kenta Yamada¹, Taichi Kawakami², Ishihara Masataka¹, Eiji Hiraki¹ ¹Okayama University, Japan; ²Osaka Prefecture University College of Technology, Japan

1110 An Unequal Power Sharing Strategy for Capacitive- and Inductive-Coupling Inverters in Microgrid

Wenyang Deng, Qinhao Li, Yongjun Zhang, Yingqi Yi, Guoquan Huang South China University of Technology, China

2525 | PWM Control of 3-Phase PFC Vienna Rectifier Derived from an Average Current-Based Control of Single-Phase PFC Boost Converter

Lotfi Beghou, Miteshkuma Popat, Steven MacDonald Leonardo DRS, Canada

2392 Computation-Cost-Invariant Universal Space-Vector Pulse-Width Modulation for Multilevel Inverters

Fa Chen, Wei Qiao, Hongmei Wang, Liyan Qu University of Nebraska Lincoln, United States

1640 Unified Cost Function Model Predictive Control for a Three-Stage Smart Transformer

Luca Tarisciotti¹, Giampaolo Buticchi², Giovanni De Carne³, Yang Jiajun², Chunyang Gu², Patrick Wheeler⁴ ¹University Andres Bello, Chile; ²University of Nottingham Ningbo, China; ³Karlsruhe Institute of Technology, Germany; ⁴University of Nottingham, United Kingdom

Session F24: Control Aspects in Power Electronic Systems – 3

2339 Oversampling Multi-Variable Control for Soft-Switching Solid-State Transformer

Decheng Yan, Aniruddh Marellapudi, Rajendra Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

1068 | Complete Time-Delay Compensation Method for LCL-Type Grid-Connected Inverter with Capacitor-Current Active Damping

Shaojie Li, Hua Lin, Xingwei Wang, Ting Hua Huazhong University of Science and Technology, China

2054 Noise Mitigation in Control Effort in Three-Phase DC-AC Converters Using LQG/LTR Tracker

Jesus D. Vasquez-Plaza, Juan F. Patarroyo-Montenegro, Andres F. Lopez-Chavarro, Enrique A. Sanabria-Torres, Daniel D. Campo-Ossa, Fabio Andrade *University of Puerto Rico, Puerto Rico*

1504 Output Current Limiting for ON-OFF Controlled Very High Frequency Class E DC-DC Converter

Ying Li, Xinbo Ruan, Si Chen Nanjing University of Aeronautics and Astronautics, China

1043 A Constant Current Digital Control Method for Primary-Side Regulation Active-Clamp Flyback Converter in CCM Mode

Chong Wang¹, Daying Sun¹, Xiang Zhang¹, Wenhua Gu¹, Sang Gui² ¹Nanjing University of Science and Technology, China; ²Wuxi Taclink Optoelectronics Technology Company Limited, China

1800 A Comparison between Single-Stage and Dual-Stage High-Gain GaN DC/DC Converters for Li-Ion Battery Modules

Miguel Crespo¹, Pablo García², Konstantin Edl³, Ramy Georgious⁴, Cristian Blanco², Igor Cantero¹ ¹Cegasa, Spain; ²University of Oviedo, Spain; ³IsarAerospace Technologies GmbH, Germany; ⁴ENFASYS, Spain

Session F25: Modeling and Control in Power Electronic Systems

1811 Data-Driven Modeling of Power-Electronics-Based Power Systems considering the Operating Points Variation

Mengfan Zhang¹, Xiongfei Wang¹, Qianwen Xu² ¹Aalborg University, Denmark; ²KTH Royal Institute of Technology, Sweden

1858 | Modeling and Impedance Analysis of a Turbine-Generator-Rectifier System with Electromechanical Dynamic Interactions in More Electric Aircraft

Qing Lin¹, Bo Wen¹, Rolando Burgos¹, John Noon² ¹Virginia Polytechnic Institute and State University, United States; ²Moog Inc., United States

2265 Comparison of Anti-Windup Alternatives for Parallel Controllers

Cristina González Moral¹, Diego Fernández Laborda², Juan M. Guerrero Muñoz², Carlos Rivas¹, David Diaz Reigosa²

¹Electrotécnica Industrial y Naval S.L., Spain; ²University of Oviedo, Spain

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2039 | Adaptive Voltage Positioning Design of Single Stage 48/1V Sigma Converter for Fast Transient Response

Xin Lou¹, Qiang Li¹, Mohamed H. Ahmed² ¹Virginia Polytechnic Institute and State University, United States; ²Texas Instruments, United States

Session F26: Power Converter EMII

2388 Common Mode EMI Analysis in Power Electronics Enabled Power System

Ashik Amin, Tahmid Ibne Mannan, Seungdeog Choi Mississippi State University, United States

1056 A Fully Integrated CM Choke with Improved DM Noise Attenuation

Shiqi Jiang, Panbao Wang, Wei Wang, Wei Wei, Guihua Liu, Dianguo Xu Harbin Institute of Technology, China

1205 | Switching Transient Traced Scheme Based on Sinusoidal Waveform to Reduce EMI for IGBTs

Jianan Chen, Dong Jiang, Wei Sun Huazhong University of Science and Technology, China

1749 | Planar Common-Mode EMI Filter Design and Optimization in a 100-kW SiC-Based Generator-Rectifier System for High-Altitude Operation

Xingchen Zhao, Jiewen Hu, Lakshmi Ravi, Dong Dong, Rolando Burgos Virginia Polytechnic Institute and State University, United States

Session F27: Converter Power Quality I

2140 Quantitative Analysis of Third-Harmonic Neutral-Point Current, Its Impacts, and Mitigation in Three-Level NPC Inverters

D. Venkatramanan¹, V. Nimesh², Brian Johnson², Sairaj Dhople¹ ¹University of Minnesota, United States; ²University of Washington, United States

2289 Evaluation of Objective Functions Used in Bio-Inspired Harmonic Optimization Algorithms for Multilevel Converters

Kaiqi Ren, Zhaoyuan Li, Kehu Yang China University of Mining and Technology, China

1741 | Four-Wire Active Power Filter Based on Asymmetric Cascaded H-Bridges

Samuel C.S. Júnior¹, Cursino Jacobina¹, Edgard L.L. Fabricio² ¹Federal University of Campina Grande, Brazil; ²Federal Institute of Paraíba, Brazil

2262 Improved LCL Filter Design Procedure for Grid-Connected Voltage-Source Inverter System

Xingyu Yang, Mohammad Alathamneh, R.M. Nelms Auburn University, United States

Session F28: Reliability, Diagnostics and Fault Analysis of Power Converters – 1

1307 | A Family of Redundant-Switch Configurations for Improving Fault-Tolerant Feature of Power Converters

Tohid Rahimi¹, Hossein Khoun Jahan², Saeed Peyghami³, Ding Lei¹, Frede Blaabjerg³, Pooya Davari³ ¹Shandong University, China; ²Azarbaijan Regional Electric Company, Iran; ³Aalborg University, Denmark

1535 | Performance Evaluation of the Multiwinding Redundancy Approach in MTB DC-DC Converters

Thiago Pereira, Felix Hoffmann, Marco Liserre Christian-Albrechts-Universität zu Kiel, Germany

1762 | Diagnosing Power Module Degradation with High-Resolution, Data-Driven Methods

Christoph H. van der Broeck¹, Timothy A. Polom², Rik De Doncker³ ¹FEV Europe GmbH, Germany; ²Silicon Austria Labs GmbH, Austria; ³RWTH Aachen University, Germany

2102 | Fault Detection and Management of the Three-Phase 4-Leg Voltage Source Inverter

Mi Tang¹, Pericle Zanchetta¹, M. di Benedetto², A. Lidozzi², L. Solero² ¹University of Nottingham, United Kingdom; ²Roma Tre University, Italy

Session F29: Reliability, Diagnostics and Fault Analysis of Power Converters – 2

1787 | Employing the Generative Adversarial Networks (GAN) for Reliability Assessment of Converters

Amirali Davoodi¹, Saeed Peyghami¹, Yongheng Yang², Tomislav Dragičević³, Frede Blaabjerg¹ ¹Aalborg University, Denmark; ²Zhejiang University, China; ³Technical University of Denmark, Denmark

1298 | Reliability of Wind Turbine Power Modules Using High-Resolution Wind Data Reconstruction: A Digital Twin Concept

Nikolaos Iosifidis¹, Yanghao Zhong¹, Borong Hu², Biyun Chen³, Li Ran¹, Subhash Lakshminarayana¹, Chunjiang Jia⁴, Paul McKeever⁴, Chong Ng⁴

¹University of Warwick, United Kingdom; ²University of Cambridge, United Kingdom; ³Guangxi University, China; ⁴Offshore Renewable Energy Catapult, United Kingdom

1511 | A Comparative Study on Converter-Level On-State Voltage Measurement Circuits for Power Semiconductor Devices

Yingzhou Peng, Huai Wang Aalborg University, Denmark

1384 An Ultra-Fast Short Circuit Protection for Three-Phase GaN Electric Drives

Darian Verdy Retianza, Luc Spooren, Jeroen van Duivenbode, Henk Huisman Eindhoven University of Technology, The Netherlands

1788 | An Application of Feature Engineering and Machine Learning Algorithms on Condition Monitoring of SiC Converters

Afshin Loghmani Moghaddam Toussi, Amir Sajjad Bahman, Francesco Iannuzzo, Frede Blaabjerg Aalborg University, Denmark

Topic G: Electrical Machines

Session G01: Electric Machines in Transportation

1766 Experimental Investigation of a Slotless Skewed Stator with a Composite Winding Layer Suzanne Collins, Philip Mellor, Nick Simpson University of Bristol, United Kingdom

1577 Optimization of an IPM Traction Motor considering the Electric Drive Unit System Requirements Jonathan Godbehere, Mircea Popescu, Melanie Michon *Motor Design Ltd., United Kingdom*

2001 | Comparison of Candidate Designs and Performance Optimization for an Electric Traction Motor Targeting 50 kW/L Power Density

Nanjun Tang, Ian P. Brown Illinois Institute of Technology, United States

2402 | A Comprehensive Comparison of Concentrated Winding and Distributed Continuous Winding Machine Topologies for Hybrid Electric Vehicles

Tausif Husain, Cong Ma, Narges Taran, Zhao Wan BorgWarner Inc., United States

Session G02: Permanent Magnet Machines – 1

1625 Effect of the Interaction of Different Manufacturing Imperfections on the Unbalanced Radial Forces in a Sub-Fractional HP Single-Phase BLDC Motor

Nejat Saed, Stefan Leitner, Annette Mütze Graz University of Technology, Austria

2565 | Determination of the Symmetric Short-Circuit Currents of Synchronous Permanent Magnet Machines Using Magnetostatic Flux Maps

Simone Ferrari, Paolo Ragazzo, Gaetano Dilevrano, Gianmario Pellegrino Politecnico di Torino, Italy

1320 Cogging Torque Analysis in a Series Hybrid Variable Flux Machine Using Lumped Magnetic Circuits

Dwaipayan Barman, Pragasen Pillay Concordia University, Canada

2142 | A Generalized Theory to Predict the Torque Harmonics in Permanent Magnet Machines

Anant K. Singh¹, Ramakrishnan Raja¹, Tomy Sebastian¹, Kaushik Rajashekara² ¹Halla Mechatronics, United States; ²University of Houston, United States

Session G03: Modeling of Electric Machines – 1

2363 | The DQ-Theta Flux Map Model of Synchronous Machines

Simone Ferrari, Gaetano Dilevrano, Paolo Ragazzo, Gianmario Pellegrino Politecnico di Torino, Italy

2272 | Fast Flux Mapping of PM and Synchronous Reluctance Machines: Method Description and Comparison with Full FEA Approach

Matteo Carbonieri¹, Wen L. Soong², Amin Mahmoudi³, Nicola Bianchi¹ ¹University of Padova, Italy; ²University of Adelaide, Australia; ³Flinders University, Australia

1165 | Optimization of a Line-Start Motor for Centrifugal Loads within Premium Efficiency According to IEC Standard

Diego Troncon¹, Luigi Alberti¹, Leone Donazzan², Mauro Daneluzzi², Massimo Trova² ¹University of Padova, Italy; ²Orange1 Spa, Italy

1947 Optimum Design Study on HEFSM Using Variably Magnetizable PM with Low L/D Ratio and Novel PM Arrangement for EV/HEV Traction Applications

Takeshi Okada, Mitsuru Saito, Takashi Kosaka, Hiroaki Matsumori, Nobuyuki Matsui Nagoya Institute of Technology, Japan

Session G04: Permanent Magnet Machines – 2

1411 | Recent Advances in Analysis and Design of Axial Flux Permanent Magnet Electric Machines

F.N.U. Nishanth¹, Joachim Van Verdeghem², Eric L. Severson¹ ¹University of Wisconsin Madison, United States; ²Université catholique de Louvain, Belgium

2085 | Investigation of Asymmetric Axial-Flux Hybrid Excited Electrodynamic Wheels for Maglev Transportation

Wei Qin¹, Ma Yuhua², Lv Gang¹, Wang Fuyao¹, Song Chengrui¹, Zhang Jielong¹ ¹Beijing Jiaotong University, China; ²Taiyuan Institute of China Coal Technology and Engineering Group, China

2372 | A Survey on the Design and Analysis of Magnetic Screws

Doha Mostafa, Hussain A. Hussain Kuwait University, Kuwait

2468 | Examination for a Hybrid Excitation Motor with Reverse Saliency while Having a Field Winding on a Rotor

Ryusyo Nakazawa¹, Masatsugu Takemoto², Satoshi Ogasawara¹, Koji Orikawa² ¹Hokkaido University, Japan; ²Okayama University, Japan

Session G05: Electric Machines: Fault Analysis

2275 | Impact of Static and Dynamic Eccentricity on the Performance of Permanent Magnet Synchronous Machines with Modular Stator Core

Danilo Riquelme¹, Werner Jara¹, Carlos Madariaga², Juan Tapia², Gerd Bramerdorfer³, Javier Riedemann⁴ ¹Pontificia Universidad Católica de Valparaiso, Chile; ²University of Concepcion, Chile; ³Johannes Kepler University Linz, Austria; ⁴The University of Sheffield, United Kingdom

2463 | Performance of Dual Wound Synchronous Reluctance Machines for High Performance Applications considering Winding Faults

Mazharul Chowdhury^{1,2}, Mohammad Islam², Iqbal Husain¹ ¹North Carolina State University, United States; ²Halla Mechatronics, United States

1760 | Test Metrics and Damage Fingerprints in Multistranded Compressed Aluminium Windings

Dominic North, Joshua Hoole, Nick Simpson, Philip Mellor University of Bristol, United Kingdom

1127 An Investigation into the Diagnosis of Interturn Winding Faults in a Scaled-Down DFIG Using the MCSA and DWT of the Stator and Rotor Current

Ester Hamatwi, Paul Barendse, Azeem Khan University of Cape Town, South Africa

1125 | Development of a Test Rig for Fault Studies on a Scaled-Down DFIG

Ester Hamatwi, Paul Barendse, Azeem Khan University of Cape Town, South Africa

Session G06: Thermal Analysis of Electric Machines

1564 | Model Calibration of Oil Jet and Oil Spray Cooling in Electrical Machines with Hairpin Windings

Chuan Liu¹, Yew Chuan Chong², Melanie Michon², James Goss², David Gerada¹, Zeyuan Xu¹, Chris Gerada¹, He Zhang³ ¹University of Nottingham, United Kingdom; ²Motor Design Ltd., United Kingdom; ³University of Nottingham Ningbo, China

2464 Approaches for Improving Lumped Parameter Thermal Networks for Outer Rotor SPM Machines

Daniel Wöckinger¹, Gerd Bramerdorfer¹, Silvio Vaschetto², Andrea Cavagnino², Alberto Tenconi², Wolfgang Amrhein¹, Frank Jeske³

¹Johannes Kepler University Linz, Austria; ²Politecnico di Torino, Italy; ³ebm-papst St. Georgen GmbH & Co. KG, Germany

2182 | Electromagnetic and Thermal Evaluation of Surface-Mounted PM Vernier Machines

Mostafa Ahmadi Darmani¹, Silvio Vaschetto¹, Andrea Cavagnino¹, Mircea Popescu² ¹Politecnico di Torino, Italy; ²Motor Design Ltd., United Kingdom

2183 Comparison of Superposition Equivalent Loading Methods for Induction Machine Temperature Tests

Silvio Vaschetto¹, Emmanuel Agamloh², Federica Graffeo¹, Andrea Cavagnino¹ ¹Politecnico di Torino, Italy; ²Baylor University, United States

Session G07: Electric Machines Materials and Additive Manufacturing

1771 Additive Manufacturing of a Conformal Hybrid-Strand Concentrated Winding Topology for Minimal AC Loss in Electrical Machines

Nick Simpson¹, Jakob Jung², Axel Helm², Phil Mellor¹ ¹University of Bristol, United Kingdom; ²Additive Drives GmbH, Germany

1934 | Multi-Permeability Optimization Approach for the Iron Core of a Synchronous Reluctance Machine - an Application of Additive Manufacturing

Thang Q. Pham, Shanelle N. Foster Michigan State University, United States

1650 | Selection of Soft Magnetic Composite Material for Electrical Machines Using 3D FEA Simulations

Maged Ibrahim¹, Sumeet Singh², Dwaipayan Barman², Fabrice Bernier¹, Jean-Michel Lamarre¹, Serge Grenier³, Pragasen Pillay²

¹National Research Council of Canada, Canada; ²Concordia University, Canada; ³Rio Tinto Fer et Titane, Canada

1722 Flux Switching Permanent Magnet Motor with Metal Amorphous Nanocomposite Soft Magnetic Material and Rare Earth Free Permanent Magnets

Satoru Simizu¹, Kevin Byerly¹, Kyle Schneider¹, Heonyoung Kim², Mark Nations², Sneha Narasimhan², Richard Beddingfield², Subhashish Bhattacharya², Michael E. McHenry¹ ¹Carnegie Mellon University, United States; ²North Carolina State University, United States

Session G08: Loss Analysis in Electric Machines

1048 | Experimental Determination of Conductor Lay and Impact on AC Loss in Volume Manufactured Machines Using X-Ray Computed Tomography

Joshua Hoole¹, Nick Simpson¹, Philip H. Mellor¹, Abdeljalil Daanoune² ¹University of Bristol, United Kingdom; ²hofer powertrain UK Ltd., United Kingdom

1645 | Loss Mitigation Techniques for a Novel Toroidal Permanent Magnet Motor

Maged Ibrahim, Fabrice Bernier, Jean-Michel Lamarre National Research Council of Canada, Canada

1708 | Computationally Efficient Prediction of Statistical Variance in the AC Losses of Multi-Stranded Windings

Philip Mellor, Joshua Hoole, Nick Simpson University of Bristol, United Kingdom

1802 | Experimental Evaluation of Iron Losses in Radial Flux Permanent Magnet Synchronous Machines

Gereon Goldbeck, Gerd Bramerdorfer, Daniel Wöckinger, Christoph Dobler, Wolfgang Amrhein Johannes Kepler University Linz, Austria

Session G09: Noise and Vibrations in Electric Machines

1809 | Effects of Stator Laminations on Acoustic Noise of Electrical Machines Issah Ibrahim, David Alister Lowther

McGill University, Canada

1673 | Analysis of Claw Deflections and Radial Magnetic Forces in Low-Cost Sub-Fractional Horsepower BLDC Claw-Pole Motors

Stefan Leitner, Nejat Saed, Annette Mütze Graz University of Technology, Austria

2319 Dominant Spatial Order Airgap Force Based Current Profiling Coupled with Fast Vibration Prediction in Switched Reluctance Machines for NVH Mitigation

Shuvajit Das¹, Md Ehsanul Haque¹, Anik Chowdhury¹, Yilmaz Sozer¹, David Colavincenzo², Fernando Venegas², Jeffrey Geither²

¹The University of Akron, United States; ²Bendix Commercial Vehicle Systems, United States

2358 | Direct Acceleration Harmonic Control with Current Harmonics Injection Method to Reduce Acoustic Noise and Vibration in Switched Reluctance Machines

Omer Gundogmus, Shuvajit Das, Anik Chowdhury, Abdul Wahab Bandarkar, Yilmaz Sozer *The University of Akron, United States*

Session G10: High Speed and Bearingless Machines

1900 | Normalized Analytical Model of Stresses in a Surface Mounted Permanent Magnet Rotor

Martin Johnson, Kyle Hanson, Eric L. Severson University of Wisconsin Madison, United States

1575 | Requirements for Full Passive Suspension on a Bearingless Motor with Electrodynamic Axial Stabilization and Radial Permanent Magnet Bearings

Guilherme Cavalcante Rubio, Yusuke Fujii, Akira Chiba Tokyo Institute of Technology, Japan

1943 | Principles and Test Result of Novel Full Passive Magnetic Levitation Motor with Diamagnetic Disk

Yoshiki Ozawa¹, Yusuke Fujii¹, Akira Chiba¹, Hiroya Sugimoto², Haruhiko Suzuki³, Hannes Bleuler⁴ ¹Tokyo Institute of Technology, Japan; ²Tokyo Denki University, Japan; ³Fukushima College, Japan; ⁴EPFL, Switzerland

2288 | Analysis and Design of Multi-Phase Combined Windings for Bearingless Machines

Anvar Khamitov, Eric L. Severson University of Wisconsin Madison, United States

Session G11: Electrical Machines – 1

2315 | Design and Comparative Performance Analysis of Transverse Flux and Axial Flux Topologies for Permanent Magnet Synchronous Machines

Anik Chowdhury¹, Shuvajit Das¹, Teppei Tsuda², Naoto Saito², Subrata Saha², Yilmaz Sozer¹ ¹The University of Akron, United States; ²Aisin Corporation, Japan

2441 | Performance Comparison of Step Skew in Interior and Surface-Mount Permanent Magnet Machines

Md Sariful Islam, Amina Shrestha, Mohammad Islam Halla Mechatronics, United States

1672 | Impact of Electric Field on Magnetic Flux Distribution in Electrical Machines with Very Large Size

Siqi Lin, Amir Ebrahimi, Jens Friebe Leibniz Universität Hannover, Germany

2133 | PWM Torque Ripple Compensation for a Dual Three Phase Synchronous Machine

Claudio Bianchini¹, Ambra Torreggiani¹, Matteo Davoli², Alberto Bellini³, Ludovico Ortombina⁴, Nicola Bianchi⁴

¹University of Modena and Reggio Emilia, Italy; ²Raw Power srl, Italy; ³University of Bologna, Italy; ⁴University of Padova, Italy

1458 On Shortening the Numerical Transient in Time-Stepping Finite Element Analysis of Induction Motors under Inter-Turn Short Circuit Faults

Hossein Nejadi Koti, Zahra Valipoor, Hao Chen, Nabeel A. O. Demerdash *Marquette University, United States*

1321 | Design of an Outer Rotor PMSM with Soft Magnetic Composite Stator Core

Mohanraj Muthusamy, Pragasen Pillay Concordia University, Canada

1655 Novel Bent Steel Sheet Strip Based Two-Pole Single-Phase BLDC Motor Topology for Low-Cost Fan Applications

Stefan Leitner, Nejat Saed, Annette Mütze Graz University of Technology, Austria

Session G12: Electrical Machines – 2

2166 | Analytical Model of the Ferromagnetic Properties in Laminations Damaged by Cutting

Zbigniew Gmyrek¹, Andrea Cavagnino² ¹Lodz University of Technology, Poland; ²Politecnico di Torino, Italy

2036 | State Estimation and Run-Out Reduction for Magnetically Levitated Motor Systems

Nathan Petersen, Timothy Slininger, Eric L. Severson University of Wisconsin Madison, United States

1394 | Comparison of the Flux Reversal and Vernier Hybrid Machine for a Hinged Wave Energy Converter

Lewis Chambers¹, Nick Baker¹, Mike Galbraith², Edward Spooner² ¹Newcastle University, United Kingdom; ²Fountain Design Limited, United Kingdom

2045 | Induction Motor Shaft-Frame Voltage Analysis

Fernando J.T.E. Ferreira, José Alberto, Anibal T. de Almeida University of Coimbra, Portugal

2451 | Design Optimization and Performance Analysis of Bifilar Wound Switched Reluctance Motors

Abdul Wahab Bandarkar¹, Muntasir Islam¹, Senol Sancar¹, Lavanya Vadamodala¹, Md Ehsanul Haque¹, Yilmaz Sozer¹, Reginald Garcia²

¹The University of Akron, United States; ²Future Motors, United States

2263 Influence of Constructive Parameters on the Performance of an Axial-Flux Induction Machine with Solid and Magnetically Anisotropic Rotor

Carlos Madariaga¹, Juan Tapia¹, Nicolás Reyes¹, Werner Jara², Michele Degano³ ¹University of Concepcion, Chile; ²Pontificia Universidad Católica de Valparaiso, Chile; ³University of Nottingham, United Kingdom

2191 | A Comparison of Cryogenic-Cooled and Superconducting Electrical Machines

Marco Biasion¹, João F. P. Fernandes², Paulo José da Costa Branco², Silvio Vaschetto¹, Andrea Cavagnino¹, Alberto Tenconi¹

¹Politecnico di Torino, Italy; ²Universidade de Lisboa, Portugal

Session G13: Electrical Machines – 3

1918 | Hybrid Solid State Switch for the Efficiency Improvement in Controlling AC Motors Yuzhi Zhang, Utkarsh Raheja, Pietro Cairoli ABB Inc., United States

1227 | 3D Thermal Network Modeling for Axial-Flux Permanent Magnet Machines with Experimental Validation

Calvin Corey, William Wink Leonard DRS Naval Power Systems, United States

1778 | Modeling of Rotor Flux Barriers in a Brushless Doubly-Fed Reluctance Machine

Shivang Agrawal, Hadi Chouhdry, Arijit Banerjee University of Illinois at Urbana-Champaign, United States

1922 | Partial Discharge Analysis and Insulation Design of High Speed Slotless Machine for Aerospace Applications

Ritvik Chattopadhyay¹, Md Sariful Islam², Rajib Mikail³, Iqbal Husain¹ ¹North Carolina State University, United States; ²Halla Mechatronics, United States; ³ABB, United States

2264 | Frequency-Domain Analysis and Design of Thomson-Coil Actuators

Bruno Lequesne¹, Tyler Holp², Steve Schmalz², Michael Slepian², Hongbin Wang² ¹E-Motors Consulting, LLC, United States; ²Eaton, United States

2193 Design Optimization Procedure of Air-Cored Resonant Induction Machines

Zhao Jin¹, Matteo F. Iacchetti¹, Alexander C. Smith¹, Rajesh P. Deodhar², Yoshiyuki Komi³, Ahmad Anad Abduallah², Chiaki Umemura³

¹The University of Manchester, United Kingdom; ²IMRA Europe SAS UK Research Centre, United Kingdom; ³Aisin Seki Co., Ltd., Japan

2367 | Loss Minimization Control of an Electronic Pole Changing 4-Pole/2-Pole Induction Motor

Taohid Latif¹, Mohamed Zubair M. Jaffar², Iqbal Husain¹ ¹North Carolina State University, United States; ²FEV North America Inc., United States

2330 Modelling and Build of an Integrated Linear Engine Generator Designed for Power Density

Ramn Moeini Korbekandi, Nick J. Baker, Mehmet Kulan, Dawei Wu ¹Newcastle University, United Kingdom; ²University of Birmingham, United Kingdom

Session G14: Modeling of Electric Machines – 2

1242 | Simplified 3-D Hybrid Analytical Modelling of Magnet Temperature Distribution for Surface-Mounted PMSM with Segmented Magnets

Dawei Liang¹, Z.Q. Zhu¹, J.H. Feng², S.Y. Guo², Y.F. Li², A.F. Zhao², J.W. Hou² ¹The University of Sheffield, United Kingdom; ²CRRC Zhuzhou Institute Co. Ltd., China

1494 | Optimization of IM Rotor Bars Inclination Angle Using Analytical Model in Free FEA Software

Thanh Tung To¹, Emad Roshandel², Amin Mahmoudi², Zhi Cao², Solmaz Kahourzade¹ ¹University of South Australia, Australia; ²Flinders University, Australia

1510 | 2D Subdomain Model of the Ladder Linear Induction Machine with considering Saturation Effect

Emad Roshandel¹, Amin Mahmoudi¹, Solmaz Kahourzade² ¹Flinders University, Australia; ²University of South Australia, Australia

2254 | Loss Analysis of Induction Motors Fed by Inverters by Using Simple Models of Major and Minor Hysteresis Loops in Stator and Rotor Cores

Katsumi Yamazaki, Yoshito Sato, Keigo Terauchi Chiba Institute of Technology, Japan

1042 | Analytical Magnetic Model for Variable-Flux Interior Permanent Magnet Synchronous Motors

Bingnan Wang¹, Kyung-Hun Shin¹, Yuki Hidaka², Shota Kondo², Hideaki Arita², Kazumasa Ito² ¹Mitsubishi Electric Research Laboratories, United States; ²Mitsubishi Electric Corporation, Japan

1684 | Hybrid Approach for the Modeling of Magnetic Force Excitations in Multipole Wind Turbine Generators considering Air Gap Imperfections

Alexander Kern¹, Christoph Mülder¹, Kay Hameyer², Jianning Dong¹ ¹*RWTH Aachen University, Germany;* ²*Delft University of Technology, The Netherlands*

Session G15: IPMSM and Synchronous Reluctance Machines

1031 Comparative Study of Three-Phase and Dual Three-Phase Machines considering PWM Effect

Yawei Wang¹, Joshua Taylor², Berker Bilgin² ¹Huazhong University of Science and Technology, China; ²McMaster University, Canada

1204 | Space-Vector State Dynamic Model of the Synchronous Reluctance Motor considering Self, Cross-Saturation and Iron Losses

Angelo Accetta¹, Maurizio Cirrincione², Marcello Pucci¹, Antonino Sferlazza³ ¹CNR-INM, Italy; ²University of the South Pacific, Italy; ³University of Palermo, Italy

1283 Design of Notches on Rotor Surface to Minimize Cogging Torque in Dual-Layered IPMSM by Optimizing Squared Gap Flux Density Waveform

Marika Kobayashi, Shigeo Morimoto, Masayuki Sanada, Yukinori Inoue Osaka Prefecture University, Japan

1617 Permanent Magnet Eddy Current Loss Measurement at Higher Frequency and Temperature Effects under Ideal Sinusoidal and Non-Sinusoidal External Magnetic Fields

Nijan Yogal¹, Christian Lehrmann¹, Markus Henke² ¹Physikalisch-Technische Bundesanstalt, Germany; ²Technical University of Braunschweig, Germany

1852 Combined Dimensional and Topology Optimization of Interior Permanent Magnet Synchronous Machine Rotors Using a Permanent Magnet Function Interpolation Method

Feng Guo, Ian P. Brown Illinois Institute of Technology, United States

2154 Comparative Analysis of Two Different Types of Blended Permanent Magnet Assisted Synchronous Reluctance Machine

Qingqing Ma¹, Ayman EL-Refaie¹, Alireza Fatemi², Thomas Nehl² ¹Marquette University, United States; ²General Motors, United States

2211 | Time-Efficient Multi-Physics Optimization Approaches for the Design of Synchronous Reluctance Motors

Christophe De Gréef¹, Virginie Kluyskens¹, François Henrotte^{1,2}, Christophe Versèle³, Christophe Geuzaine², Bruno Dehez¹ ¹Université catholique de Louvain, Belgium; ²Université de Liège, Belgium; ³Alstom Belgium, Belgium

2241 Variable-Magnetization Interior Permanent Magnet Motor Yield Widely Variable Flux Due to Small Magnetizing Current and Operating at High Power over a Wide Speed Range

Kazuto Sakai, Kyouhei Yoneda, Wataru Suzuki Toyo University, Japan

Session G16: Other Synchronous Machines – 1

1040 | Multi-Objective Optimization of a Dual Stator Brushless Hybrid Excitation Motor Based on Response Surface Model and NSGA2

Xu Wang, Ying Fan, Xingchi Lu, Qiushuo Chen Southeast University, China

1047 | Multi-Objective Optimization Design of Unequal Halbach Array Permanent Magnet Vernier Motor Based on Optimization Algorithm

Qiushuo Chen, Ying Fan, Yutong Lei, Xu Wang Southeast University, China

1261 | Outer and Inner Rotor Line-Start Permanent-Magnet Synchronous Motors: An Electromagnetic and Thermal Comparison Study

M.F. Palangar¹, Wen L. Soong², A. Mahmoudi¹ ¹Flinders University, Australia; ²University of Adelaide, Australia
1388 | Performance Comparison of Large-Scale Design-Optimised Non-Overlap and Overlap Winding Wound Rotor Synchronous Generators

Karen S. Garner, Maarten J. Kamper Stellenbosch University, South Africa

1483 | Study on Power Tracking Excitation Control and Parameters Sensitivity of Dual-Excited Synchronous Generator

Guorui Xu¹, Zhenzhen Wang¹, Weili Li², Yang Zhan¹, Haisen Zhao¹, Yingli Luo¹ ¹North China Electric Power University, China; ²Beijing Jiaotong University, China

1081 | Inter-Turn Short Circuit Fault Identification of Salient Pole Synchronous Generators by Descriptive Paradigm

Hossein Ehya¹, Arne Nysveen¹, Jose A. Antonino-Daviu², Bilal Akin³ ¹Norwegian University of Science and Technology, Norway; ²Universitat Politecnica de Valencia, Spain; ³The University of Texas at Dallas, United States

Session G17: Other Synchronous Machines – 2

1893 | Comparison of Optimized Fault-Tolerant Modular Stator Machines with U-Shape and H-Shape Core Structure

Eddy Perez¹, Werner Jara¹, Carlos Madariaga², Juan Tapia², Gerd Bramerdorfer³, Javier Riedemann⁴, Ilya Petrov⁵, Juha Pyrhönen⁵

¹Pontificia Universidad Católica de Valparaiso, Chile; ²University of Concepcion, Chile; ³Johannes Kepler University Linz, Austria; ⁴The University of Sheffield, United Kingdom; ⁵Lappeenranta University of Technology, Finland

1983 | A Design Procedure for Hybrid Rotor PMSM to Achieve Wide Constant Power Speed Ratio

Dheeraj Bobba, Bulent Sarlioglu University of Wisconsin Madison, United States

2063 | Design and Metamodel-Based Optimization of a High Power Density Wound Field Traction Motor

Nanjun Tang, Dominick Sossong, Ian P. Brown Illinois Institute of Technology, United States

2201 | Design of High Torque Density Reduced-Rare-Earth Consequent Pole PMBLDC Motor for Ceiling Fan

Sharankumar Shastri, Utkarsh Sharma, Bhim Singh Indian Institute of Technology Delhi, India

2558 | Design and Performance Comparison of Nine-Phase Ferrite Spoke Interior Permanent Magnet Machines with Concentrated Windings for Traction Applications

Zhiwei Zhang The Ohio State University, United States

2022 | Performance Comparison of Consequent-Pole and Homopolar Consequent-Pole Bearingless Motors for Low Speed Applications

Hiroya Sugimoto, Miyabi Terashima Tokyo Denki University, Japan

Session G18: Switched Reluctance and Flux Switching Machines

1183 A Novel MTPA Control Strategy for Multiple Torque Component Single Air Gap Magnetless Machines

Shaofeng Jia, Xiaozhuang Dong, Deliang Liang, Shuai Feng Xi'an Jiaotong University, China

1223 Optimal Design of a Novel Double-Stator Linear-Rotary Flux-Switching Permanent-Magnet Generator for Offshore Wind-Wave Energy Conversion

Guozhen Zhang¹, Rui Nie¹, Jikai Si¹, Chun Gan², Yihua Hu³ ¹Zhengzhou University, China; ²Huazhong University of Science and Technology, China; ³University of York, United Kingdom

1979 | Six-Phase Switched Reluctance Motors with Small Torque Ripple, Radial Force Ripple, DC Current Ripple, Copper Loss, and Number of Switches

Takayuki Kusumi, Eiji Hiraki Okayama University, Japan

2150 | Design Methodology and Considerations to Energy Efficient Switched Reluctance Motor for Ceiling Fan Application

Vipin Kumar Singh, Utkarsh Sharma, Bhim Singh, Sharankumar Shastri Indian Institute of Technology Delhi, India

2364 Reliability Models to Estimate Mean Time to Failure of Switched Reluctance Machines

Lavanya Vadamodala, Shuvajit Das, Anik Chowdhury, Abdul Wahab Bandarkar, Md Ehsanul Haque, Yilmaz Sozer

The University of Akron, United States

2472 An Experimental Verification of a Dual-Mode Reluctance Motor for Electric Vehicle Applications

Kyohei Kiyota¹, Haruka Isogai², Kenji Amei², Takahisa Ohji² ¹Tokyo Institute of Technology, Japan; ²University of Toyama, Japan

2532 Analysis and Benchmarking of Radial Flux Cycloidal Magnetic Gears with Reduced Permanent Magnet Piece Count Using Consequent Poles

Matthew Johnson¹, Shima Hasanpour², Matthew C. Gardner³, Hamid A. Toliyat² ¹U.S. Army Research Laboratory, United States; ²Texas A&M University, United States; ³The University of Texas at Dallas, United States

Session G19: Actuators, Axial Flux and Linear Machines

1785 | Statistical Analysis of Manufacturing Tolerances Effect on Axial-Flux Permanent Magnet Machines Cogging Torque

Andrés Escobar¹, Gonzalo Sánchez¹, Werner Jara¹, Carlos Madariaga², Juan Tapia², Michele Degano³, Javier Riedemann⁴

¹Pontificia Universidad Católica de Valparaiso, Chile; ²University of Concepcion, Chile; ³University of Nottingham, United Kingdom; ⁴The University of Sheffield, United Kingdom

2013 | Design Optimization and Experimental Study of Coreless Axial-Flux PM Machines with Wave Winding PCB Stators

Peng Han¹, Damien Lawhorn¹, Yaser Chulaee¹, Donovin Lewis¹, Greg Heins², Dan M. Ionel¹ ¹University of Kentucky, United States; ²Regal Beloit Corporation, Australia

2214 | Design of a High Speed Printed Circuit Board Coreless Axial Flux Permanent Magnet Machine

Federico Marcolini, Giulio De Donato, Fabio Giulii Capponi, Federico Caricchi Sapienza University of Rome, Italy

2160 | Design and Analysis of Double-Sided Thomson Coil Actuator for Extra Fast Opening Operation

Ali Al-Qarni, Ayman EL-Refaie Marquette University, United States

2056 | Permanent Magnet Linear Generator Design for Surface Riding Wave Energy Converters

Farid Naghavi¹, Shrikesh Sheshaprasad¹, Matthew Gardner², Aghamarshana Meduri¹, HeonYong Kang¹, Hamid Toliyat¹

¹Texas A&M University, United States; ²The University of Texas at Dallas, United States

2342 On the Design and Stability of a Reluctance Actuator for Precision Motion Systems

Mohammad Al Saaideh, Natheer Alatawneh, Mohammad Al Janaideh Memorial University, Canada

1172 | Planar Levitation and Propulsion of a Solid-State Craft over Conducting Surfaces

Andrew W. Meldrum, Will Robertson, Wen L. Soong The University of Adelaide, Australia

1075 | Force and Torque Assessment in a Rotating to Linear Motion Magnetic Converter with Gearing Capability

Mauro Andriollo, Simone Bernasconi, Andrea Tortella University of Padova, Italy

Session G20: Electrical Machines – 4

1196 | Additively Manufactured Hollow Conductors for High Specific Power Electrical Machines: Aluminum vs Copper

Fan Wu, Ayman M. EL-Refaie, Ali Al-Qarni Marquette University, United States

1258 | Rotor Loss and Temperature Field of Synchronous Condenser under Single-Phase Short Circuit Fault Affected by Different Materials of Rotor Slot Wedge

Guorui Xu, Peidong Hu, Zhiqiang Li, Haisen Zhao, Yang Zhan North China Electric Power Uninversity, China

1821 | Studies of Measurement Uncertainties in the Characterization of Soft Magnetic Materials and Their Impact on the Electric Machine Performance Prediction

Christoph Dobler, Daniel Wöckinger, Gerd Bramerdorfer, Gereon Goldbeck, Wolfgang Amrhein Johannes Kepler University Linz, Austria

1252 Characteristics Evaluation of Magnetic Multiple Spur Gear for High Speed Motor Drive System

Kohei Aiso¹, Kan Akatsu², Yasuaki Aoyama³ ¹Shibaura Institute of Technology, Japan; ²Yokohama National University, Japan; ³Hitachi, Ltd., Japan

1992 | Design Optimization of a Very High Power Density Motor with a Reluctance Rotor and a Modular Stator Having PMs and Toroidal Windings

Peng Han¹, Murat G. Kesgin¹, Dan M. Ionel¹, Rohan Gosalia², Nakul Shah², Charles J. Flynn², Chandra S. Goli³, Somasundaram Essakiappan³, Madhav Manjrekar³ ¹University of Kentucky, United States; ²QM Power, Inc., United States³University of North Carolina Charlotte, United States

Session G21: Noise and Vibrations in Electric Machines – 2

1212 | Transient Stray Flux Analysis via MUSIC Methods for the Detection of Uniform Gearbox Teeth Wear Faults

Israel Zamudio-Ramirez¹, Roque A. Osornio-Rios¹, Jose Antonino-Daviu² ¹Universidad Autonoma de Queretaro, Mexico; ²Universitat Politecnica de Valencia, Spain

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1302 | Analytical and Experimental Investigations of Magnetostriction Influence on Strain Measurement in Switched Reluctance Machines

Yifei Cai¹, Haruki Sobue¹, Candra Adi Wigna¹, Akira Chiba¹, Kunihiro Senda², Souichiro Yoshizaki³ ¹Tokyo Institute of Technology, Japan; ²JFE Techno-Research Corporation, Japan; ³JFE Steel Corporation, Japan

1585 | Reduction of Both of Radial Force and Torque Ripple in Double Inverter Fed PMSM

Takumi Soeda, Hitoshi Haga Nagaoka University of Technology, Japan

1901 | Study on IPMSM Rotor Shape for Reduction of Harmonics and Vibration

Seung-Hyeon Lee¹, In-Jun Yang², Si-Woo Song², Won-Ho Kim¹, Ik-sang Jang³ ¹Gachon University, Korea; ²Hanyang University, Korea; ³Hyundai Mobis, Korea

1995 Vibration Performance of a Power Electronic Transformer under Different Phase-Shift Modulation Methods

Xiaokang Peng, Zicheng Liu, Dong Jiang Huazhong University of Science and Technology, China

2127 | Demagnetization Detection in PMSMs Using Search Coils Exploiting Machine's Symmetry

Marcos Orviz Zapico¹, David Diaz Reigosa¹, Hyeon Jun Lee², Muhammad Saad Rafaq², Sang Bin Lee², Fernando Briz del Blanco¹

¹University of Oviedo, Spain; ²Korea University, Korea

2163 | Research on High Frequency Vibration Reduction Using Carrier Phase Shifted PWM for 4*3-Phase Windings Permanent Magnet Synchronous Motor

She Yan, Qiyuan Wang, Yunsong Xu, Zicheng Liu, Haiyang Fang, Dong Jiang Huazhong University of Science and Technology, China

2266 | Air Gap Length Detection Method by Analysing Third-Order Harmonic Component of No-Load Line-Line Voltages on Three-Group and Three-Phase PMSMs

Kodai Okazaki¹, Kan Akatsu², Kan Yang² ¹Mitsubishi Electric Co., Ltd., Japan; ²Yokohama National University, Japan

Session G22: Modeling of Electric Machines – 3

1097 | Analytical Modeling and Design Optimization of a Vernier Permanent Magnet Motor

Bingnan Wang¹, Lei Zhou^{1,2}, Hongyu Wang¹, Chungwei Lin¹ ¹Mitsubishi Electric Research Laboratories, United States; ²The University of Texas at Austin, United States

1207 | Characteristic Analysis of IPMSM for EV Traction considering the Effect of Field and Armature Excitations on AC Copper Loss

Soo-Hwan Park, Jun-Woo Chin, Kyoung-Soo Cha, Jun-Yeol Ryu, Myung-Seop Lim *Hanyang University, Korea*

1236 Cost-Efficient 2D Analysis for PM Eddy Current Loss in PMSM by Coupled A- and T-Ω Method

Jun-Yeol Ryu, Jun-Woo Chin, Myung-Seop Lim Hanyang University, Korea

1237 | Efficiency Analysis of Brushless Doubly-Fed Induction Generator Based on Improved Steady-State Equivalent Circuit

Yangsheng Zhang¹, Yi Liu¹, Wei Xu¹, Jose Rodriguez² ¹Huazhong University of Science and Technology, China; ²Universidad Andres Bello, Chile

1646 Development and Evaluation of a Power Hardware-in-the-Loop (PHIL) Emulator Testbench for Aerospace Applications

He Song¹, John Noon¹, Igor Cvetkovic¹, Bo Wen¹, Srdjan Srdic², Gernot Pammer², Dushan Boroyevich¹, Rolando Burgos¹

¹Virginia Polytechnic Institute and State University, United States; ²EGSTON Power Electronics, Austria

2380 | A Generalized Prandtl-Ishlinskii Model for Hysteresis Modeling in Electromagnetic Devices

Mohammad Al Saaideh, Natheer Alatawneh, Mohammad Al Janaideh Memorial University, Canada

Session G23: High Speed Machines - 1

1144 | Rotor Reinforcement in High-Speed Motors by Polymer Composites

Anthony Coppola, Alireza Fatemi General Motors, United States

1537 | Modeling and Optimal Design of a Very High Speed Motor Slotless Technology with Toroidal Winding for Serial Production

Stephane Tavernier¹, Christophe Espanet¹, Gael Andrieux² ¹Moving Magnet Technologies, France; ²Compact Power Motion GmbH, Germany

1687 | Design Approach of Hairpin Winding Motor with High Parallel Path Numbers

Shaohong Zhu, Krzysztof Paciura, Richard Barden *Cummins Inc., United Kingdom*

1697 | Suppression of Winding AC Losses in High-Speed Permanent Magnet Machines by Novel Transposition Technologies

Xinyue Chen, Haiyang Fang, Dawei Li, Ronghai Qu, Xinggang Fan, Haobo Hu Huazhong University of Science and Technology, China

1781 | High Speed Permanent Magnet Machine Design for Optimum Volumetric Power Density

Zhentao Stephen Du, Jagadeesh Tangudu Raytheon Technologies Research Center, United States

1891 | Suspension Force Design Guidelines for Bearingless Permanent Magnet Machines

Bharat Ramadas, Eric L. Severson University of Wisconsin Madison, United States

2073 | Bearingless Generator Design and Optimization for High-Speed Applications

Imthiaz Ahmed, Eric L. Severson University of Wisconsin Madison, United States

Session G24: Electrical Machines – 5

2080 | Modular Fault-Tolerant Machine Design with Improved Electromagnetic Isolation for Urban Air Mobility (UAM) Aircraft

James Swanke, Hao Zeng, Thomas M. Jahns University of Wisconsin Madison, United States

2483 | Design and Analysis of a High Specific Power Outer Rotor Surface Mounted Permanent Magnet Machine Equipped with Additively Manufactured Windings

Ali Al-Qarni, Ayman EL-Refaie, Fan Wu Marquette University, United States

1532 | Hybrid Spoke Permanent Magnet Synchronous Generator Design for Wind Power Generation System

Dong-Ho Kim¹, Su-Yong Kim², In-Jun Yang¹, Si-Woo Song¹, Ju Lee¹, Won-Ho Kim³ ¹Hanyang University, Korea; ²Korea Electronics Technology Institute, Korea; ³Gachon University, Korea

2326 | Performance and Cost Comparison of Conventional- and Vernier PM Wind Generators for Small-Scale Uncontrolled Passive Wind Energy Systems

C.J.J. Labuschagne, M.J. Kamper Stellenbosch University, South Africa

1985 | Modular Modeling and Distributed Control of Permanent-Magnet Modular Motor Drives (MMDs) for Electric Aircraft Propulsion

Hao Zeng, James Swanke, Thomas M. Jahns, Bulent Sarlioglu University of Wisconsin Madison, United States

Session G25: High Speed Machines – 2

2027 On the Modeling of Bearing Voltage and Current in PWM Converter-Fed Electric Machines Using Electromagnetic Finite Element Analysis

Peng Han¹, Yibin Zhang¹, Murat G. Kesgin¹, Greg Heins², Dean Patterson², Mark Thiele², Dan M. Ionel¹ ¹University of Kentucky, United States; ²Regal Beloit Corporation, Australia

2130 | Radial and Axial Inlet and Outlet Design for End Winding Cooling of High-Speed Integrated Flux-Switching Motor-Compressor

Leyue Zhang, Hao Ding, Ahmed Hembel, Gregory Nellis, Bulent Sarlioglu University of Wisconsin Madison, United States

2138 | Application of Flat Rectangular Wire Concentrated Winding for AC Loss Reduction in Electrical Machines

Shaohong Zhu, Krzysztof Paciura, Richard Barden *Cummins Inc., United Kingdom*

2387 | Multiphysics Optimization Model to Design High-Power Ultra-High-Speed Machine for Portable Mechanical Antenna Application

Md Khurshedul Islam, Seungdeog Choi Mississippi State University, United States

2403 | Rotor Design for 2 Pole Bearingless Interior Permanent Magnet Slice Motor

Krishan Kant, David L. Trumper Massachusetts Institute of Technology, United States

2408 | Analytical Calculation of the Mechanical Stress on IPMSM Bridges with Decomposition of the Centrifugal Force

Guoyu Chu¹, Rukmi Dutta¹, John Fletcher¹, Howard Lovatt², M.F. Rahman¹ ¹University of New South Wales, Australia; ²CSIRO, Australia

2492 | Modelling, Analysis and Design Considerations of Multi-Phase Bearingless Permanent Magnet Synchronous Machine

Alessandro Marfoli, Mauro Di Nardo, Seamus Garvey, Michele Degano, Rajiv Vashisht, Robert Turnbull, Chris Gerada University of Nottingham, United Kingdom

Topic H: Electric Drives

Session H01: PM Motor Drives - 1

2120 | Practical Compensation Strategy for Accurate Torque Control in Mass-Produced High-Speed Traction IPM E-Drives

Ran Cao¹, Dakai Hu², Yue Cao¹ ¹Oregon State University, United States; ²The MathWorks, Inc., United States

2186 | Torque-Sensorless Identification of IPMSM Torque Map

Hyung-June Cho¹, Joohyun Lee¹, Yong-Cheol Kwon², Seung-Ki Sul¹ ¹Seoul National University, Korea; ²PLECKO Co., Ltd., Korea

2126 | Direct Flux and Load Angle Vector Control of Permanent Magnet Synchronous Motors

Sandro Rubino, Fabio Mandrile, Luisa Tolosano, Eric Armando, Radu Bojoi Politecnico di Torino, Italy

1888 | Modeling and Compensation of Nonlinearity in Voltage-Source-Inverters Fed Dual Three-Phase PMSM Drives

Kailiang Yu, Zheng Wang, Pengcheng Liu, Yihan Chen Southeast University, China

Session H02: Control for Electric Drives

1079 | Gradient-Based Predictive Pulse Pattern Control

Mirza Abdul Waris Begh¹, Petros Karamanakos¹, Tobias Geyer² ¹Tampere University, Finland; ²ABB System Drives, Switzerland

1136 A Computationally Efficient Robust Direct Model Predictive Control for Medium Voltage Induction Motor Drives

Andrei Tregubov¹, Petros Karamanakos¹, Ludovico Ortombina² ¹Tampere University, Finland; ²University of Padova, Italy

1553 | High Frequency Signal Injection Sensorless Control of Finite-Control-Set Model Predictive Control with Deadbeat Solution

Ximeng Wu¹, Z.Q. Zhu¹, Nuno M.A. Freire² ¹The University of Sheffield, United Kingdom; ²Siemens Gamesa Renewable Energy A/S, Denmark

2375 A Direct Model Predictive Control Strategy for High-Performance Synchronous Reluctance Motor Drives

Jacopo Riccio¹, Petros Karamanakos², Shafiq Odhano³, Mi Tang¹, Mauro Di Nardo¹, Pericle Zanchetta^{1,4} ¹University of Nottingham, United Kingdom; ²Tampere University, Finland; ³Newcastle University, United Kingdom; ⁴Università degli Studi di Pavia, Italy

Session H03: New Technologies, Sensors, Reliability and Testing

1847 | Multi-Core Microcontroller Hardware in the Loop System for Electric Machine Control

Nicholas Krause¹, Antonio Di Gioia², Ian P. Brown¹ ¹Illinois Institute of Technology, United States; ²IEMA US Inc., United States

2075 | Design of a Low-Latency Power Electronics-Based Power-HIL System for an EV Motor Controller

Troy Eskilson, Carl Ngai Man Ho University of Manitoba, Canada

1073 Inverter-Embedded Partial Discharge Testing for Reliability Enhancement of Stator Winding Insulation in Low Voltage Machines

Hyeon-Jun Lee¹, Hanju Kim¹, Jigyun Jeong¹, Kibok Lee², Sang Bin Lee¹, Greg C. Stone³ ¹Korea University, Korea; ²Incheon National University, Korea; ³Iris Power - A Qualitrol Company, Canada

2302 | E-Drive SiC MOSFET Inverter with Self Calibrating VON-Based Junction

Temperature Estimator

Fausto Stella, Paolo Pescetto, Gianmario Pellegrino Politecnico di Torino, Italy

Session H04: Sensorless Control of Electric Drives – 1

2542 | Skin Effect of Squirrel Cage Induction Motor under High Frequency Signal Injection

Joon-Hee Lee¹, Yong-Cheol Kwon², Seung-Ki Sul¹ ¹Seoul National University, Korea; ²Plecko Co, Ltd., Korea

1755 | Design and Analysis of PLL Speed Estimator for Sensorless Rotor-Flux Oriented Control of Induction Motor Drives

Prasun Mishra¹, Cristian Lascu¹, Michael Møller Bech¹, Bjorn Rannestad², Stig Munk-Neilsen ¹Aalborg University, Denmark; ²KK Wind Solutions, Denmark

1030 | High Frequency Injection Transient Disturbance Mitigation for Sensorless Control of Salient Pole Machines

Zhendong Zhang, Jacob Lamb Rockwell Automation, United States

1557 Analysis of Rotor Eccentricity Effects on Saliency Tracking Based Sensorless Control of Permanent Magnet Synchronous Machine

Ximeng Wu¹, Z.Q. Zhu¹, Yang Chen¹, Zhanyuan Wu² ¹The University of Sheffield, United Kingdom; ²Siemens Gamesa Renewable Energy, United Kingdom

Session H05: Sensorless Control of Electric Drives – 2

2493 Switching Frequency Signal-Injection Sensorless Control Robust to Non-Ideal Characteristics of Inverter System for Dual Three-Phase PMSM

Yoon-Ro Lee, Jiwon Yoo, Seung-Ki Sul Seoul National University, Korea

2510 Gain Scheduling of Full-Order Flux Observer for Sensorless PMSM Drives considering Magnetic Spatial Harmonics

Jiwon Yoo, Inhwi Hwang, Yoon-Ro Lee, Seung-Ki Sul Seoul National University, Korea

2519 | Rotor Initial Position Estimation Method of SMPMSM with Polarity Detection Based on Cross-Coupling Inductance Variation

Hwigon Kim, Joohyun Lee, Seung-Ki Sul Seoul National University, Korea

2257 Sensorless Control of a High-Speed PMSM with Rapid Acceleration for Air Compressors Using a High-Order Extended State Observer

Mingjin Hu¹, Wenfei Yu¹, Jiaxing Lei¹, Zheng Wu¹, Wei Hua², Yinfeng Hu² ¹Southeast University - Nanjing, China; ²Southeast University - Yancheng, China

Session H06: Electric Drive Switching

2122 Advances on Analysis, Modeling and Accurate Self-Commissioning Compensation of Inverter Dead-Time Distortion Based on a Physical Model

Massimiliano Biason¹, Sandro Calligaro², Mattia Iurich¹, Roberto Petrella¹, Amir Shahdadi¹ ¹University of Udine, Italy; ²Free University of Bozen, Italy

1495 | A New Space-Vector PWM Technique of Two-Level Inverter Fed Asymmetrical Six-Phase Machine: Analysis and Performance Evaluation

Sayan Paul, Kaushik Basu Indian Institute of Science, India

1963 New PWM Switching Strategy for a Dual Inverter Fed Open Winding Motor Drive System

Yuto Maeda¹, Hiroaki Matsumori¹, Takashi Kosaka¹, Nobuyuki Matsui¹, Hiroki Iwai², Teppei Tsuda², Subrata Saha²

¹Nagoya Institute of Technology, Japan; ²Aisin Corporation, Japan

2141 | A Real-Time Sinusoidal Voltage-Adjustment Power Supply System Based on Interleaved BUCK Converters with Enhanced Reference-Tracking Capability

Xiaofeng Ding, Zhihui Zhao, Zhenyu Shan, Xinrong Song Beihang University, China

Session H07: PM Motor Drives - 2

2246 Variable DC-Link Control Strategy for Maximum Efficiency of Traction Motor Drives

Paolo Pescetto¹, Andres Sierra-Gonzalez², Elena Trancho², Gianmario Pellegrino¹ ¹Politecnico di Torino, Italy; ²Basque Research and Technology Alliance, Spain

2381 | Control of Dual Three-Phase IPMSM Drive with Cascaded DC-Link Capacitors for Third Generation EV

Andres Sierra-Gonzalez¹, Paolo Pescetto², Elena Trancho¹, Edorta Ibarra³, Gianmario Pellegrino², Fernando Alvarez-Gonzalez¹

¹Basque Research and Technology Alliance, Spain; ²Politecnico di Torino, Italy; ³University of the Basque Country, Spain

2261 A Novel Low-Speed Direct-Drive PMSM Control Strategy Based on a Two-DOF Structure

Kun Cai¹, Jie Hu¹, Mingjin Hu¹, Danfeng Sun², Huajun Zhou², Kai Liu¹, Hao Hua³, Wei Hua¹ ¹Southeast University, China; ²Shanghai Aerospace Control Technology Institute, China; ³Shanghai Jiao Tong University, China

2445 | Integrated High-Frequency SiC Based Modular Multi Three-Phase PMSM Drive for Automotive Range Extender

Nicola Bianchi¹, Sandro Calligaro², Giorgio Maldini³, Mattia Marson⁴, Mattia Iurich⁵, Roberto Petrella⁵ ¹University of Padova, Italy; ²Free University of Bozen, Italy; ³Metasystem s.p.a., Italy; ⁴Koala Electronics s.r.l., Italy; ⁵University of Udine, Italy

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2368 | Selection of Rotor Position Sensor Resolution for Variable Frequency Drives Utilizing Fixed-Position-Based Speed Estimation

Luigi Danilo Tornello¹, Giacomo Scelba¹, Giulio De Donato², Fabio Giulii Capponi², Giuseppe Scarcella¹, Mark Harbaugh³

¹University of Catania, Italy; ²Sapienza University of Rome, Italy; ³Rockwell Automation, United States

1262 A Simple PWM Strategy for Three-Level NPC Converters in Aircraft Electric Starter/ Generator System with Improved DC-Link Voltage Utilization and Reduced Common-Mode Voltage

Feng Guo¹, Tao Yang¹, Seang Shen Yeoh¹, Serhiy Bozhko¹, Patrick Wheeler¹, Ahmed M. Diab² ¹University of Nottingham, United Kingdom; ²University of Nottingham Ningbo, China

2249 | Performance Analysis of a Fault Isolation System for Fault-Tolerant Voltage-Fed PWM Motor Drives

Luigi Danilo Tornello¹, Giacomo Scelba¹, Andrea Spampinato², Gianluigi Forte² ¹University of Catania, Italy; ²STMicroelectronics, Italy

1846 | Evaluation of Topologies and Active Control Methods for Overvoltage Mitigation in SiC-Based Motor Drives

Mohamed S. Diab, Wenzhi Zhou, Xibo Yuan University of Bristol, United Kingdom

1582 Design and Benchmark of Passive and Active Inductors for a 7.5 kW Motor Drive

Zhe Kong¹, Qian Wang², Guorong Zhu¹, Haoran Wang², Huai Wang² ¹Wuhan University of Technology, China; ²Aalborg University, Denmark

Session H09: Induction Motor Drives

1813 A Multilevel Open-End Winding Six-Phase Induction Motor Drive Topology Based on Three Two-Level Three-Phase Inverters

Emerson de L. Soares¹, Ayslan C.N. Maia², Cursino B. Jacobina¹, Nayara B. de Freitas³, Nady Rocha⁴, Antonio M.N. Lima¹

¹Federal University of Campina Grande, Brazil; ²Federal Institute of Education, Science and Technology of Ceará, Brazil; ³INESC TEC, Portugal; ⁴Federal University of Paraíba, Brazil

2094 | Analysis and Control of Six Switch Inverter Symmetrical Two-Phase Induction Motor (STPIM) Drive with Front End Single-Phase Boost Rectifier

Josiah O. Haruna, Olorunfemi Ojo Tennessee Tech University, United States

1578 | Evaluation of the Output Voltage Harmonics of Typical PWM Methods in a Dual-Inverter Fed Open-End Winding Induction Motor with a Floating-Capacitor

Akihito Mizukoshi¹, Hitoshi Haga¹, Eiichi Sakasegawa² ¹Nagaoka University of Technology, Japan; ²National Institute of Technology, Kagoshima College, Japan

1996 | Parameter Identification of Inverter-Fed Induction Machines at Standstill Based on Signal Injection

Anh Tan Nguyen, Van Nam Nguyen, Dong-Choon Lee Yeungnam University, Korea

1478 | Regenerating-Mode Stabilization of Indirect-Field-Orientation-Controlled Induction Motor for Inertial Load Drive

Masaki Nagataki¹, Keiichiro Kondo¹, Osamu Yamazaki², Kazuaki Yuki², Yosuke Nakazawa² ¹Waseda University, Japan; ²Toshiba Corporation, Japan

2357 | Field Weakening Operation of Open-Winding Induction Motor Dual Drives Using a Floating Capacitor Bridge Inverter

Saeed Wdaan, Chatumal Perera, John Salmon University of Alberta, Canada

2297 | Torque Pulsation Reduction in Three-Phase Doubly Fed Induction Machine for Wireless Energy Transfer Applications

Gabriele Rizzoli, Michele Mengoni, Giacomo Sala, Luca Zarri, Angelo Tani University of Bologna, Italy

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1408 | Improved Controller Optimization of Flux-Weakening Strategy for Salient Permanent-Magnet Synchronous Motor Based on Genetic Algorithm

Moustafa Magdi Ismail^{1,2}, Wei Xu², Yi Liu², Abdul Khalique Junejo³, Mohamed G. Hussien⁴ ¹Minia University, Egypt; ²Huazhong University of Science and Technology, China; ³Quaid-e-Awam University of Engineering, Science and Technology, Pakistan; ⁴Tanta University, Egypt

2347 | Model Reference Adaptive Current Control Method for Dual Three Phase Permanent Magnet Synchronous Machine

Anik Chowdhury, Md Ehsanul Haque, Shuvajit Das, Okan Boler, Yilmaz Sozer The University of Akron, United States

2550 Comprehensive Efficiency Analysis of Current Source Inverter Based on CSI-Type Double Pulse Test and Genetic Algorithm

Feida Chen, Sangwhee Lee, Thomas M. Jahns, Bulent Sarlioglu University of Wisconsin Madison, United States

1965 | Torque Ripple Minimization of PMSM Drive with Speed Ripple Feedback considering Non-Linearities of PMSM

Byung Ryang Park, Gyu Cheol Lim, Jonghun Choi, Cheolmin Hwang, Jung-Ik Ha Seoul National University, Korea

1340 | Deadbeat Predictive Current Control considering Inverter Nonlinearity in Permanent Magnet Synchronous Machine

Xin Yuan, Jiahao Chen, Yuefei Zuo, Christopher H.T. Lee Nanyang Technological University, Singapore

1364 | Harmonics Compensation for High Reliability under Grid Voltage Distortion Using Electrolytic Capacitor-Less Dual Inverter with Periodical Torque Fluctuation Load

Yuuki Ohno, Hitoshi Haga Nagaoka University of Technology, Japan

2365 | Hall-Effect Sensors as Multipurpose Devices to Control, Monitor and Diagnose AC Permanent Magnet Synchronous Machines

Daniel Fernandez¹, David Reigosa¹, Yonghyun Park², Sangbin Lee³, Fernando Briz¹ ¹University of Oviedo, Spain; ²Electree Co. Ltd., Korea; ³Korea University, Korea

Session H11: Control of Electric Drives – 1

1166 Input-Output Feedback Linearization Control with On-Line Inductances Estimation of Synchronous Reluctance Motors

Angelo Accetta¹, Maurizio Cirrincione², Filippo D'Ippolito³, Marcello Pucci¹, Antonino Sferlazza³ ¹CNR-INM, Italy; ²University of the South Pacific, Fiji; ³University of Palermo, Italy

2327 | Pseudo Multi Level Space Vector Modulation Technique for Multi Source Inverters

O. Salari, K. Hashtrudi Zaad, A. Bakhshai, P. Jain Queen's University, Canada

1855 | Comparison of Fault-Tolerant Control Methods Reducing Torque Ripple of Multi-Phase BLDC Motor Drive System under Open-Phase Faults

Hyeoncheol Park, Taeyun Kim, Yongsug Suh Jeonbuk National University, Korea

1921 | Parameter Sensitivity of Deadbeat Flux Vector Control for Six-Step Operation of Permanent Magnet Synchronous Machines

Marc S. Petit¹, Bulent Sarlioglu² ¹Miller Electric Mfg., LLC, United States; ²University of Wisconsin Madison, United States

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1814 | Flux-Linkage Based Fundamental and Harmonic Current Control of Saturated Salient **AC Machines**

Vinod Chowdary Peddi, Anno Yoo, Brent S. Gagas General Motors, United States

2276 Driving Cycle Based Modelling and Control of Solar-Battery Fed RelSyn Motor Drive for **Light Electric Vehicle with Energy Regeneration**

Saurabh Mishra, Anshul Varshney, Bhim Singh, Hina Parveen Indian Institute of Technology Delhi, India

Session H12: Control of Electric Drives – 2

2153 | Finite Control Set Model-Based Predictive Current Control with Variable Sampling Interval for Induction Machine

Qing Chen¹, Xiaonan Gao¹, Peter Stolze², Ralph Kennel¹ ¹Technical University of Munich, Germany; ²MAN Energy Solutions SE, Germany

1838 | Two-Degree-of-Freedom Quasi-PIR Controller for Smooth Speed Control of Permanent **Magnet Vernier Machine**

Yuefei Zuo, Jingwei Zhu, Xin Yuan, Christopher H.T. Lee Nanyang Technological University, Singapore

2491 | Online PI Current Controller Tuning Based on Machine High-Frequency Parameters

Diego F. Laborda, Juan Manuel Guerrero, Marcos Orviz Zapico, Daniel Fernández, David Díaz Reigosa, Fernando Briz

University of Oviedo, Spain

1799 | Parameter-Free Predictive Current Control for Synchronous Machine Controlled by **High-Frequency Signal Injection Sensorless**

Hyeon-Seong Kim, Kibok Lee Incheon National University, Korea

1386 Three-Phase Motor Drive Topology with the Fault-Tolerant Capability of Open-Circuit on the Multiplexing Bridge

Xiangwen Sun, Zicheng Liu, Zhekai Li, Qianchen Sun, An Li, Dong Jiang Huazhong University of Science and Technology, China

1608 Sensorless Acceleration Estimation and Acceleration Feedback Control to Improve the Disturbance Torque Rejection on Galvano Motor System

Yi-Jen Lin¹, Po-Huan Chou², Chi-Jun Wu¹, Shih-Chin Yang¹ ¹National Taiwan University, Taiwan; ²Industrial Technology Research Institute, Taiwan

Session H13: Sensorless Control of Drives

1186 | High-Precision Sensorless Control Method with Fast Dynamic Response for High-Speed PMSM Based on Discrete-Time Back-EMF Deadbeat Observer

Zhihao Song¹, Wenxi Yao¹, Kevin Lee² ¹Zhejiang University, China; ²Eaton, United States

2354 Phase Current Sensorless Control of Switched Reluctance Machines Using **Dynamic Interleaving**

Md Ehsanul Haque¹, Anik Chowdhury¹, Okan Boler¹, Shuvajit Das¹, Yilmaz Sozer¹, Fernando Venegas², David Colavincenzo²

¹The University of Akron, United States; ²Bendix Commercial Vehicle Systems, United States

1084 | Low-Speed Position Estimation of the Brushless Synchronous Starter/Generator by Using the Main Exciter as a Quasi Resolver

Shuai Mao¹, Jianqiu Li¹, Xu Han², Weiguo Liu², Zunyan Hu¹, Liangfei Xu¹, Minggao Ouyang¹ ¹Tsinghua University, China; ²Northwestern Polytechnical University, China

1085 | Adaptive Observer Design for Wide-Speed Sensorless IPMSM Drives via Equivalent Control Method

Qilian Lin, Ling Liu, Han Song, Dongsong Jin, Deliang Liang, Shaofeng Jia *Xi'an Jiaotong University, China*

1531 | Experimental Investigation on the Self-Sensing Capability of Synchronous Machines for Signal Injection Sensorless Drives

Matteo Berto, Luigi Alberti, Silverio Bolognani University of Padova, Italy

2128 Use HF Signal Injection for Simultaneous Rotor Angle, Torque and Temperature Estimation in PMSMs

Marcos Orviz Zapico, David Diaz Reigosa, Diego Fernández Laborda, Maria Martínez Gómez, Juan Manuel Guerrero Muñoz, Fernando Briz del Blanco University of Oviedo, Spain

1694 | Rotor Temperature Estimation for Saliency-Based Control of Induction Motors Using Symmetrical Transient Reluctance

Eduardo Rodriguez Montero¹, Markus Vogelsberger², Thomas Wolbank¹ ¹Technical University of Vienna, Austria; ²Bombardier Transportation Austria GmbH, Austria

Session H14: Diagnostics, Fault Tolerance and Reliability in Electric Drives

1957 | Current-Sensor and Switch-Open Fault Diagnosis Based on Discriminative Machine Learning Model for PMSM Driving System

Jae-Hoon Shim¹, Jun Lee², Jung-Ik Ha¹ ¹Seoul National University, Korea; ²Samsung Electronics, Korea

1344 | A Novel SPWM-Based Common-Mode Voltage Elimination Modulation Method for Dual Three-Phase Motors

Yang Huang¹, Ximu Zhang¹, Jared Walden¹, Hua Bai¹, Fanning Jin², Xiaodong Shi², Bing Cheng² ¹University of Tennessee Knoxville, United States; ²Mercedes-Benz R&D North America, Inc., United States

1210 | A Novel Ring-Shaped Fractal Antenna for Partial Discharge Detection

Yinka Leo Ogundiran, Antonio Griffo, Shubham Sundeep, Fernando Alvarez Gonzalez, Jiabin Wang The University of Sheffield, United Kingdom

1234 An On-Line DC-Link Capacitance Estimation Method for Motor Drive System Based on Intermittent Active Control Strategy

Tianze Meng, Pinjia Zhang Tsinghua University, China

2078 | Time-Domain Based Diagnosis of Stator Incipient Faults in DTC Driven Induction Motors Using External ElectroMagnetic Signatures

Hassan H. Eldeeb^{1,2,3}, Caleb Secrest¹, Haisen Zhao^{2,4}, Osama A. Mohammed² ¹BorgWarner Inc., United States; ²Florida International University, United States; ³Ain Shams University, Egypt; ⁴North China Electric Power University, China

2204 Comparative Analysis of Torque Pulsations Measurement Methods for PMSM Drives Maria Martinez, Diego F. Laborda, David Reigosa, Fernando Briz *University of Oviedo, Spain*

1198 Vibration and Loss Reduction of Permanent Magnet Synchronous Motor Driven by Synchronous PWM Control with Carrier Wave Phase Shifts

Takafumi Hara¹, Shun Taniguchi¹, Toshiyuki Ajima¹, Masanori Sawahata¹, Masahiro Hori¹, Tsukagoshi Takaya², Katsuhiro Hoshino² ¹Hitachi, Ltd., Japan; ²Hitachi Astemo, Ltd., Japan

1524 | Transient Hall Sensor Fault Compensation for Hall-Based Field Oriented Control Motor Drive

Heng-Ching Lin, Jyun-You Chen, Guan-Ren Chen, Shih-Chin Yang National Taiwan University, Taiwan

Session H15: Medium Voltage and Drive Applications

1272 Novel Characterization of Si- and SiC-Based PWM Inverter Bearing Currents Using Probability Density Functions

Ryan Collin, Alex Yokochi, Annette von Jouanne Baylor University, United States

2222 | Development of Inverter Duty Motor Bearings for Si- and SiC-Based Variable Frequency Drive Applications Including Advanced 4D Finite Element Modeling

Annette von Jouanne, Ryan Collin, Madeline Stephens, Ben Phillips, Hellen Chen, Caleb Li, Emmanuel Agamloh, Alex Yokochi Baylor University, United States

1812 | Effect of Neutral Grounding Resistance on Grid-Tie Active Front End Power Converter Systems under Normal and Abnormal Conditions

Zhijun Liu, Gary L. Skibinski Rockwell Automation, United States

2308 | Adjustable Speed Medium Voltage Drive Fed by a 24-Pulse AC-DC Converter and 5-Level Multi-Level Inverter

Rohit Kumar, Bhim Singh, Piyush Kant, Vivek Narayanan Indian Institute of Technology Delhi, India

1135 | Modeling of Phase-Shifting Transformer Based on Space-Phasor Notations for the Applications in Medium Voltage Drives

Srinivas Gude¹, River Chen¹, Sam Li¹, Yongqiang Lang² ¹Delta Electronics Inc., Taiwan; ²Delta Electronics Inc., China

1588 An Energy Recovery Scheme for RCD Snubber in the Series Configuration of IGBTs

Mostafa Zarghani¹, Saeed Peyghami², Francesco Iannuzzo², Frede Blaabjerg², Shahriyar Kaboli¹ ¹Sharif University of Technology, Iran; ²Aalborg University, Denmark

Session H16: Electric Drive Applications

1382 Adaptive-Observer-Based Sensor Fault Resilient Control for Single-Phase Grid-Connected Converters in High-Speed Railway Traction Systems

Jinhui Xia¹, Ze Li², Yuanbo Guo², Xiaohua Zhang² ¹Zhejiang University, China; ²Dalian University of Technology, China

2037 A Stable and Robust DC Power System for More Electric Aircraft

Galina Mirzaeva¹, Dmitry Miller¹, Graham Goodwin¹, Patrick Wheeler² ¹The University of Newcastle, Australia; ²University of Nottingham, United Kingdom

1417 A 1.2 kV 100 kW Four-Level ANPC Inverter with SiC Power Modules and Capacitor Voltage Balance for EV Traction Applications

Jun Wang, Ian Laird, Xibo Yuan, Wenzhi Zhou University of Bristol, United Kingdom

2212 | BEV Range Improvement Using Highly Efficient Downsized DC-DC Converter

Lei Hao¹, Chandra Namuduri¹, Chengwu Duan², Suresh Gopalakrishnan¹, Norman Bucknor¹ ¹General Motors, United States; ²General Motors, China

1704 | Iron Losses Impact on High-Speed Drives

Emilio Carfagna¹, Emilio Lorenzani¹, Karthik Debbadi², Sante Pugliese², Marco Liserre² ¹University of Modena and Reggio Emilia, Italy; ²Christian-Albrechts-Universität zu Kiel, Germany

1268 | Integration and Cooling Strategies for WBG-Based Current-Source Inverters-Based Motor Drives

Woongkul Lee, Renato A. Torres, Hang Dai, Thomas M. Jahns, Bulent Sarlioglu University of Wisconsin Madison, United States

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Session 101: Power Module and Integration – In Memory of Prof. Braham Ferreira

2538 | EMI Propagation Path Modeling of 3-Level T-Type NPC Power Module with Stacked DBC Enabled EMI Shielding

Asif Imran Emon¹, Mustafeez Ul Hassan¹, Abdul Basit Mirza¹, Zhao Yuan², Fang Luo¹ ¹Stony Brook University, United States; ²University of Arkansas, United States

1367 | Design and Analysis of a PCB-Embedded 1.2 kV SiC Half-Bridge Module

Jack Knoll¹, Gibong Son¹, Christina DiMarino¹, Qiang Li¹, Hannes Stahr², Mike Morianz² ¹Virginia Polytechnic Institute and State University, United States; ²Austria Technologie & Systemtechnik AG, Austria

2117 | Design, Fabrication, and Testing of a 1.7 kV SiC Switching Cell for a High-Density Integrated Power Electronics Building Block (iPEBB)

Narayanan Rajagopal¹, Christina DiMarino¹, Rolando Burgos¹, Taha Moaz¹, Igor Cvetkovic¹, Dushan Boroyevich¹, Olivier Mathieu² ¹Virginia Polytechnic Institute and State University, United States; ²Rogers Corporation, Germany

2398 | Layout, Packaging, and Efficiency Implications of a 1.7 kV Hybrid Si/SiC Reverse Blocking Switch Module in Soft-Switching Current Source Converters

Aniruddh Marellapudi, Bradford Houska, Mickael J. Mauger, Prasad Kandula, Deepak Divan *Georgia Institute of Technology, United States*

1377 A Novel SiC MOSFET Module for High-Power Soft-Switching Converter

Xiaolei Luo, Min Chen Zhejiang University, China

1960 Paralleling of Four 650V/60A GaN HEMTs for High Power Traction Drive Applications

Partha Pratim Das, Subhransu Satpathy, Suyash Sushilkumar Shah, Subhashish Bhattacharya, Victor Veliadis North Carolina State University, United States

Session IO2: WBG and UWBG Devices

2503 | High Voltage Output Characteristics and Short Circuit Robustness of HV SiC MOSFETs

Ashish Kumar, Raj Kokkonda Kumar, Subhashish Bhattacharya, Jayant Baliga, Victor Veliadis North Carolina State University, United States

1744 | 3.3 kV SiC JBS Diodes Employing a P2O5 Surface Passivation Treatment to Improve Electrical Characteristics

Arne Benjamin Renz¹, Oliver James Vavasour¹, Vishal Ajit Shah¹, Vasantha Pathirana², Tanya Trajkovic², Yeganeh Bonyadi³, Ruizhu Wu¹, Jose Angel Ortiz-Gonzalez¹, Xiaoyun Rong¹, Guy William Clarke Baker¹, Philip Mawby¹, Peter Michael Gammon¹

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2406 Static and Dynamic Characterization of 650 V GaN E-HEMTs in Room and Cryogenic Environments

Mahmoud Mehrabankhomartash¹, Shiyuan Yin¹, Alfonso J. Cruz¹, Lukas Graber¹, Maryam Saeedifard¹, Simon Evans², Florian Kapaun³, Ivan Revel², Gerhard Steiner³, Ludovic Ybanez², Chanyeop Park⁴ ¹Georgia Institute of Technology, United States; ²Airbus, France; ³Airbus, Germany; ⁴Mississippi State University, United States

1827 | Performance Evaluation of Future T-Type PFC Rectifier and Inverter Systems with Monolithic Bidirectional 600V GaN Switches

F. Vollmaier¹, N. Nain², J. Huber², J.W. Kolar², K.K. Leong³, B. Pandya³ ¹Silicon Austria Labs GmbH, Austria; ²ETH Zürich, Switzerland; ³Infineon Technologies AG, Austria

1350 | Performance Evaluation of 650 V SiC MOSFET under Low Temperature Operation

Yuqi Wei, Md Maksudul Hossain, Xia Du, Rosten Sweeting, Alan Mantooth University of Arkansas, United States

1432 Active-Device Losses in Resonant Power Converters: A Case Study with Class-E Inverters

Nirmana Perera, Remco van Erp, Jessy Ançay, Armin Jafari, Elison Matioli École Polytechnique Fédérale de Lausanne, Switzerland

Session I03: Passive Components

2269 | Permeability Engineered Soft Magnetics for Power Dense Energy Conversion

Kevin Byerly¹, Satoru Simizu¹, Michael E. McHenry¹, Paul R. Ohodnicki², R. Byron Beddingfield³, Subhashish Bhattacharya³, Geraldo Nojima⁴ ¹Carnegie Mellon University, United States; ²University of Pittsburgh, United States; ³North Carolina State University, United States; ⁴Eaton, United States

2409 Characterization of Inductor Magnetic Cores for Cryogenic Applications

Shiyuan Yin¹, Mahmoud Mehrabankhomartash¹, Alfonso J. Cruz¹, Lukas Graber¹, Maryam Saeedifard¹, Simon Evans², Florian Kapaun³, Ivan Revel², Gerhard Steiner³, Ludovic Ybanez², Chanyeop Park⁴ ¹Georgia Institute of Technology, United States; ²Airbus, France; ³Airbus, Germany; ⁴Mississippi State University, United States

1369 | A Novel Measurement Method for DC Superimposition Characteristics of Three-Phase Coupled Inductors with Powder Cores

Yamato Mishima¹, Tatsuya Aoki¹, Kazuya Matsuta¹, Jun Imaoka¹, Masayoshi Yamamoto¹, Kosuke Yoshimoto² ¹Nagoya University, Japan; ²Daido Steel Co., Ltd., Japan

1638 | Condition Monitoring for Capacitors in Modular Multilevel Converter Based on High-Frequency Transient Analysis

Hongjian Xia¹, Yi Zhang², Huai Wang², Minyou Chen¹, Wei Lai¹, Dan Luo¹, Yulong Hu¹ ¹Chongqing University, China; ²Aalborg University, Denmark

Session IO4: Gate Drivers – 1

1293 A Low Level-Clamped Active Gate Driver for Crosstalk Suppression of SiC MOSFET Based on dv/dt Detection

Hong Li, Zhidong Qiu, Tiancong Shao, Yangbin Zeng, Haitao Du, Chengdong Yin *Beijing Jiaotong University, China*

1113 Investigations on Online Junction Temperature Measurement for SiC-MOSFETs Using the Gate-Signal Injection Method

Johannes Ruthardt, David Hirning, Kanuj Sharma, Maximilian Nitzsche, Philipp Ziegler, Manuel Fischer, Jörg Roth-Stielow University of Stuttgart, Germany

1806 A High-Efficiency Charge-Pump Gate Drive Power Delivery Technique for Flying Capacitor Multi-Level Converters with Wide Operating Range

Rahul K. Iyer, Nathan M. Ellis, Zichao Ye, Robert C.N. Pilawa-Podgurski University of California Berkeley, United States

2541 Noise Immune Cascaded Gate Driver Solution for Driving High Speed GaN Power Devices

Abdul Basit Mirza, Asif Imran Emon, Sama Salehi Vala, Fang Luo Stony Brook University, United States

Session 105: Gate Drivers – 2

2240 A Closed-Loop Current Source Gate Driver with Active Voltage Balancing Control for Series-Connected GaN HEMTs

Zhengda Zhang, Chunhui Liu, Yunpeng Si, Yifu Liu, Mengzhi Wang, Qin Lei Arizona State University, United States

2498 Design and Selection of Optimal Inductor for Current Source Gate Drivers

Rajat Shahane, Satish Belkhode, Anshuman Shukla Indian Institute of Technology Bombay, India

1941 | Gate Driver for 10 kV SiC MOSFET Power Module with High-Speed Current Sensing

Mark Cairnie, Christina DiMarino Virginia Polytechnic Institute and State University, United States

1881 Active Control and Gate-Driver Design for Voltage Balancing of Both MOSFETs and Body-Diodes in Series-Connected SiC MOSFETs

Xiang Lin, Lakshmi Ravi, Dong Dong, Rolando Burgos Virginia Polytechnic Institute and State University, United States

1225 | Balancing the Switching Losses of Paralleled SiC MOSFETs Using a Stepwise Gate Driver

Christoph Lüdecke, Alireza Aghdaei, Michael Laumen, Rik W. De Doncker *RWTH Aachen University, Germany*

1547 An Active Gate Driver for Dynamic Current Sharing of Paralleled SiC MOSFETs

Xun Wang¹, Yang He¹, Junming Zhang¹, Shuai Shao¹, Han Li², Cheng Luo² ¹Zhejiang University, China; ²Eaton, China

Session I06: Gate Drivers – 3

2118 | Digital Gate Driving (DGD) is Double-Edged Sword: How to Avoid Huge Voltage Overshoots Caused by DGD for GaN FETs

Ryunosuke Katada¹, Katsuhiro Hata¹, Yoshitaka Yamauchi¹, Ting-Wei Wang^{1,2}, Ryuzo Morikawa¹, Cheng-Hsuan Wu¹, Toru Sai¹, Po-Hung Chen², Makoto Takamiya¹ ¹The University of Tokyo, Japan; ²National Chiao Tung University, Taiwan

1154 A 1ns-Resolution Load Adaptive Digital Gate Driver IC with Integrated 500ksps ADC

for Drive Pattern Selection and Functional Safety Targeting Dependable SiC Applications Shusuke Kawai, Takeshi Ueno, Hiroaki Ishihara, Satoshi Takaya, Koutaro Miyazaki, Kohei Onizuka *Toshiba Corporation, Japan*

2040 An Intelligent Gate Driver with Self-Diagnosis and Prognosis for SiC MOSFETs

Sanghun Kim, Dongwoo Han, Xiaofeng Dong, Hui Li, Jinyeong Moon, Yuan Li, Fang Z. Peng Florida State University, United States

2091 | Comparison of Gate-Drive Switching Control for GaN HEMT Power Devices

Patrick Palmer¹, Edward Shelton², Mohammad Miri¹, Carissa King¹, Dan Rogers² ¹Simon Fraser University, Canada; ²University of Oxford, United Kingdom

2395 | A Trajectory Control Gate Driver for Wide Band Gap Devices in Standard Packages Julien Morand, Julio Brandelero

Mitsubishi Electric R&D Centre Europe, France

2156 | Gate-Source Voltage Analysis for Switching Crosstalk Evaluation in SiC MOSFETs Half-Bridge Converters

Luciano Salvo¹, Mario Pulvirenti¹, Angelo Giuseppe Sciacca¹, Giacomo Scelba², Mario Cacciato² ¹STMicroelectronics, Italy; ²University of Catania, Italy

Session 107: Magnetics – 1

1476 | A Novel Magnetic Integrated Unit for a Full-Soft-Switching Full- Bridge Converter

Cheng Deng¹, Li Tan¹, Andrés Escobar-Mejia² ¹Xiangtan University, China; ²Universidad Tecnológica de Pereira, Colombia

2239 Symmetric Four-Phase Inverse Coupled Inductors for GaN-Based Interleaving Four-Phase Point-of-Load Converters

Longyang Yu¹, Wei Mu¹, Chengzi Yang¹, Lei Zhu¹, Zhiyuan Qi¹, Laili Wang¹, Yilong Yao¹, Yuquan Su², Chi Zhang²

¹Xi'an Jiaotong University, China; ²MiSiliconn Semiconductor Technologies Co., Ltd., China

1414 | A Novel PCB-Embedded Coupled Inductor Structure for Integrated Voltage Regulator

Feiyang Zhu, Qiang Li, Fred C. Lee Virginia Polytechnic Institute and State University, United States

2416 | An Integrated Magnetic Structure for Bi-Directional Two-Channel Interleaved Boost Converter with Coupled Inductor

Abdul Basit Mirza, Asif Imran Emon, Sama Salehi Vala, Fang Luo Stony Brook University, United States

1481 | A Passive Integrated Unit for Parallel-Resonant Isolated Bidirectional DC-DC Converter

Cheng Deng¹, Zhou You¹, Andrés Escobar-Mejia² ¹Xiangtan University, China; ²Universidad Tecnológica de Pereira, Colombia

1477 | A Passive Integration Unit for Electronic Ballast with Multiresonant Converter

Cheng Deng¹, Zhilin Zhou¹, Andrés Escobar-Mejia² ¹Xiangtan University, China; ²Universidad Tecnológica de Pereira, Colombia

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Session 108: Magnetics – 2

1412 An Accurate Analytical Model to Evaluate the Winding Loss of a Single-Layer Multi-Turn Planar Air-Core PCB-Inductor

Mingdong Wu, Li Wang, Daniyal Ahmed, Meng Peng, Ling Mao Nanjing University of Aeronautics and Astronautics, China

1974 Dimensional Effects of Core Loss and Design Considerations for High Frequency Magnetics

Ahmed Nabih, Rimon Gadelrab, Qiang Li, Fred C. Lee Virginia Polytechnic Institute and State University, United States

1569 An Integrated Planar Inductor Based on a Novel Magnetic Core Structure

Shuting Feng, Yongmei Gan, Longyang Yu, Huaqing Li, Chaojie Li, Wei Mu *Xi'an Jiaotong University, China*

1100 | A Simple and Accurate Leakage Inductance Adjustment Method for Medium Frequency Transformer

Xuan Guo, Chi Li, Zedong Zheng, Yongdong Li Tsinghua University, China

1416 Modeling and Analysis of Multi-Phase Coupled Inductor Structures for Voltage Regulators

Feiyang Zhu, Qiang Li, Fred C. Lee Virginia Polytechnic Institute and State University, United States

Session 109: Magnetics – 3

2221 | Laminated Permanent Magnets Enable Compact Magnetic Components in Current Source Converters

Xiangyu Han, Zheng An, Mickael J. Mauger, Joseph Benzaquen, Rajendra Prasad Kandula, Deepak Divan Georgia Institute of Technology, United States

2453 Analysis and Suppression of Corner Electrical Field in Magnetic Flux Valve

Junwei Cui, Chao Jia, Liyan Qu, Wei Qiao University of Nebraska Lincoln, United States

1203 | Compact Design of a Wide Bandwidth High Current Sensor Using Tilted Magnetic Field Sensors

Philipp Ziegler, Yiru Zhao, Jörg Haarer, Johannes Ruthardt, Manuel Fischer, Jörg Roth-Stielow University of Stuttgart, Germany

1041 | Controlled Measurement Setup to Characterize a Magnetic Material up into Deep Saturation

Jeremias Kaiser, Thomas Dürbaum Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

1616 | Design Methodology to Reduce the Lumped Winding Capacitance of Spiral Winding Transformer in LLC Converters

Mingde Zhou, Haoyu Wang, Dongdong Shu ShanghaiTech University, China

2467 | A 700kHz 800V/14V GaN-Based DC-DC Converter with Optimized Integrated Transformer for Electrical Vehicles

Huu Phuc Kieu¹, Donghan Lee¹, Sewan Choi¹, Sangjin Kim² ¹Seoul National University of Science and Technology, Korea; ²Hyundai Motor Company, Korea

Session I10: Application of Power Modules

1409 Analytic Model of the Voltage Oscillation in a Power Conversion System with DC-Link Capacitors

Shuang Zhao, Wibawa Chou Infineon Technologies AG, United States

1062 | Lithium-Ion Capacitors: Charge Delivery Capability and Voltage Dependence

of Capacitance Hengzhao Yang ShanghaiTech University, China

2058 | Investigating the Effect of Multilevel Inverters on Motor Stator Insulation Stress

Arshiah Yusuf Mirza, Hiep Nguyen, Ali M. Bazzi, Yang Cao University of Connecticut, United States

1229 | Electret: A Solution to Partial Discharge in Power Electronics Applications

Farhina Haque, Omar Faruqe, Chanyeop Park Mississippi State University, United States

1713 | Linearly Scalable Cost-Efficient Parallel Method for High-Power Wide-Bandgap-Based Converters

Shang Gao, Zheyu Zhang Clemson University, United States

Session I11: Semiconductor Devices

1635 | Commercialization of Diamond Semiconductor Devices

Manpuneet K. Benipal¹, Jesse Brown¹, Franz Koeck², Anna Zaniewski¹, Mohammad Faizan Ahmad¹, Robert Nemanich² ¹Advent Diamond, Inc., United States; ²Arizona State University, United States

1544 Analysis on Static Current Sharing of N-Paralleled Silicon Carbide MOSFETs

Yang He¹, Xun Wang¹, Junming Zhang¹, Shuai Shao¹, Han Li², Cheng Luo² ¹Zhejiang University, China; ²Eaton, China

1837 | Junction-Temperature Sensing of Paralleled SiC MOSFETs Utilizing Temperature Sensitive Optical Parameters

Lukas A. Ruppert, Sven Kalker, Rik W. De Doncker RWTH Aachen University, Germany

2015 | Static and Dynamic Characteristics of SiC MOSFET under Extremely High Temperature

Xiaohui Lu, Laili Wang, Zaojun Ma, Qingshou Yang Xi'an Jiaotong University, China

1357 | Reverse Recovery Testing of Small-Signal Schottky Diodes

Weston D. Braun, Eric A. Stolt, Lei Gu, Juan M. Rivas-Davila Stanford University, United States

1431 Analysis on Parasitic Capacitance to Prevent False Turn-On in GaN HEMT

Toshihiro Iwaki, Takashi Sawada, Jun Imaoka, Masayoshi Yamamoto Nagoya University, Japan

1586 Dominant Model Parameter Extraction for Analyzing Current Imbalance in Parallel Connected SiC MOSFETs

Yohei Nakamura^{1,3}, Michihiro Shintani², Takashi Sato³ ¹ROHM Co., Ltd., Japan; ²Nara Institute of Science and Technology, Japan; ³Kyoto University, Japan

2051 | Circuit-Semiconductor Dynamic Coupling Analysis for PiN Diode Reverse Recovery

Ruiwen Chen¹, Zhi Yang¹, Xiaoli Tian², Mingyang Wang¹, Yu Pan³, Sideng Hu¹ ¹Zhejiang University, China; ²Chinese Academy of Sciences, China; ³Shanghai Institute of Space Power-Sources, China

Session I12: Thermal Management

1141 | Vascular Polymer Encapsulation for Integrated Thermal Management and Packaging of Electronics

Anthony Coppola, Alireza Fatemi General Motors, United States

1903 | Directly Integrated Vapor Chamber as an Efficient Heat Spreader for High Heat Flux SiC MOSFET Dies in Power Modules

Wei Mu¹, Binyu Wang¹, Shenghe Wang², Fengtao Yang¹, Dingkun Ma¹, Laili Wang¹ ¹Xi'an Jiaotong University, China; ²State Grid Anhui Electric Power Co., Ltd., China

1375 | Thermal Management Strategy for IGBT Modules in PV Systems Based on the Benefit-Cost Ratio

Cheng Qian¹, Xiong Du¹, Rui Du¹, Jun Zhang² ¹Chongqing University, China; ²Hohai University, China

1774 | Multiscale Electrothermal Design of a Modular Multilevel Converter for Grid-Tied Applications

Xuhui Feng¹, Ramchandra Kotecha¹, Sreekant Narumanchi¹, Akanksha Singh¹, Barry Mather¹, Ke Wang², Boxue Hu², Jin Wang² ¹National Renewable Energy Laboratory, United States; ²The Ohio State University, United States

"National Renewable Energy Laboratory, United States; "The Onio State University, United States

1191 | Experimental Characterization of Frequency-Domain Thermal Impedance for Power Module under Different Boundary Conditions

Leheng Wang, Mengqi Xu, Ke Ma Shanghai Jiao Tong University, China

1850 | Thermal Dissipation Approach Comparison and Evaluation for SiC Surface Mount Devices

Victoria Baker¹, Boran Fan¹, Jack Knoll¹, Rolando Burgos¹, Warren Chen² ¹Virginia Polytechnic Institute and State University, United States; ²Raytheon Technologies Research Center, United States

1696 Influence Analysis of Thermally Conductive Epoxy Resin on the Electrical Design of a Compact AC/DC Converter

Maximilian Nitzsche, Jörg Haarer, Julian Weimer, Dominik Koch, Jörg Roth-Stielow University of Stuttgart, Germany

Topic K: Emerging Technologies and Applications

Session K01: Wireless Power Transfer - 1

1400 Analysis of a Wireless Power Transfer System with an Inverse Coupled Current Doubler Rectifier

Lixin Shi, Alberto Delgado, Regina Ramos, Pedro Alou Universidad Politécnica de Madrid, Spain

2032 | Heuristic Algorithm-Based Design Method for Class-E Switching Circuits

Wenqi Zhu, Yutaro Komiyama, Kien Nguyen, Hiroo Sekiya Chiba University, Japan

2351 | High Power, High Efficiency Wireless Power Transfer at 27.12 MHz Using CMCD Converters

Jack Rademacher, Xin Zan, Al Avestruz University of Michigan, United States

1057 | Multi-Coil Constant Voltage Output Analysis Based on State Deconstruction for Wireless Power Transfer System

Sheng Liu, Yue Feng, Hao Chen, Jiande Wu, Xiangning He *Zhejiang University, China*

Session K02: Measurements and Testing

1636 | Microchannel-Based Calorimeter for Rapid and Accurate Loss Measurements on High-Efficiency Power Converters

Remco van Erp, Nirmana Perera, Elison Matioli École Polytechnique Fédérale de Lausanne, Switzerland

1314 | Design and Operation of a Medium Voltage Pulse Test Apparatus for Short-Circuit Testing of DC Solid State Circuit Breakers

Andy Schroedermeier, Andrew Rockhill Eaton, United States

1552 | Gate Driver Design for 1.2 kV SiC Module with PCB Integrated Rogowski Coil Protection Circuit

Marco Stecca, Panagiotis Tiftikidis, Thiago Soeiro, Pavol Bauer Delft University of Technology, The Netherlands

2382 | Thermal-HIL Real-Time Testing Platform for Evaluating Cooling Systems of Power Rectifiers

Carl Ngai Man Ho, Yin Fang, Yanming Xu, Isuru Jayawardana University of Manitoba, Canada

Session K03: Emerging Technologies and Applications – 1

1420 | Efficiency Optimization of Wireless Power Transfer Systems Having Multiple Receivers with Cross-Coupling by Resonant Frequency Adjustment of Receivers

Arpan Laha, Abirami Kalathy, Praveen Jain Queen's University, Canada

1701 A 27.12-MHz kV-Scale Power Amplifier with a Tunable Multistage Matching Network for a Compact Ion-Beam Accelerator

Yuetao Hou¹, Sreyam Sinha¹, Di Ni¹, Qing Ji², Arun Persaud², Peter Seidl², Thomas Schenkel², Amit Lal¹, Khurram K. Afridi¹

¹Cornell University, United States; ²Lawrence Berkeley National Laboratory, United States

2030 | Standing Wave Induced Field Focusing Transceiver for Wireless Capacitive Power Transfer

Tanner Mingen, Matthew Pearce, Tyler Marcrum, Charles Van Neste Tennessee Tech University, United States

2466 | Energy Recovery Circuit for LC Cell Driver

Jacob Huff, Miao Wang, Mark J. Scott Miami University, United States

Session K04: Wireless Power Transfer – 2

1522 A Modular Multilevel Converter Based Inductive Power Transfer System

Wenwei Victor Wang, Feiyang Jackman Lin, Duleepa J. Thrimawithana, Grant Covic University of Auckland, New Zealand

1758 | Multiple-Transmitter with Phase-Shift and Dynamic ZVS Angle Controls at Fixed Operating Frequency for Cross-Interference Free Wireless Power Transfer Systems

Kodai Matsuura, Masataka Ishihara, Akihiro Konishi, Kazuhiro Umetani, Eiji Hiraki Okayama University, Japan

2057 | Roadway Embeddable Multi-MHz Capacitive Wireless Charging System with Matching Network Realized Using Wiring Parasitics

Sounak Maji, Sreyam Sinha, Khurram K. Afridi Cornell University, United States

2390 A 13.56 MHz Bidirectional IPT System with Wirelessly Synchronised Transceivers for Ultra-Low Coupling Operation

Nunzio Pucci, Juan M. Arteaga, Christopher H. Kwan, David C. Yates, Paul D. Mitcheson Imperial College London, United Kingdom

2202 | GaN-Based Wireless Charging System with Self-Driven Rectifier

Federica Cammarata^{1,2}, Santi Agatino Rizzo², Giacomo Scelba², Giuseppe Longo¹, Filippo Scrimizzi¹, Giuseppe Ballarin³ ¹STMicroelectronics, Italy; ²University of Catania, Italy; ³Wurth Elektronik, Italy

2318 | Wireless Power Transfer System with Variable Mutual Inductance Control for Battery Charging

Ruibang Li¹, Chenxu Zhao¹, Yongbin Jiang², Min Wu¹, Shuting Feng¹, Laili Wang¹, Yunqing Pei¹, Hong Zhang¹ ¹Xi'an Jiaotong University, China; ²UNISOC (Shanghai) Technologies Co., Ltd., China

1012 Inverter Phase Current Balancing for Wireless Power Transfer Systems Based on Parallel Resonant Networks

Yiming Zhang¹, Zhiwei Shen¹, Xin Li², Shuxin Chen², Yi Tang² ¹Fuzhou University, China; ²Nanyang Technological University, Singapore

2210 Analysis of Wireless Power Transfer System Employing Active Shielding with Virtual Inductance and Two-Port Equivalent Circuit

Keita Furukawa, Keisuke Kusaka, Jun-ichi Itoh Nagaoka University of Technology, Japan

Session K05: Wireless Power Transfer – 3

2047 | A Variable Compensation Inverter Rectifier (VCIR) Based Approach to Compensate for Coupling Variations in Wireless Power Transfer Systems

Sreyam Sinha¹, Ashish Kumar², Khurram K. Afridi¹ ¹Cornell University, United States; ²Texas Instruments, United States

1938 | Bidirectional Class E2 Resonant Converter in Wireless Power Transfer Systems

Minki Kim, Jungwon Choi University of Minnesota Twin Cities, United States

1471 | A Control Strategy for ZVS Realization in LCC-S Compensated WPT System with Semi Bridgeless Active Rectifier for Wireless EV Charging

Mingyang Li, Junjun Deng, Deliang Chen, Wenbo Wang, Zhenpo Wang, Yang Li Beijing Institution of Technology, China

1928 An LCC-S Compensated Wireless Power Transfer System with Dual Switch-Controlled Capacitors for Multi-Frequency Receivers

Ke Li, Wen Ding, Jiangnan Yuan Xi'an Jiaotong University, China

1341 | Parallel Contactless Transmission of Power and Rotor Temperature of Electrical Machines via Magnetically-Coupled Resonance and Capacitive Radio Frequency

Liancheng Zhang¹, Shaoyu Cheng², Yilong Wang³, Hassan H. Eldeeb⁴, Guorui Xu², Haisen Zhao² ¹North China Institute of Aerospace Engineering, China; ²North China Electric Power University, China; ³Beijing Information Science and Technology University, China; ⁴BorgWarner Noblesville Technical Center, United States

144 | Medium Voltage to Low Voltage Contactless Power Transformation for Data Centers

Guangqi Zhu¹, Birger Pahl¹, Richard J. Fons¹, Isaac Wong², Subhashish Bhattacharya², Byron Beddingfield² ¹Eaton, United States; ²North Carolina State University, United States

2231 | Adaptive Power Transmission for Multi-Target of Microwave Wireless Power Transmission System

Xirui Zhu, Ke Jin, Jianying Ding, Yiwen Xiao Nanjing University of Aeronautics and Astronautics, China

1538 | Wireless Power Transfer System for Automatic Revolving Doors

Mohamad Abou Houran, Xu Yang, Wenjie Chen, Ahsan Hanif, Alaaeldien Hassan, Mengjie Qin *Xi'an Jiaotong University, China*

Session K06: Energy Harvesting

1329 | A Dual-Resonance Electromagnetic Vibration Energy Harvester for Wide Harvested Frequency Range

Zhijie Feng, Han Peng, Yong Chen, Jiahua Chen, Kangyi Sun Huazhong University of Science and Technology, China

1250 | A Single-Stage Dual-Mode AC-DC Converter for Vibration Energy Harvesting with Uninterrupted Output

Jiayong Yuan, Han Peng, Hanyi Sun, Hongfei Xiao Huazhong University of Science and Technology, China

1659 | A Coil Connection Switching Strategy for Maximum Power Delivery in Electromagnetic Vibration Energy Harvesting System

Hongfei Xiao, Han Peng, Jiayong Yuan Huazhong University of Science and Technology, China

1546 | A Self Start-Up Circuit in Low Voltage Power Conversions for Electromagnetic Energy Harvesting with Optimized Power Distributions

Jiahua Chen¹, Han Peng¹, Zhijie Feng¹, Kai Gao², Shaojing Wang², Peng Xu² ¹Huazhong University of Science and Technology, China; ²State Grid Shanghai Electric Power Research Institute, China

2450 | Performance Comparison of Burst-Mode MPPT and Perturb and Observe MPPT Algorithms for Photovoltaic Energy Harvesting Applications

F. Selin Bagci, Katherine A. Kim National Taiwan University, Taiwan

Session K07: Measurements and Testing

1224 A Simple Measurement Method of Common Source Inductance for GaN Devices

Jiarui Wu¹, Xu Yang¹, Kangping Wang¹, Jiwen Wei¹, Zhiyuan Qi¹, Wenjie Chen¹, Qiaoliang Chen² ¹Xi'an Jiaotong University, China; ²Longteng Semiconductor Co., Ltd., China

1332 | Film Capacitors ESL Extraction Based on SiC MOSFET Switching Transient Process

Jianfeng Niu¹, Zejun He², Yun Lei¹, Mingyang Wang¹, Jing Zhou¹, Sideng Hu¹ ¹Zhejiang University, China; ²Ningbo Jiangbei Gofront Herong Electric Co., Ltd., China

1487 | GaN-Based ±5kV/100kHz PWM Generator for Advanced Partial Discharge Characterization Zhicheng Guo, Tianxiang Chen, Ruiyang Yu, Alex Q. Huang

The University of Texas at Austin, United States

1380 An Effective Impedance-Phase Method for Sensorless Measurement of Li-Ion Battery Cells' Internal Temperature

Ala A. Hussein¹, Abbas A. Fardoun² ¹Prince Mohammad Bin Fahd University, Saudi Arabia; ²Al-Marref University, Lebanon

1381 An Extended Kalman Filter with Exponential Thermoelectric Measurement Model for Sensorless Surface Temperature Estimation of Li-Ion Batteries

Mahroo Sajid¹, Ali Wadi¹, Mamoun Abdel-Hafez¹, Ala A. Hussein² ¹American University of Sharjah, United Arab Emirates; ²Prince Mohammad Bin Fahd University, Saudi Arabia

Session K08: Emerging Technologies and Applications – 2

2559 | High-Performance Distributed Power Electronics Communication Network Design with 5 Gbps Data Rate and Sub-Nanosecond Synchronization Accuracy

Yu Rong¹, Zhiyu Shen², Boran Fan¹, Vladimir Mitrovic¹, Jianghui Yu¹, Slavko Mocevic¹, Jun Wang³, Dushan Boroyevich¹, Rolando Burgos¹

¹Virginia Polytechnic Institute and State University, United States; ²Delta Electronics (America) Ltd., United States; ³University of Nebraska Lincoln, United States

1105 | Analysis and Design of a Latching Current Limiter Based on a SiC N-MOSFET

Abraham López¹, Pablo F. Miaja¹, Manuel Arias¹, Arturo Fernández² ¹University of Oviedo, Spain; ²European Space Agency, The Netherlands

1898 | Design and Development of Modular Hybrid DC Breaker Scheme for DC Distribution Systems

D.K.J.S. Jayamaha¹, Ken K.M. Siu², Carl N.M. Ho¹, A.D. Rajapakse¹ ¹University of Manitoba, Canada; ²University of North Texas, United States

2431 | High Density Power Converter Design for Pulsed NMR Applications

Yu Yao, Harish S. Krishnamoorthy University of Houston, United States

1497 | Electrical Variable Capacitor of Reduced Switch Count and Voltage Stress for 13.56MHz RF Plasma System

Juhwa Min, Yongsug Suh Jeonbuk National University, Korea

2109 | Parallel Operation of Gradient Power Amplifiers without Large Current-Sharing Reactor

Mingyu Xue, Haicong Zhang, Bin Cao, Xu Chu Shanghai United-Imaging Healthcare Co.,Ltd., China

Session K09: Emerging Technologies and Applications – 3

1441 An Adjustable Stiffness Torsional Magnetic Spring with a Linear Stroke Length

Dawei Che¹, Jonathan Z. Bird¹, Alex Hagmuller², Md Emrad Hossain¹ ¹Portland State University, United States; ²Aquaharmonics Inc., United States

1173 Auto-Tuning Control of a Switched-Mode Power Converter for Tailored Pulse-Shape Biased Plasma Etching Applications

Qihao Yu, Erik Lemmen, Korneel Wijnands, Bas Vermulst Eindhoven University of Technology, The Netherlands

2457 | Liquid Conductor Electric Machines: A New Cooling Approach for Pulsed Power Applications

Bryan Paul Ruddy¹, Yi Chen Mazumdar², Jason Yunhe Guan³ ¹University of Auckland, New Zealand; ²Georgia Institute of Technology, United States; ³Fisher and Paykel Healthcare, New Zealand

1440 | Analysis and Experimental Testing of a New Type of Variable Stiffness Magnetic Spring with a Linear Stroke Length

Md Emrad Hossain, Jonathan Z. Bird, Victor Albarran, Dawei Che Portland State University, United States

1530 | Harmonics Suppression Using a GaN-Based Flying-Capacitor Multilevel Inverter with PWM Operation at 13.6 MHz

Fiqih Tri Fathulah Rusfa, Hideaki Fujita Tokyo Institute of Technology, Japan

Technical Session Chairs



Mao Meiqin, Hefei University of Technology, China Shangzhi Pan, Wuhan University, China

A02 | Renewable and Sustainable Energy Systems

Mao Meiqin, Hefei University of Technology, China Shangzhi Pan, Wuhan University, China

A03 | Power Converters for Renewable and Sustainable Energy Systems

Subhashish Bhattacharya, North Carolina State University, USA

A04 | Control of Photovoltaic Systems

Yongheng Yang, Zhejiang University, China Gabriele Rizzoli, University of Bologna, Italy

A05 Energy Storage Systems Hengzhao Yang, ShanghaiTech University, China

A06 | Microgrids and Grid Integration of Renewables Weimin Wu, Shanghai Maritime Univerity, China

A07 | Power Electronics for Renewable Energy Systems

Dao Zhou, Aalborg University, Denmark

A08 | Control of Renewable Energy Systems Ali Khajehoddin, University of Alberta, Canada

A09 | Grid Integration of Renewables

Bhim Singh, Indian Institute of Technology Delhi, India

A10 Wind Enegy Systems

Ke Ma, Shanghai Jiao Tong University, China **Gabriele Rizzoli,** University of Bologna,Italy

A11 Other Topics in Renewables

Jae-Do Park, University of Colorado Denver, USA

A12 | Architectures for Renewable and Hybrid Renewable Energy Systems

Tiefu Zhao, The University of North Carolina at Charlotte, USA

A13 | Renewable Energy and Storage Systems Alessandro Serpi, University of Cagliari, Italy

A14 | Applications for Renewable and Sustainable Energy Systems

Basu Kaushik, Indian Institute of Science, India

B01 | Power Converters for Distributed Resources and Microgrids

Hassan Mustafeez UI, Stony Brook University, USA Johannes Voss, RWTH Aachen University, Germany

B02 | V2G and G2V

David Lowther, McGill University, Canada

B03 | Control of DC Microgrids

Jae-Do Park, University of Colorado Denver, USA Ngai Man Ho, University of Manitoba, Canada

B04 | Grid Intelligence for Unique Loading Scenarios

Homer Alan Mantooth, University of Arkansas, USA Mehrdad Aghamohamadi, Flinders University, Australia

B05 Power Converter Utilization in Microgrids

Fei Wang, The University of Tennessee, Knoxville, USA **Dong Cao,** University of Dayton, USA

B06 | Smart Buildings and Energy Management Strategies

Dan Ionel, University of Kentucky, USA Giri Venkataramanan, University of Wisconsin-Madison, USA

B07 | Stability and Power Quality

Yue Zhao, University of Arkansas, USA **Chao Wu,** Aalborg University, Denmark

B08 Control of Distributed Resources and Microgrids

Pablo GarciaFernandez, University of Oviedo, Spain Joseph Pou, Nanyang Technological University, Singapore

B09 | Control of Renewable Energy Resources

Wei Qiao, University of Nebraska-Lincoln, USA **Kai Sun,** Tsinghua University, China

B10 | Control of Grid-Tied Inverters

Vikram Roy Chowdhury, Georgia Institute of Technolog, USAXibo Yuan, The University of Bristol, UK

B11 Control of DC Microgrids

Subhashish Bhattacharya, North Carolina State University, USALuis Herrera, University at Buffalo, USA

B12 | Microgrid Control

Jing Wang, NREL, USA

Carlos Gomez-Aleixandre, University of Oviedo, Spain

B13 | Solid State Transformers

Robert Cuzner, University of Wisconsin-Milwaukee, USA

Harish Krishnamoorthy, University of Houston, USA

B14 | Power Converters for Distributed Resources and Microgrids

Victor Veliadis, PowerAmerica, North Carolina State University, USA

Asier Garcia-Bediaga, IKERLAN S COOP, Spain

B15 | High Power, Power Electronic Systems for Utility Applications

Eduard Muljadi, Auburn University, USA Jingyang Fang, TU Kaiserslautern, Germany

B16 | Hybrid Transformers

Joseph Benzaquen, Georgia Institute of Technology, USA

Shahab Mehraeen, Louisiana State University, USA

C01 | Big Data, Machine Learning, Cyber Security

Kevin Hermanns, PE Systems, Germany Minjie Chen, Princeton University, USA Subham Sahoo, Aalborg University, Denmark

C02 | Artificial Intelligence and Machine Learning

Kevin Hermanns, PE Systems, Germany Minjie Chen, Princeton University, USA Subham Sahoo, Aalborg University, Denmark

C03 | Other Topics in Big Data, Machine Learning, Cyber Security and Design Automation

Kevin Hermanns, PE Systems, Germany Minjie Chen, Princeton University, USA Subham Sahoo, Aalborg University, Denmark

C04 | Data Analysis for Batteries and Energy Storage

Kevin Hermanns, PE Systems, Germany Minjie Chen, Princeton University, USA Subham Sahoo, Aalborg University, Denmark

C05 | Cyber Security and Cyber Attacks

Kevin Hermanns, PE Systems, Germany Minjie Chen, Princeton University, USA Subham Sahoo, Aalborg University, Denmark

D01 | Electric Drivetrains

Matt Lee, Michigan State University, USA

D02 | Battery Management Systems for Transportation

Subrata Saha, Aisin Corporation

D03 Charging Techniques for Transportation Peng Han, *Ansys, Inc.*

D04 Transportation Electrification – 1 Ali Bazza, University of Connecticut, USA

D05 | Transportation Electrification – 2 JiangBiao He, University of Kentucky, USA

D06 Transportation Electrification – 3 Md. Sariful Islam, *Halla Mechatronics*

D07 | Electric Vehicle Charging

Bulent Sarlioglu, University of Wisconsin – Madison, USA

D08 | EV Battery Management – 1 Ozge Taskin, Ricardo UK Ltd D09 | EV Battery Management – 2

Renato Amorim Torres, University of Wisconsin – Madison, USA

E01 DC-DC Non-Isolated – 1 Olivier Trescases, University of Toronto, Canada

E02 DC-DC Isolated – 1 Yilmaz Sozer, University of Akron, USA

E03 | DC-DC Isolated – 2 Ali Khajehoddin, University of Alberta, USA

E04 | AC-DC Single Phase Converters – 1 Iustin Radu Bojoi, Politecnico di Torino, Italy

E05 | AC-DC & DC-AC Topologies & Control Luca Tarisciotti, University Andres Bello, Chile

E06 DC-AC Multiphase Converters Ali Bazzi, University of Connecticut, USA

E07 | Multilevel Converters – In Memory of Prof. Akira Nabae

Hirofuma Akagi, Tokyo Institute of Technology, Japan Fang Z. Peng, Florida State University, USA

E08 | DC-DC Non-Isolated – 2 Santanu K. Mishra, Indian Institute of Technology

E09 DC-DC Non-Isolated – 3 Fang Luo, Stony Brook University, New York, USA

E10 DC-DC Isolated – 3 Qiang Li, Center for Power Electronics Systems, Virginia Tech, USA

E11 | DC-DC Isolated – 4 Paolo Mattavelli, University of Padova, Italy

E12 | DC-DC Isolated – 5 Hengzhou Yang, Shanghai Tech University, China

E13 | DC-DC Isolated – 6 Maohang Qiu, University of Dayton, USA

E14 | AC-DC Single Phase Converters – 2 Concettina Buccella, University of L'Aquila, Italy E15 | AC-DC Single Phase Converters – 3

Jee-Hoon Jung, Ulsan National Institute of Science and Technology, South Korea

E16 | AC-DC MultiPhase Converters – 11 Mahshid Amirabadi, Northeastern University, USA

E17 | DC-AC Single Phase Converter – 1 Jiangbiao He, University of Kentucky, USA

E18 | DC-AC Single Phase Converter – 2 Xibo Yuan, The University of Bristol, UK

E19 AC-AC Isolated Damian Summers-Oslebo, Naval Sea Systems Command (NAVSEA), USA

E20 | Multilevel Converters – Topologies – 1 Seung-Ki Sul, Seoul National University

E21 | Multilevel Converters – Topologies – 2 Marco Di Benedetto, *Roma Tre University, Italy*

E22 | Multilevel Converters – Topologies – 3 Mahima Gupta, Portland State University, USA

E23 | Multilevel Converters – Control – 1 Roberto Petrella, University of Udine, Italy

E24 | Multilevel Converters – Control – 2 Subhashish Bhattacharya, NC State University, USA

E25 | DC-AC Multi-Phase Converters – 2 Riccardo Leuzzi, University of Pavia, Italy

F01 Dynamic Modeling of Power Converters Alex Hanson, *University of Texas at Austin, USA*

F02 | Reliability, Diagnostics and Fault Analysis of Power Converters

Meng Huang,, Wuhan University, China

F03 | **Control of DC-DC converters Carl Ho;,** University of Manitoba, Canada

F04 | **Power Converter Modeling and Control Yuhua Du,** *Temple University, USA* F05 | Power Converter Stability

Yuhua Du, Temple University, USA

F06 | Power Converter EMI Hang Dai, University of Wisconsin-Madison, USA

F07 Converter Power Quality Shuang Zhao, *Infineon Technologies*

F08 | **Design and Control of Power Converters Jungwon Choi,** *University of Minnesota, USA*

F09 | **Power Converter Stability and Control Yuhua Du,** *Temple University, USA*

F10 | Control Aspects of Grid-connected Converters

Petros Karamanakos, Tampere University, USA

F11 | Power Converter Control Petros Karamanakos, Tampere University, USA

F12 | Dynamic Modeling of Power Converters Jungwon Choi, University of Minnesota, USA

F13 | Modulation of Power Converters Kevin Bai, The University of Tennessee, USA

F14 | **Design and Control of Power Converters I Alex Hanson,** University of Texas at Austin, USA

F15 Utility Applications of Power Electronics Jun Wang, University of Nebraska-Lincoln, USA

F16 Other Topics in Design, Control, Modelling and Optimization of Power Converters

Helen Cui, The University of Tennessee, USA

F17 | **Power Converter Modeling and Control – 1 Xiaonan Lu,** *Temple University, USA*

F18Power Converter Modeling and Control – 2Tianqi Hong, Argonne National Laboratory, USA

F19 | Power Converter Modeling and Control – 3 Tianqi Hong, Argonne National Laboratory, USA

F20 | Power Converter Modeling and Control – 4 Yuhua Du, Temple University, USA F21 | Power Converter Stability | Tianqi Hong, Argonne National Laboratory, USA

F22 | Control Aspects in Power Electronic Systems – 1

Jianzhe Liu, Argonne National Laboratory, USA

F23 | Control Aspects in Power Electronic Systems – 2

Jianzhe Liu, Argonne National Laboratory, USA

F24 | Control Aspects in Power Electronic Systems – 3

Li Zhang, Nanyang Technological University, Singapore

F25Modeling and Control in PowerElectronic SystemsJun Wang, University of Nebraska-Lincoln, USA

F26 | Power Converter EMI | Hang Dai, University of Wisconsin-Madison, USA

F27 | Converter Power Quality | Zhiwei Zhang, The Ohio State University, USA

F28 | Reliability, Diagnostics and Fault Analysis of Power Converters – 1

Omer Gundogmus, GE Global Research Center

F29 | Reliability, Diagnostics and Fault Analysis of Power Converters – 2

Omer Gundogmus, GE Global Research Center

G01 | Electric Machines in Transportation Nick Simpson, University of Bristol, UK

G02 | Permanent Magnet Machines – 1 Silvio Vaschetto, Politecnico di Torino, Italy

G03 | Modeling of Electric Machines – 1 Alessandro Serpi, University of Cagliari, Italy

G04 | **Permanent Magnet Machines – 2 Eric Severson,** University of Wisconsin-Madison, USA

G05 | Electric Machines: Fault Analysis

Jose Antonino-Daviu, Technical University of Valencia, Spain **G06** | Thermal Analysis of Electric Machines Silvio Vaschetto, Politecnico di Torino, Italy

G07 | Electric Machines Materials and Additive Manufacturing

Shanelle Foster, Michigan State University, USA

G08 Loss Analysis in Electric Machines Nick Simpson, University of Bristol, UK

G09 Noise and Vibration in Electric Machines Jose Antonino-Daviu, Technical University of Valencia, Spain

G10 | **High Speed and Bearingless Machines Eric Severson,** University of Wisconsin-Madison, USA

G11 | **Electrical Machines – 1 Alessandro Serpi,** University of Cagliari, Italy

G12 | Electrical Machines – 2 Andrea Cavagnino, Politecnico di Torino, Italy

G13 | **Electrical Machines – 3 Gerd Bramerdorfer,** *JKU Linz, Austria*

G14 | **Modeling of Electric Machines – 2 Gerd Bramerdorfer,** *JKU Linz, Austria*

G15 | IPMSM and Synchronous Reluctance Machines

Prerit Pramod, Nexteer Automotive, USA

G16 Other Synchronous Machines – 1 Prerit Pramod, Nexteer Automotive, USA

G17 | Other Synchronous Machines – 2 Andrea Cavagnino, Politecnico di Torino, Italy

G18 | Switched reluctance and flux switching machines

Giulio De Donato, University of Roma La Sapienza, Italy

G19 Actuators, Axial Flux and Linear Machines Giulio De Donato, University of Roma La Sapienza, Italy **G20** | Electrical Machines – 4 Rukmi Dutta, University of New South Wales, Australia

G21 Noise and Vibration in Electric Machines – 2 David Reigosa, University of Oviedo, Spain

G22 | Modeling of Electric Machines – 3 Greg Heins, Regal Beloit, Australia

G23 High Speed Machines – 1 Rajesh Deodhar, IMRA Europe SAS, UK

G24 | Electrical Machines – 5 Rukmi Dutta, University of New South Wales, Australia

G25 | **High Speed Machines – 2 Greg Heins,** *Regal Beloit, Australia*

H01 | PM Motor Drives – 1 Peng Han, Ansys, Inc.

H02 Control for Electric Drives Roberto Petrella, University of Udine, Italy

H03 | New Technologies, Sensors, Reliability and Testing Jul-Ki Seok, Yeungnam University, Korea

H04 | Sensorless Control of Electric Drives – 1 Yang Xu, Ford Motor Company

H05 | Sensorless Control of Electric Drives – 2 Roberto Petrella, University of Udine, Italy

H06 | Electric Drive Switching Mahesh Swamy, Milwaukee Tool, USA

H07 | PM Motor Drives – 2 Paolo Pescetto, Politecnico Di Torino, Italy

H08 | Electric Drives Pinjia Zhang, Tsinghua University, China

H09 | Induction Motor Drives Pan Di, GE Global Research

H10 | PM Motor Drives – 1 Luca Zarri, University of Bologna, Italy H11 | Control of Electric Drives – 1 Yang Xu, Ford Motor Company

H12 | Control of Electric Drives – 2 Paolo Pescetto, Politecnico Di Torino, Italy

H13 | Sensorless Control of Drives Peng Han, Ansys, Inc.

H14 | Diagnostics, Fault Tolerance and Reliability in Electric Drives

Giacomo Scelba, University of Catania, Italy

H15 | Medium Voltage and Drive Applications Kevin Lee, Eaton Corp.

H16 | Electric Drive Applications Giacomo Scelba, University of Catania, Italy

IO1 | Power Module and Integration – In Memory of Bram Ferreira

Adam Skorek, Université du Québec à Trois Rivières, Canada

IO2 WBG and UWBG Devices Jose Ortiz Gonzalez, University of Warwick, UK

103 Passive Components Hengzhao Yang, *ShanghaiTech University, China*

IO4 Gate Drivers – 1Tanya Gachovska, Solantro Semiconductors Corp.

I05 | Gate Drivers – 2 Zheyu Zhang, Clemson University, USA

IO6 Gate Drivers – 3 Patrick Palmer, Simon Fraser University, Canada

107 | Magnetics – 1 Shuo Wang, University of Florida, USA

108 | Magnetics – 2 Shuo Wang, University of Florida, USA 109 | Magnetics - 3

Christina DiMarino, Center for Power Electronics Systems, Virginia Tech, USA

I10 Application of Power Modules

Yarui Peng, University of Arkansas, USA

III Semiconductor Devices

Francesco lannuzzo, Aalborg University, Denmark

I12 | Thermal Management

Adam Skorek, Université du Québec à Trois Rivières, Canada

K01 | Wireless Power Transfer – 1 Mehdi Narimani, McMaster University, Canada

K02 Measurements and Testing Ariya Sangwongwanich, Aalborg University, Denmark

K03 Emerging Technologies and Applications – 1 Huai Wang, *Aalborg University, Denmark*

K04 | Wireless Power Transfer – 2 Mahshid Amirabadi, Northeastern University, USA

 K05 Wireless Power Transfer – 3
Prasad Rajendrda Kandula, Georgia Institute of Technology, USA

K06 Energy Harvesting Huai Wang, Aalborg University, Denmark

K07 | Measurements and Testing Ariya Sangwongwanich, Aalborg University, Denmark

K08 | Emerging Technologies and Applications – 2

Harish Sarma Krishnamoorthy, University of Houston, USA

K09 | Emerging Technologies and Applications – 3

Harish Sarma Krishnamoorthy, University of Houston, USA

Product Sessions



These half-hour, industry-driven sessions, provide an in-depth look off the show floor from our exhibitors, showcasing their innovative products and services.

8:30AM-9:00 AM



Low Voltage Ride Through (LVDT) Capability of Solar Energy Inverters Using an FPGA-based Real-Time Simulator

This Hardware-in-the-Loop demo consists of an inverter controller for grid-connected solar energies and an OP4510 real-time simulator. The controller, developed by the GREENLAB of Hefei University of Technology, is capable of low-voltage ride through—while the Electric Hardware Solver (eHS) is running on the OP4510, and simulates the entire grid-connected solar-energy inverter in real-time on the FPGA at a time step of less than 250 nanoseconds. The design of circuit schematic is done using the new OPAL-RT Schematic Editor. The model receives the PWM gating signals from external controller via digital inputs, and feeds the voltage and current measurement to controller via analog outputs. Also, the HIL model can perform soft-start, soft-stop or soft-reset, as well as update the PID parameters of the external controller via RS232 protocol. Therefore, users can conduct numerous tests automatically using API scripts. Particularly, the scenario features allows the user to pre-define different levels of voltage-sag or the short-circuit level of the host grid for the requirement of low voltage ride through (LVDT) tests.

9:00AM-9:30 AM



Evolution of Power Delivery for Cloud Computing

New architectures and technologies are increasing power density and efficiency reducing TCO (Total Cost of Ownership.) From AC-DC to the Point of Load, we will look at the power delivery topologies leveraging ST's unique portfolio, the most complete in the market, with the latest innovations in GaN transistors and drivers.

3:30PM-4:00PM



G3R[™] SiC MOSFETs, Unparalleled Performance and Robustness

High-efficiency energy usage has become a critical deliverable in next-generation power converters and silicon carbide (SiC) power devices continue to be the key components driving this revolution. In this session, GeneSiC will discuss the superiority of its third-generation (G3R™) SiC MOSFETs, including the performance advantages, design considerations as well as the importance of quality and reliability in demanding applications.

Student Demonstrations

Student Demonstrations provide an opportunity for students from various universities and countries to showcase their emerging technology research outcomes and interact with academia and industry.



High Power Density GaN-Based Online Uninterruptible Power Supply Maida Farooq, Danish Shahzad, Prof. Khurram Afridi Cornell University, USA

High Power Density GaN-Based Online Uninterruptible Power Supply

Mausamjeet Khatua, Prof. Khurram Afridi Cornell University, USA

Demonstration of Power Sink with Wide Power-Bandwidth to Emulate Residential Loads Hitesh Kumar, Prof. Santanu K. Mishra Indian Institute of Technology Kanpur, India

Common Mode EMI Analysis in Power Electronics Enabled Power System

Ashik Amin, Tahmid Ibne Mannan, Prof. Seungdeog Choi Mississippi State University, USA

Machine Learning Methods and Open-Source Database for Magnetic Core Loss Modeling Haoran Li, Mian Liao, Shukai Wang, Prof. Minjie Chen

Princeton University, USA

Vertical-Stacked Liquid-Cooled 48 V-1 V CPU Voltage Regulator with Extreme Power Density Youssef Elasser, Ping Wang, Prof. Minjie Chen,

Dr. Jaeil Baek Princeton University, USA

A 700kHz 800V/14V GaN-based Isolated DC-DC Converter with Optimized Integrated Transformer for Electrical Vehicles

Huu Phuc Kieu, Donghan Lee, Prof. Sewan Choi Seoul National University of Science and Technology, South Korea

Blockchain-Enabled Security Module for Firmware Security-Enhanced Smart Inverter BoHyun Ahn, Seerin Ahmad, Swathi Pedavalli, Prof. Taesic Kim Texas A&M University-Kingsville, USA

Liquid Metal based Cooling for Power Electronics Systems with Inductor Integrated Magnetohydrodynamics Pump

Junchong Fan, Yue Zhang, Prof. Jin Wang The Ohio State University, USA Use of 3D Printing Technology to Improve the Voltage Distribution Across Inductor's Turns Faisal Alsaif, Prof. Jin Wang The Ohio State University,USA

Designing of Flying Capacitor (FC) Module based on GaN Chip

Pasan Gunawardena, Xuesong Wu, Prof. Yunwei Li University of Alberta, Canada

High-Voltage, High-Current Pulse Generator Xin Zan, Prof. Al-Thaddeus Avestruz *University of Michigan, Ann Arbor, USA*

High Performance Integrated Motor Drive using WBG-enabled Current-Source Converters

Renato Amorim Torres, Hang Dai, Prof. Bulent Sarlioglu, Prof. Thomas Jahns University of Wisconsin-Madison, USA

Composite Hybrid Energy Storage System

Marium Rasheed, Josh Larsen, Prof. Regan Zane Utah State University, USA

Software Competition

Demonstration of Power Sink with Wide Power-Bandwidth to Emulate Residential Loads Hitesh Kumar, Prof. Santanu K. Mishra Indian Institute of Technology Kanpur, India

Machine Learning Methods and Open-Source Database for Magnetic Core Loss Modeling Haoran Li, Mian Liao, Shukai Wang, Prof. Minjie Chen

Princeton University, USA

Blockchain-Enabled Security Module for Firmware Security-Enhanced Smart Inverter

BoHyun Ahn, Seerin Ahmad, Swathi Pedavalli, Prof. Taesic Kim Texas A&M University-Kingsville, USA

PowerSynth an MCPMs layout Optimization Tool

Quang Le, Imam Al Razi, Tristan Evans, Prof. Alan Mantooth, Prof. Yarui Peng *University of Arkansas, USA*

Active Life Balancing to Condition Li-ion Battery Packs

Marium Rasheed, Prof. Regan Zane Utah State University, USA

Exhibitor Listing



Allegro MicroSystems **Bodo's Power Systems** Efficient Power Conversion Corporation **EGSTON Power Electronics FREEDM Systems Center** GanPower International GeneSiC **GMW** Associates Halla Mechatronics How2Power.com HVR Advanced Power Components Inc. **IEEE** Future Networks **IEEE** - Industrial Application Society **IEEE** - Power Electronics Society Infineon Magna-Power Magnetics **MathWorks MDPI** - Machines **OPAL RT** Payton America Inc Picotest Plexim, Inc Powersim **Richardson RFPD** Rohde & Schwarz USA Sanrex Corporation **STMicroelectronics** Taiwan Semiconductor Inc. Vicor Voltx.ai Wiley Wolfspeed



IEEE ENERGY CONVERSION CONGRESS & EXPO **Betroit, Michigan, USA** @ct.9-13

IMPORTANT DATES

January 15, 2022 Digest submission

May 1, 2022 Author notification

July 1, 2022 Final papers with IEEE copyright forms







General Chair Emmanuel Agamloh Baylor University, USA

ECCE 2022 Technical Program Co-Chairs

Navid R. Zargari Rockwell Automation, Canada

Annette Muetze Graz University of Technology, Austria

Andrea Cavagnino Politecnico di Torino, Italy

Mohammad Islam Halla Mechatronics, USA

Gerry Moschopoulos University of Western Ontario, Canada

Brandon Grainger University of Pittsburgh, USA

Contact email: ecce2022tpc@gmail.com

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Call for Papers

The Fourteenth Annual IEEE Energy Conversion Congress and Exposition (ECCE 2022) will be held in Detroit, Michigan, USA, from October 9 to October 13, 2022. ECCE is a pivotal international event on energy conversion. ECCE 2022 will feature both industry-driven and application-oriented technical sessions as well as an exposition. The conference will bring together practicing engineers, researchers and other professionals for interactive and multidisciplinary discussions on the latest advances in areas related to energy conversion.

Technical papers are solicited on any subject pertaining to the scope of the conference including, but not limited to, the following major topics:

Energy Conversion Systems & Applications

- High power/voltage power conversion
- High voltage isolation techniques
- Energy harvesting
- Energy conversion for information technology and communication systems
- Energy efficiency for residential, commercial, and industrial applications

Component, Converter & Subsystem Technologies

- Power electronic devices (silicon and wide bandgap) and applications
- Passive components and materials
- Power electronic packaging integration
- Reliability, advanced fault protection systems,
- diagnostics, prognostics, and health management
- Thermal management and advanced
- cooling technologies

- ▶ Big data and artificial intelligence in energy conversion
- Renewable and alternative energy power electronic systems
- Smart grids, microgrids, and utility applications (HVDC, FACTS, and Solid State Transformers)
- Electrical energy storage
- Wireless power transfer
- Electromagnetic interference and electromagnetic compatibility
- Power conversion topologies, modulation, and control
- Electrical drive systems and topologies and their control
- Rotating/linear electromechanical devices
- Enabling technologies for Industry 4.0: advanced manufacturing, additive manufacturing, digital twins, cloud design, big data analytics

Digest Submission: Prospective authors are requested to submit a single column, single spaced digest no longer than five (5) pages summarizing the proposed paper. The digest should include key equations, figures, tables, and references as appropriate, but no author names or affiliations. Digests not conforming to these requirements will be rejected without review. The digests must clearly state the objectives of the work, its significance in advancing the state of the art, and the methods and specific results in sufficient detail. All digests will go through a double-blind peer review process to ensure a confidential and fair review. The papers presented at the conference will be included in the IEEE Xplore Digital Library. Please refer to the conference website for a detailed list of technical topics and the digest submission method.


IEEE ENERGY CONVERSION CONGRESS & EXPO **Betroit, Michigan, USA** @ct.9-13

IMPORTANT DATES

February 11, 2022 Tutorial proposal due

April 8, 2022 Notification of acceptance

July 1, 2022 Full tutorials materials due







General Chair Emmanuel Agamloh

Baylor University, USA

Tutorial Co-Chairs

Pete Wung University of Dayton, USA

Xu She Carrier Corporation, USA

Xiaonan Lu Temple University, USA

Others

- Pedagogy for undergraduate learning or under-represented groups
- Post-COVID technology innovations
- Entrepreneurship, technology
- transfer, business management Use of standards for
- specific applications

The 14th Annual IEEE Energy Conversion Congress and Exposition (ECCE 2022) will be held in Detroit, Michigan, USA, from October 9 to October 13, 2022. ECCE is a pivotal international event on energy conversion. It will bring together practicing engineers, researchers, and other professionals for interactive discussions on the latest advances in areas related to energy conversion.

The ECCE organizing committee invites proposals for tutorials to be presented at ECCE 2022. Each tutorial is 3 hours long, excluding break times. Each accepted tutorial will receive one conference registration together with an honorarium of \$1,000. Presenters potentially may be expected to present both in-person and pre-recorded.

Please note that publication of a technical paper will still require a paid full registration. All tutorial proposals should be submitted via the ECCE 2022 web portal under "Call for Tutorials". Please follow the Tutorial Proposal Form on the website as a submission template. The proposals will be reviewed by a panel of subject matter experts.

One or more of the following elements are strongly encouraged in the tutorial proposals: D. ECCE 2022 regionally oriented topics at the host city,

- A. Industry led or co-hosted lectures;
- Interactive instructor-audience approaches, including hands-on B demonstrations and practices;
- C. Application focused session on tools or methods for the practicing engineer.

Tutorials considered to be less attractive to the audience are:

- a) Topics that are too narrowly focused;
- b) Lectures that are not balanced between theory and application;
- Tutorial topics or teams presented previously in immediate c)
- past ECCE or other major IAS/PELS conferences;

Potential topic areas include but are not limited to:

Energy Conversion Systems and Applications

- Renewable energy, including under-represented ocean-wave, tidal, geothermal
- Smart grids, micro-grids, nano-grids
- Electrical energy storage, including real physics or controlled virtual storage
- Energy conversion for information technology and communication systems
- Energy harvesting and conversion

Component, Converter and Subsystem Technologies

- Power electronic devices
- Power conversion topologies, modeling, and control
- Electric machines and drives
- Passive components, magnetics, and materials
- > Packaging, integration, and advanced manufacturing
- EMI and EMC

- Smart and energy efficient buildings
- Energy efficiency for advanced manufacturing
- Big data and machine learning in energy conversion
- Cybersecurity in energy conversion systems
- > Transportation electrification, including aircraft and urban aerial mobility
- Battery charging technologies
- Resiliency in energy systems
- Thermal management, advanced cooling technologies
- Wireless power transfer
- High voltage power conversion, including insulation technologies
- Design automation or optimization
- Reliability, diagnostics, prognostics, and health management
- Fault-tolerant converters and systems
- www.ieee-ecce.org/2022 Detroit, Michigan, USA – October 9–13, 2022
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F. Topics that engage the audience in formats that serves to communicate with the attendees.

welcome:

d) Tutorials that narrowly focus on presenter's own research works that are already publicly available e) Solicitation of a particular product or service.

Collaborative cross-disciplinary topics and tutorial teams are

e.g. transportation electrification;





Format: Maximum 5 pages. All pages are formatted to 8-1/2 by 11 inch or A4 paper with margins of one inch on every side. All texts use single space, Times New Roman, black ink, and a font size of 11 or 12.

Recommended Sections:

1. Tutorial Title

2. Instructor Team

Name(s), affiliation(s), and contact information

3. Abstract

No more than 500 words. Accepted abstract will be published through the conference website, program, and proceedings.

4. Tutorial Outline

Outline shall only define the topics and subtopics. No detailed descriptions please. Time allocation and instructor breakdown by topics is recommended.

5. Lecture Style and Requirements

Briefly describe the tutorial format, which may include traditional lecture, software/hardware demonstration, interactive audience polls/quizzes, worksheets, discussion, etc. Note any equipment or space requirements beyond a laptop and projector. Also list the targeted audience and tutorial difficulty level, including any pre-requisite knowledge.

6.Instructor Biography

No more than 200 words for each person. Each biography shall include the qualifications most relevant to the proposal. Past tutorial/teaching experience and outcome can be highlighted. External website link can be included but may not be reviewed.



IEEE ENERGY CONVERSION CONGRESS & EXPO Betroit, Michigan, USA @ct.9-13

IMPORTANT DATES

April 1, 2022 Special session proposal due

May 20, 2022 Notification of acceptance

July 1, 2022 Final session plan due









General Chair Emmanuel Agamloh Baylor University, USA

Special Session Co-Chairs

Yue Cao Oregon State University, USA

Sara Roggia MagniX, USA

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The 14th Annual IEEE Energy Conversion Congress and Exposition (ECCE 2022) will be held in Detroit, Michigan, USA, from October 9 to October 13, 2022. Special Sessions are solicited focusing on emerging technologies and industry-oriented topics. Industry and government organizers or speakers are of particular interest. Guest speakers will be invited on the day their session is scheduled. No written papers are required. Materials presented in the Special Sessions will not be included in the conference proceedings. Each session will be assigned either one or two 100-minute slot(s), subject to conference program scheduling.

Different session formats are solicited: 1) Formal presentations; 2) Informal talks with or without slides; 3) Full Q&A panel; 4) Debate; 5) Other creative or hybrid styles.

One or more of the following elements are strongly encouraged in the special session proposals: A) Significant industry or government involvement; B) Industrial application oriented; C) ECCE 2022 regionally oriented topics; D) Collaborative crossdisciplinary topics or teams; E) Creative formats that engage the audience, especially industry.

Factors considered as less attractive to the audience are: a) Non-emerging topics; b) Academic lectures; c) Similar teams with similar topics from the immediate past ECCE; d) Solicitation of a particular product or service; e) Unclear plans including unconfirmed speakers.

Potential topic areas include but are not limited to:

Energy Conversion Systems and Applications

- ▶ Transportation electrification, including EV, trucks, aircraft, UAV, ▶ Resiliency in energy systems trains, ships Smart and energy efficient buildings Energy conversion for information technology
- Energy storage systems, including real or virtual storage
- Charging stations, vehicle to grid
- Additive manufacturing
- Renewable energy integration
- Smart grids, micro-grids, nano-grids

Components, Converters, and Subsystems

- Power semiconductor devices, magnetics, capacitances
- Power conversion topologies, modeling, and control
- Electric machines and drives
- Packaging, integration, and advanced manufacturing
- ▶ EMI and EMC

Others

- Advanced testing and validation, including demo
- Standards development
- Education and career development

Cybersecurity in energy conversion

Design automation and optimization

Thermal management, advanced cooling technologies

Big data and machine learning in energy conversion

- ▶ Wireless power transfer
- High voltage power conversion, including insulation technologies
- Reliability, diagnostics, prognostics, and health management
- Entrepreneurship, technology transfer, business management
- Post-COVID technology innovations

Proposal Submission Guidelines: All special session proposals must be submitted via the ECCE 2022 web portal under "Call for Special Sessions". Please follow the Proposal Form on the website as a submission template. The proposals will be reviewed by a panel of subject matter experts.



IEEE ENERGY CONVERSION CONGRESS & EXPO **Betroit, Michigan, USA** @ct.9-13

Format: Maximum 5 pages. All pages are formatted to 8.5x11" or A4 paper with margins of one inch on every side. All texts use single space, Times New Roman, and a font size of 11 or 12. A Word template will be posted on the official website under Call for Special Sessions.

Recommended Sections:

1. Special Session Title

2. Proposed Session Format

Formal	presentations	

Informal talks

2x100 minutes

Full Q&A panel

Debate

Create own style – see Call For Proposal.

Describe the format at a high level, and note any creative activities such as software/hardware demonstration, virtual tours, interactive audience polls, etc.

3. Proposed Timing

100 minutes

4. Session Organizers

List name(s), title(s), affiliation(s), and email(s).

5. Session Speakers/Panelists

List names, titles, and affiliations. Clearly note each speaker's availability: choose "confirmed" or "tentative"; failure to do so will be treated as all tentative.

6. Abstract

No more than 500 words. Accepted abstract will be published through the conference website and program book.

7. Session Outline

Only list the proposed topics/titles/activities. No detailed descriptions necessary. Indicate time allocation and speaker breakdown, if possible.

8. Organizer Biography

No more than 200 words for each person. External website link can be included but may not be reviewed.

9. Speaker/Panelist Biography

No more than 200 words for each person. External website link can be included but may not be reviewed.

SAVE THE DATE





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