ECCE 2021

IEEE ENERGY CONVERSION CONGRESS & EXPO

Virtual Conference ≋ Oct. 10-14

Virtual Conference PROGRAM

October
10-14

Sponsored by the IEEE Power Electronics And Industry Applications Societies

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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 on-demand 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 on-demand 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!

Giovanna Oriti

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!

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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	BREAK			
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.			

Nearly 900 Technical Sessions available for flexible viewing to best accommodate your schedule.

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.				

Wednesday, October 13, 2021

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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Monday, October 11 **8:30AM-9:00AM**

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, teaching the science of electric machines and is a co-founder of the Prometheus team in NTUA, which participates in EV fuel economy contests and holds the Panhellenic fuel consumption record today.

Monday, October 11 **9:00AM-9:30AM**

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.

SPEAKERS AND PRESENTATIONS:

> **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 **9:00AM-10:30AM | 10:30AM-12:00PM**

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.

SPEAKERS AND PRESENTATIONS:

> **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 wide-bandgap 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**
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.

SPEAKERS AND PRESENTATIONS:

> **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

SPEAKERS AND PRESENTATIONS:

> **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 **12:30PM-2:00PM**

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 intiatives 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.).

SPEAKERS AND PRESENTATIONS:

> **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.

SPEAKERS AND PRESENTATIONS:

> **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 **12:30PM-2:00PM**

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.

SPEAKERS AND PRESENTATIONS:

> **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, Marquette 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 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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MASTERGAN4				6.5	225	225

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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 Jiang[1], Zicheng Liu[1], Qiao Li[2]**
[1]Huazhong University of Science and Technology, China; [2]Hunan 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 Xiao[1],Jimmy Chih-Hsien Peng[2], Qiang Han[3]**
[1]University of Sydney, Australia; [2]National University of Singapore; [3]BC 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 dynamics, a control design approach for grid-forming inverters is introduced to guarantee 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. Jahns[1], Bulent Sarlioglu[1], Johann W. Kolar[2], Jonas Huber[2], Victor Veliadis[3]**
[1]University of Wisconsin – Madison, United States; [2]ETH Zurich, Switzerland; [3]PowerAmerica, 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 ±1400V and ±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 Liserre[1], Grahame Holmes[2], Mario Paolone[3], Rongwu Zhu[4], Roberto Rosso[5]**
[1]Christian-Albrechts-Universität zu Kiel, Germany; [2]RMIT University, Australia; [3]Swiss Federal Institute of Technology, Switzerland; [4]Harbin Institute of Technology, Shenzhen, China; [5]ENERCON, 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 Wang[1], Yousef Abdullah[2]**
[1]The Ohio State University, United States; [2]Kuwait 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 Broeck[1], Timothy A. Polom[2]**
[1]FEV Europe GmbH, Germany; [2]Silicon 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 quantification 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 medium-frequency 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 Popescu[1], Philip Mellor[2], Nick Simpson[2], James Goss, Melanie Michon[1], Jonathan Godbehere[1]**

[1]Motor Design Ltd., United Kingdom; [2]University 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 Li[1], Shuo Wang[2]**
[1]GE Research, United States; [2]University 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 guide 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 Vidal[1], Phillip Kollmeyer[1], Javier Gazzarr[2]**
[1]McMaster University, Canada; [2]MathWorks, 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 state-of-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 Lu[1], Jin Tan[2], Andy Hoke[2], Lisa Qi[3]**
[1]Temple University, United States; [2]National Renewable Energy Laboratory, United States; "
[3]ABB 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) Wang[1], Zheyu Zhang[2], Ruirui Chen[1], Shengyi Liu[3]**
[1]University of Tennessee, United States; [2]Clemson University, United States; [3]Boeing 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 Luo[1], Jiangbiao He[2]**
[1]State University of New York at Stony Brook, United States; [2]University 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 Williamson[1], Uday Deshpande[2]**
[1]Ontario Tech University, Canada; [2]D&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.

Ask the authors questions using the Chat located next to each pre-recorded video.

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. Ravyts[1], P. Nivelle[2], J. Carlous[2], R. Sabariego[3], M. Daenen[2], J. Driesen[3], J. Cappelle[1]
[1]KU Leuven - Gent, Belgium; [2]Hasselt University, Belgium; [3]KU 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 Stevanović[1], Santiago Cóbreces[2], Emanuel Serban[3], Pedro Alou[1], Martin Ordonez[3], Miroslav Vasić[1]
[1]Universidad Politécnica de Madrid, Spain; [2]Universidad de Alcalá, Spain; [3]The 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-Ghartemani[1], Ali Zakerian[1], Sayed Ali Khajehoddin[2]
[1]Mississippi State University, United States; [2]University of Alberta, Canada

1226 | Comparative Study of Transverse Flux Permanent Magnet Machines for Wind Power Applications
R. Kumar[1], Z.Q. Zhu[1], A. Duke[2], A. Thomas[2], R. Clark[2], Z. Azar[2]
[1]The University of Sheffield, United Kingdom; [2]Sheffield 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 Tiwari[1], Roy Nilsen[1], Olve Mo[2]
[1]Norwegian University of Science and Technology, Norway; [2]SINTEF 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 Hammer[1], Cosmin Pondiche[2], Martin Ordonez[1]
[1]The University of British Columbia, Canada; [2]EnerSys, 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 Acharya[1], Santanu Mishra[1], Arvind Tiwari[2]
[1]Indian Institute of Technology Kanpur, India; [2]GE 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 He[1], Ariya Sangwongwanich[1], Yongheng Yang[2], Zhongyi Quan[3], Yunwei Li[3], Francesco Iannuzzo[1]
[1]Aalborg University, Denmark; [2]Zhejiang University, China; [3]University of Alberta, Canada

1482 | A Semi Discontinuous PWM Method for Mitigating Oscillation in a Three-Level Grid-Tied PV Inverter
Zhaoxia Yang[1], Jianwu Zeng[1], Qixing Ren[2], Liangcai Wu[2], Zhengjun Liao[2]
[1]Minnesota State University, United States; [2]Growatt 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 Muduli[1], Khaled Al Jaafari[1], Khalifa Al Hosani[1], Ranjan Kumar Behera[2], Rustem R. Khusnutdinov[3], Alfred R. Safin[3]
[1]Khalifa University, United Arab Emirates; [2]Indian Institute of Technology Patna, India; [3]Kazan State Power Engineering University, Russia

1666 | Passivity Control in Modular Battery Energy Storage Systems

Ezequiel Rodriguez[1], Ramon Leyva[2], Gaowen Liang[1], Glen G. Farivar[3], Josep Pou[1], Christopher D. Townsend[4], Naga Brahmendra Yadav Gorla[3]
[1]Nanyang Technological University, Singapore; [2]Universitat Rovira i Virgili, Spain; [3]University of Western Australia, Australia

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

Gaowen Liang[1], Glen G. Farivar[1], Gorla Naga Brahmendra Yadav[1], Christopher D. Townsend[2], Salvador Ceballos[3], Hossein Dehghani Tafti[2], Josep Pou[1]
[1]Nanyang Technological University, Singapore; [2]University of Western Australia, Australia; [3]Ikerlan 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 Soldati[3], Luca Tassi[3], Alfonso Damiano[2]
[1]NEPSY srl, Italy; [2]University of Cagliari, Italy; [3]University 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 He[1], Rui Ling[1], Dongxue Li[2]
[1]Chongqing University, China; [2]Vicor 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 Anglani[1], Giovanna Oriti[2], Ruth Fish[2], Douglas L. Van Bossuyt[2]
[1]University of Pavia, Italy; [2]Naval 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. Soares[1], Cursino B. Jacobina[1], Nady Rocha[2], Victor Felipe M.B. Melo[2]
[1]Federal University of Campina Grande, Brazil; [2]Federal 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 Aghamohamadi[1], Clement Chuah[1], Amin Mahmoudi[1], John K. Ward[2], Mohammed H. Haque[3]
[1]Flinders University, Australia; [2]CSIRO, Australia; [3]University of South Australia, Australia

1859 | Sizing of Hybrid Supercapacitors for Off-Grid PV Applications
Tarek Ibrahim[1], Tamas Kerekes[1], Dezso Sera[2], Sergiu Spataru[3], Daniel-Ioan Stroe[1]
[1]Aalborg University, Denmark; [2]Queensland University of Technology, Australia;
[3]Technical 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

Session A07: Power Electronics for Renewable Energy Systems

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 Tang[1], Yongheng Yang[2], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Zhejiang 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 Karami[1], Guangqi Zhu[1], Rohit Baranwal[1], Vijay Bhavaraju[1], David W. Ganger[1], Cheng Luo[2]
[1]Eaton, United States; [2]Eaton, China

2567 | Design and Testing of a Modular Back-to-Back Power Electronics Converter for Wave Energy Harvesting
Mattia Mantellini[1], Riccardo Morici[1], Marcos Blanco[2], Marcos Lafoz[2], Gustavo Navarro[2], Luca Zarri[3]
[1]OCEM Power Electronics, Italy; [2]CIEMAT, Spain; [3]University 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 Kumar[1], D. Venkatramanan[1], Abhijit Kshirsagar[2], Ned Mohan[1]
[1]University of Minnesota Twin Cities, United States; [2]Indian 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 Sarmiento[1], Maen Marji[1], Cheaheng Lim[1], Jonghoon Kim[2], Nan Wang[1], Woonki Na[1]
[1]California State University Fresno, United States; [2]Chungnam 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 Luo[1], Weimin Wu[1], Koutroulis Eftychios[2], Frede Blaabjerg[3], Henry Shu-Hung Chung[4]
[1]Shanghai Maritime Univerity, China; [2]Technical University of Crete, Greece; [3]Aalborg University, Denmark; [4]City University of Hong Kong, China

1300 | Transient Stability Enhancement for Virtual Synchronous Generator by Combining Direct Power Control
Xuejiao Zhong[1], Yutao Lou[2], Tiliang Wen[1], Donghai Zhu[1], Xudong Zou[1], Xiang Guo[1]
[1]Huazhong University of Science and Technology, China; [2]Shanghai 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 Liu[1], Xiong Du[1], Yuming Liu[2], Dengfeng Li[2], Bo Zhang[1], Chenghui Tong[1]
[1]Chongqing University, China; [2]State 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 Wu[1], Ke Hu[2], Ming Zhang[1], Gujing Han[1]
[1]Wuhan Textile University, China; [2]Huazhong 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 Wang[1], Heng Wu[1], Xiongfei Wang[1], Laurids Dall[2], Jun Bum Kwon[3]
[1]Aalborg University, Denmark; [2]Energinet, Denmark; [3]Ørsted, Denmark

1199 | A New Type of Three-Phase Asymmetric LCL Power Filter for Grid-Tied Voltage Source Inverter
Weimin Wu[1], Yaozhong Zhang[1], Henry Shu-Hung Chung[2], Frede Blaabjerg[3]
[1]Shanghai Maritime Univerity, China; [2]City University of Hong Kong, China; [3]Aalborg University, Denmark

1709 | Analysis of Overmodulation in Power Synchronization-Based Voltage Source Converters
Federico Cecati[1], Sante Pugliese[1], Marco Liserre[1], Xiongfei Wang[2], Frede Blaabjerg[2]
[1]Christian-Albrechts-Universität zu Kiel, Germany; [2]Aalborg 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 Emami[1], Emad Roshandel[2], Amin Mahmoudi[2], Samad Taghipour Boroujeni[1], Solmaz Kahourzade[3]
[1]Shahrekord University, Iran; [2]Flinders University, Australia; [3]University of South Australia, Australia

2298 | Aggregation of Wind Turbine Grid-Side Inverters by Voltage Angle and Cable Resonance Compensation
Zichao Zhou[1], Xiongfei Wang[1], Yin Sun[2]
[1]Aalborg University, Denmark; [2]Shell 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 Cui[1], Xiangwu Yan[1], Ruibo Li[1], Wenfei Chang[1], Waseem Aslam[2]
[1]North China Electric Power University, China; [2]University 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 Mülder[1], Fabian Müller[1], Andreas Thul[1], Kay Hameyer[1], Christoph Meier[2]
[1]RWTH Aachen University, Germany; [2]Wobben Research and Development GmbH, Germany

2173 | Comparison of Active and Passive 9-Phase Wind Turbine Conversion System for an all DC Grid
Omid Beik[1], Ahmad S. Al-Adsani[2]
[1]McMasters University, Canada; [2]Public Authority for Applied Education and Training, Kuwait

2299 | Dynamic Model Validation and Harmonic Stability Analysis of Offshore Wind Power Plants
Zichao Zhou[1], Xiongfei Wang[1], Fangzhou Zhao[1], Jan R. Svensson[2], Lukasz Kocewiak[3], Mikkel Peter Sidoroff Gryning[3], Aravind Mohanaveeramani[2]
[1]Aalborg University, Denmark; [2]Power Grids Research Hitachi ABB Power Grids, Sweden; [3]Electrical Systems Ørsted Offshore A/S, Denmark

Session A11: Other Topics in Renewables

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]
[1]Chinese Academy of Sciences, China; [2]University 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 Kumar[1], Shanal Kumar[1], Giansalvo Cirrincione[2], Maurizio Cirrincione[1], Damien Guilbert[3], Krishnil Ram[1], Ali Mohammadi[1]
[1]The University of the South Pacific, Fiji; [2]University of Picardy Jules Verne, France; [3]University 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. Luna[1], Cursino B. Jacobina[2], Alexandre C. Oliveira[2], Nustenil S.M.L. Marinus[3]
[1]Federal Rural University of the Semi-arid Region, Brazil; [2]Federal University of Campina Grande, Brazil; [3]Federal Institute of Education, Science and Technology of Ceará, Brazil

2188 | Optimization of Reactive Power Distribution in Series PV-Battery-Hybrid Systems
Yiwei Pan[1], Ariya Sangwongwanich[1], Yongheng Yang[2], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Zhejiang 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 Tatusch[1], Jens Friebe[1], Anton Gorodnichev[2], Daniel Haake[2], Fabian Schnabel[2], Marco Jung[3]
[1]Leibniz Universität Hannover, Germany; [2]Fraunhofer Institute for Energy Economics and Energy System Technology, Germany; [3]Bonn-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

Session A14: Applications for Renewable and Sustainable Energy Systems

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 Qin[1], Di Zhang[2], Chuanyang Li[3], Dong Dong[4], Yang Cao[3], Zheyu Zhang[1]
[1]Clemson University, United States; [2]Naval Postgraduate School, United States;
[3]University of Connecticut, United States; [4]Virginia 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 Kim[1], Jih-Sheng Lai[2]
[1]Texas Instruments, United States; [2]Virginia Polytechnic Institute and State University, United States

2301 | Residual Power Transfer Capability Analysis of an MMC-SST under Submodule IGBT Open-Circuit Fault
Jiajie Zang[1], Jiacheng Wang[1], Jianwen Zhang[2], Jianqiao Zhou[2], Jiahu Guo[2], Dongmin Xi[3]
[1]Simon Fraser University, Canada; [2]Shanghai Jiao Tong University, China;
[3]Inner 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 Sharma[1], Vishnu Mahadeva Iyer[2], Subhashish Bhattacharya[1], Jun Kikuchi[3], Ke Zou[3]
[1]North Carolina State University, United States; [2]Indian Institute of Science, India; [3]Ford 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 Aghamohamadi[1], Amin Mahmoudi[1], John K. Ward[2], Mohammed H. Haque[3]
[1]Flinders University, Australia; [2]CSIRO, Australia; [3]University of South Australia, Australia

1243 | Recourse-Based BCD Robust Integrated Bidding Strategy for Multi-Energy Systems under Uncertainties of Load and Energy Prices
Mehrdad Aghamohamadi[1], Amin Mahmoudi[1], John K. Ward[2], Megan Sleep[1], Mohammed H. Haque[3]
[1]Flinders University, Australia; [2]CSIRO, Australia; [3]University of South Australia, Australia

1069 | Multi-Terminal Soft Open Point with Anti-Islanding and Over-Current Protection Capability
Han Deng[1], Yang Qi[2], Jingyang Fang[3], Vincent Debusschere[4], Yi Tang[1]
[1]Nanyang Technological University, Singapore; [2]Northwestern Polytechnical University;
[3]University of Kaiserslautern, Germany; [4]Grenoble Institute of Technology, France

1221 | Fault-Tolerant Distribution Network Enabled by Series Soft Open Point
Yang Qi[1], Han Deng[2], Yi Tang[2]
[1]Northwestern Polytechnical University, China; [2]Nanyang 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 Kritprajun[1], Joshua C. Hambrick[2], Leon M. Tolbert[1], Yunting Liu[1], Jiaojiao Dong[1], Lin Zhu[1], Qihuan Dong[1], Kevin Schneider[3]
[1]The The University of Tennessee Knoxville, United States; [2]Oak Ridge National Laboratory, United States;
[3]Pacific Northwest National Laboratory, United States

1892 | Development of a Power Electronics-Based Testbed for a Flexible Combined Heat and Power System
Haiguo Li[1], Dingrui Li[1], Zihan Gao[1], Yiwei Ma[1], Zhe Yang[1], Jingxin Wang[1], Fred Wang[1,2]
[1]University of Tennessee Knoxville, United States; [2]Oak Ridge National Laboratory, United States

1292 | Optimal Sizing of Grid-Tied Residential Microgrids under Real-Time Pricing
Rahmat Khezri[1], Amin Mahmoudi[1], Mohammad Hassan Khooban[2], Nesimi Ertugrul[3]
[1]Flinders University, Australia; [2]Aarhus University, Denmark; [3]University 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 Gong[1], Evan S. Jones[1], A.H.M. Jakaria[2], Aminul Huque[2], Ajit Renjit[2], Dan M. Ionel[2]
[1]University of Kentucky, United States; [2]Electric 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

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 Khezri[1], Amin Mahmoudi[1], Mohammed H. Haque[2], Kaveh Khalilpour[3]
[1]Flinders University, Australia; [2]University of South Australia, Australia; [3]University 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

Session B07: Stability and Power Quality

1374 | Impedance Modeling and Analysis of Grid Side Sampling Modular Multilevel Converter
Bo Zhang[1], Xiong Du[1], Jingbo Zhao[2], Jiapei Zhou[3], Cheng Qian[1], Chengmao Du[1]
[1]Chongqing University, China; [2]State Grid Jiangsu Electric Power Co., Ltd., China; [3]Global 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 Lai[1], Leonardo Marin[2], Andrés Tarrasó[1], Gregory N. Baltas[1], Pedro Rodriguez[1]
[1]Luxembourg Institute of Science and Technology, Luxembourg; [2]Universitat Politècnica de Catalunya, Spain

1228 | Extremum Seeking Control Based Resonant Frequency Estimation for a Grid-Tied Inverter with LCL Filter
Yuheng Wu[1], Mohammad Mahmud[1], Yue Zhao[1], Radha Krishna Moorthy[2], Madhu Sudhan Chinthavali[2]
[1]University of Arkansas, United States; [2]Oak Ridge National Laboratory, United States

2250 | Impedance Analysis of Voltage Source Converter Based on Voltage Modulated Matrix
Chao Wu[1], Xiaoling Xiong[2], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]North 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 Narayanan, 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 Ge[1], Zhikang Shuai[1], Xia Shen[1], Yu Feng[1], Huimin Zhao[1], Yang Shen[1], Z. John Shen[2]
[1]Hunan University, China; [2]Illinois Institute of Technology, United States

2043 | Enhanced DC-Link Voltage Control in a Virtual Synchronous Generator-Based Building-to-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 Kumaresan[1], Hossein Dehghani Tafti[2], Glen G. Farivar[1], Nandha Kumar Kandasamy[3], Josep Pou[1]
[1]Nanyang Technological University, Singapore; [2]University of Western Australia, Australia; [3]Singapore Institute of Technology, Singapore

2106 | Parameters Stability Region Analysis of Diesel Generation Forming Hybrid Islanded Microgrid with High Penetration of Renewable Energy
Xun Jiang[1], Meiqin Mao[1], Liuchen Chang[1], Peng Li[2], Yong Shi[1]
[1]Hefei University of Technology, China; [2]North 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 Wang[1], Kai Sun[2], Yunwei Li[1]
[1]University of Alberta, Canada; [2]Tsinghua University, China

2145 | Active Disturbance Rejection Control of Doubly-Fed Induction Generators Driven by Wind Turbines
Matthew Penne[1], Wei Qiao[1], Liyan Qu[1], Lizhi Qu[1], Renke Huang[2], Qiuhua Huang[2]
[1]University of Nebraska Lincoln, United States; [2]Pacific 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 Tarraso[1], Ngoc Bao Lai[2], Pedro Rodriguez[2]
[1]Universitat Politècnica de Catalunya, Spain; [2]Luxembourg Institute of Science and Technology, Luxembourg

1455 | Angle Droop Design for Grid-Forming Inverters considering Impacts of Virtual Impedance Control
Le Kong[1], Yaosuo Xue[2], Liang Qiao[1], Fred Wang[1,2]
[1]University of Tennessee Knoxville, United States; [2]Oak Ridge National Laboratory, United States

2115 | Switched-Boost Common-Ground Five-Level (SBCG5L) Grid-Connected Inverter with Single-Stage Dynamic Voltage Boosting Concept
Reza Barzegarkhoo[1], Majid Farhangi[1], Ricardo P. Aguilera[1], Yam P. Siwakoti[1], Sze Sing Lee[2]
[1]University of Technology Sydney, Australia; [2]Newcastle University in Singapore, Singapore

1194 | An Enhanced Single-Phase Self-Tuning Filter Based Open-Loop Frequency Estimator for Weak Grid
Anant Kumar Vema[1], Hafiz Ahmed[2], Pedro Roncero-Sánchez[3], Pradyumn Chaturvedi[4]
[1]National Institue of Technology Hamirpur, India; [2]Bangor University, United Kingdom; [3]Universidad de Castilla-La Mancha, Spain; [4]Visvesvaraya 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 Yan[1], Glen G. Farivar[1], Neha Beniwal[1], Naga Brahmendra Yadav Gorla[1], Hossein Dehghani Tafti[2], Salvador Ceballos[3], Josep Pou[1], Georgios Konstantinou[4]
[1]Nanyang Technological University, Singapore; [2]University of Western Australia, Australia; [3]Basque Research and Technology Alliance, Spain; [4]University 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 Yan[1], Glen G. Farivar[1], Neha Beniwal[1], Naga Brahmendra Yadav Gorla[1], Hossein Dehghani Tafti[2], Salvador Ceballos[3], Josep Pou[1], Georgios Konstantinou[4]
[1]Nanyang Technological University, Singapore; [2]University of Western Australia, Australia; [3]Basque Research and Technology Alliance, Spain; [4]University of New South Wales, Australia

1026 | Distributed Linear State Observer (DLSO)-Based Distributed Secondary Control for DC Microgrids under False Signal Attacks
Yajie Jiang[1], Yun Yang[2], Siew-Chong Tan[3], Shu-Yuen Ron Hui[4]
[1]The University of Hong Kong, China; [2]The Hong Kong Polytechnic University, China; [3]Nanyang Technological University, Singapore; [4]Imperial 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 Vygoder[1], Farzad Banihashemi[1], Jacob Gudex[1], Robert M. Cuzner[1], Giovanna Oriti[2]
[1]University of Wisconsin Milwaukee, United States; [2]Naval 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 Jimenez[1], Germán G. Oggier[2], Roberto A. Fantino[1], Juan Carlos Balda[1], Yue Zhao[1]
[1]Unviersity of Arkansas, United States; [2]Universidad 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 Siddaiah[1], Mark Vygoder[1], Robert M. Cuzner[1], Juan C. Ordonez[2], Mauricio B. Chagas[2]
[1]University of Wisconsin Milwaukee, United States; [2]Florida 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 Apte[1], Siqi Lin[1], Lukas Fraeger[2], Jens Friebe[1]
[1]Leibniz Universität Hannover, Germany; [2]BLOCK Transformatoren-Elektronik GmbH, Germany

1574 | Enhanced CurrenT-Type P-HIL Interface Algorithm for Smart Transformers Testing
Sante Pugliese[1], Marco Liserre[1], Giovanni De Carne[2]
[1]Christian-Albrechts-Universität zu Kiel, Germany; [2]Karlsruhe 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 Enomoto[1], Kenichiro Sano[1], Junya Kanno[2], Junichi Fukushima[2]
[1]Tokyo Institute of Technology, Japan; [2]Tokyo 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. Farivar[1], Christopher D. Townsend[2], Hossein Dehghani Tafti[2], Ezequiel Rodriguez[1], Josep Pou[1], Branislav Hredzak[3]
[1]Nanyang Technological University, Singapore; [2]University of Western Australia, Australia; [3]University of New South Wales, Australia

1083 | A Bipolar Hybrid Circuit Breaker for Low-Voltage DC Circuits
Sudipta Sen[1], Shahab Mehraeen[1], Keyue Smedley[2]
[1]Louisiana State University, United States; [2]University 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
[1]Xi'an Jiaotong University, China; [2]State 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 Leon[1], Andres Tarraso[1], Jose Ignacio Candela[1], Pedro Rodriguez[2]
[1]Polytechnic University of Catalonia, Spain; [2]Luxembourg Institute of Science and Technology, Luxembourg

1118 | Hybrid Smart Transformer for Enhanced Power System Protection Against DC with Advanced Grid Support
Moazzam Nazir[1], Johan H. Enslin[1], Klaehn Burkes[2]
[1]Clemson University, United States; [2]Savannah 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 Khan[1], Sara Ahmed[1], Omar A. Beg[2]
[1]University of Texas San Antonio, United States; [2]University 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 Paul[1], Tiefu Zhao[1], Chen Chen[2], Yunsheng Ban[3], Yao Wang[3]
[1]University of North Carolina Charlotte, United States; [2]University of Central Florida, United States; [3]Hebei University of Technology, China

1940 | Real-Time DC Pulsed Power Load Monitoring Using Simplified k-NN Algorithm
Yue Ma[1], Atif Maqsood[2], Damian Oslebo[3], Keith Corzine[1]
[1]University of California Santa Cruz, United States; [2]Dynapower Company, LLC, United States; [3]Naval 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 Narayan[1], Rahul R. Kumar[1], Giansalvo Cirrincione[2], Maurizio Cirrincione[1]
[1]The University of the South Pacific, Fiji; [2]University of Picardy Jule Verne, France

1683 | A Machine Learning Based Method to Efficiently Analyze the Cogging Torque under Manufacturing Tolerances
Andrea Reales[1], Werner Jara[1], Gabriel Hermosilla[1], Carlos Madariaga[2], Juan Tapia[2], Gerd Bramerdorfer[3]
[1]Pontificia Universidad Católica de Valparaiso, Chile; [2]Universidad de Concepcion, Chile; [3]Johannes 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 Zhang[1], Yang Huang[1], Jared Walden[1], Hua Bai[1], Fanning Jin[2], Xiaodong Shi[2], Bing Cheng[2]
[1]University of Tennessee Knoxville, United States; [2]Mercedes-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 Kwak[1], Myungbok Kim[1], Jonghoon Kim[2]
[1]Korea Institute of Industrial Technology, Korea; [2]Chungnam National University, Korea

2292 | Artificial Intelligence-Based Hardware Fault Detection for Battery Balancing Circuits
Kyoung-Tak Kim[1], Hyun-Jun Lee[1], Joung-hu Park[1], Gomanth Bere[2], Justin J. Ochoa[2], Taesic Kim[2]
[1]Soongsil University, Korea; [2]Texas 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 Tang[1], Ariya Sangwongwanich[1], Yongheng Yang[2], Charlotte Overgaard Wilhelmsen[1], Sebastian Birkedal Kristensen[1], Jens Laurids Sørensen[1], Jens Muff[1], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Zhejiang 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 Leng[1], Subham Sahoo[2], Frede Blaabjerg[2]
[1]Sichuan University, China; [2]Aalborg 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 Zhang[1], Gurupraanesh Raman[1], Gururaghav Raman[1], Jimmy Chih-Hsien Peng[1], Weidong Xiao[2]
[1]National University of Singapore, Singapore; [2]The 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 Tresca[1], Riccardo Leuzzi[1], Andrea Formentini[2], Luca Rovere[3], Norma Anglani[1], Pericle Zanchetta[1,3]
[1]Università di Pavia, Italy; [2]University of Genoa, Italy; [3]University of Nottingham, United Kingdom

1239 | Electromagnetic and Direct-Cooling Analysis of a Traction Motor
John Wanjiku[1], Lan Ge[2], Zhiyuan Zhang[2], Kang Chang[2], Chengtao Wu[2], Fuliang Zhan[2]
[1]Siemens Digital Industries Software, Canada; [2]Siemens 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 Das[1], Anik Chowdhury[1], Md Ehsanul Haque[1], Md Tawhid Bin Tarek[1], Yilmaz Sozer[1], David Colavincenzo[2], Fernando Venegas[2], Jeffrey Geither[2]
[1]The University of Akron, United States; [2]Bendix Commercial Vehicle Systems, United States

Session D02: Battery Management Systems for Transportation

1174 | Model-Based Design Methodology for Capacitor-Based Equalization Circuits
Francesco Porpora[1], Mauro Di Monaco[1], Giuseppe Tomasso[1], Matilde D'Arpino[2]
[1]University of Cassino and Southern Lazio, Italy; [2]The Ohio State University, United States

2389 | Predictive Battery SoC Control for Dual Propulsion Differential Four Wheel Drive Electric Vehicle
Utkal Ranjan Muduli[1], Khaled Al Jaafari[1], Ranjan Kumar Behera[2], Abdul R. Beig[1], Khalifa Al Hosani[1], Jamal Y. Alsawalhi[1]
[1]Khalifa University, United Arab Emirates; [2]Indian 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 Du[1], Fei Diao[1], Yue Zhao[1], Kevin Uvodich[2], Nenad Miljkovic[2]
[1]University of Arkansas, United States; [2]University 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 Ravi[1], Jiewen Hu[1], Xingchen Zhao[1], Dong Dong[1], Rolando Burgos[1], Sriram Chandrasekaran[2], Saeed Alipour[2], Richard Eddins[3]
[1]Virginia Polytechnic Institute and State University, United States; [2]Raytheon Technologies, United States; [3]GE 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 Matsumori[1], Yuto Maeda[1], Takashi Kosaka[1], Nobuyuki Matsui[1], Hiroki Iwai[2], Teppei Tsuda[2], Subrata Saha[2]
[1]Nagoya Institute of Technology, Japan; [2]Aisin Corporation, Japan

Session D04: Transportation Electrification – 1

2501 | A Novel Buck-Boost Type DC-DC Converter Topology for Electric Vehicle Applications
Mohammad Saleh Khan[1], Soumya Shubhra Nag[1], Anandarup Das[1], Changwoo Yoon[2]
[1]Indian Institute of Technology Delhi, India; [2]Seoul National University of Science and Technology, Korea

1614 | Development of an Engine Starter Generator and Implementation of a Power Efficient Starting Procedure
Lukas Killingseder[1], Wolfgang Gruber[2], Alexander Burgstaller[1], Martin Freudenthaler[1]
[1]BRP-Rotax GmbH & Co. KG, Austria; [2]Johannes 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 Zhou[1], Giuseppe Guidi[2], Kjell Ljokelsoy[2], Jon Are Suul[1,2]
[1]Norwegian University of Science and Technology, Norway; [2]SINTEF Energy Research, Norway

2311 | Low-Frequency Oscillations Analysis in AC Railway Networks Using Eigenmode Identification
Paul Frutos[1], Juan Manuel Guerrero[1], Iker Muniategui[2], Iban Vicente[2], Aitor Endemano[2], Fernando Briz[1]
[1]University of Oviedo, Spain; [2]Ingeteam SA, Spain

1303 | Impedance Based Design Method for Interoperable Wireless Power Transfer Systems
Denis Kraus[1], Marius Hassler[1], Grant Covic[2], Hans-Georg Herzog[1]
[1]Technical University of Munich, Germany; [2]The 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 Wei[1], Maohang Qiu[1], Shuai Yang[1], Xiaoyan Liu[1], Jeff Taylor[2], Dong Cao[1]
[1]University of Dayton, United States; [2]Event 38 Unmanned Systems, United States

2352 | Phase Collaborative Interleaving Method to Reduce DC-Link Current Ripple in Switched Reluctance Machine Drive
Md Ehsanul Haque[1], Anik Chowdhury[1], Shuvajit Das[1], Yilmaz Sozer[1], Fernando Venegas[2], David Colavincenzo[2]
[1]The University of Akron, United States; [2]Bendix 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 Das[1], Anik Chowdhury[1], Teppei Tsuda[2], Naoto Saito[2], Subrata Saha[2], Yilmaz Sozer[1]
[1]The University of Akron, United States; [2]Aisin 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 Varghese[1], Geza Joos[1], Syed Qaseem Ali[2]
[1]McGill University, Canada; [2]OPAL-RT Technologies, Inc., Canada

2328 | Position Fault Detection and Failover Method for UAM PMSM Control
Taeyoen Lee[1], Heekwang Lee[2], Bonkil Koo[1], Kwanghee Nam[1]
[1]Pohang University of Science and Technology, Korea; [2]Hyundai 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 Lee[1], Myung-Yong Kim[2], Seung-Hwan Lee[1]
[1]University of Seoul, Korea; [2]Korea Railroad Research Institute, Korea

1013 | Current Balancing of a Multi-Phase Inverter for Wireless Power Transfer Systems Based on Mutually Negatively Coupled Inductors
Yiming Zhang[1], Yuanchao Wu[1], Shuxin Chen[2], Xin Li[2], Yi Tang[2]
[1]Fuzhou University, China; [2]Nanyang Technological University, Singapore

Session D07: Electric Vehicle Charging

2344 | Efficiency of Motor and Inverter Reconfigured as a Boost-Buck Connected Integrated BEV Charger
Erik Hoevenaars[1], Marc Hiller[2]
[1]Robert Bosch GmbH, Germany; [2]Karlsruhe 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 Yang[1], Yingfeng Cai[1], Chris Mi[2]
[1]Jiangsu University, China; [2]San 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 Yang[1], Yingfeng Cai[1], Chris Mi[2]
[1]Jiangsu University, China; [2]San 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 Li[1], Chaoyu Dong[1,2], Yunfei Mu[1], Xiaohong Dong[3], Jingming Cao[1], Hongjie Jia[1]
[1]Tianjin University, China; [2]Imperial College London, United Kingdom; [3]Hebei University, China

1727 | The Effect of Pulsed Current on the Lifetime of Lithium-Ion Batteries
Xinrong Huang[1], Siyu Jin[1], Jinhao Meng[2], Remus Teodorescu[1], Daniel-Ioan Stroe[1]
[1]Aalborg University, Denmark; [2]University 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 Ma[1], Xiuqing Yi[2], Wei Li[1], Feng Gao[1], Fujia Yu[3]
[1]Shandong University, China; [2]Shandong University of Traditional Chinese Medicine, China; [3]State 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-Hernandez[1], Asier Garcia-Bediaga[1], Irma Villar[1], Gonzalo Abad[2]
[1]Ikerlan Technology Research Centre (BRTA), Spain; [2]Mondragon 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 Amiri[1], Wilson Eberle[1], Deepak Gautam[2], Chris Botting[2]
[1]The University of British Columbia, Canada; [2]Delta-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 Amiri[1], Wilson Eberle[1], Deepak Gautam[2], Chris Botting[2]
[1]The University of British Columbia, Canada; [2]Delta-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 Wen[1], Dong Jiao[1], Jih-Sheng Lai[1], Johan Strydom[2], Bing Lu[2]
[1]Virginia Polytechnic Institute and State University, United States; [2]Texas 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 Salvo[1], Matteo Bulzi[1], Jacopo Riccio[2], Riccardo Leuzzi[1], Pericle Zanchetta[1], Norma Anglani[1]
[1]University of Pavia, Italy; [2]University 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]
[1]Technische Universität Braunschweig, Germany; [2]Leibniz 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 Yang[1], Robson Bauwelz Gonzatti[1,2], Hamed Pourgharibshahi[1], Fang Peng[1]
[1]Florida State University, United States; [2]Federal University of Itajuba, Brazil

2475 | A Hybrid Binary Multilevel Cascaded Inverter for Medium-Voltage Applications
Jih-Sheng Lai[1], Bryan Gutierrez[1], Moonhyun Lee[2], Chih-Shen Yeh[3], Hao Wen[1], Dong Jiao[1], Zhengming Hou[1], Hsinche Hsieh[1]
[1]Virginia Polytechnic Institute and State University, United States; [2]Rivian, United States; [3]Transphorm, 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 Han[1], Fang Z. Peng[1], Suman Dwari[2]
[1]Florida State University, United States; [2]Raytheon 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 Yu[1], Chengzi Yang[1], Wei Mu[1], Fengtao Yang[1], Huaqing Li[1], Laili Wang[1], Yuquan Su[2], Chi Zhang[2]
[1]Xi'an Jiaotong University, China; [2]MiSiliconn 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 Sarkar[1], Nachiketa Deshmukh[1], Pankaj Kumar[1], Sandeep Anand[2]
[1]Indian Institute of Technology Kanpur, India; [2]Indian 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 Pal[2], Ranganathan Gurunathan[1], Kaushik Basu[2]
[1]Bloom Energy (I) Pvt Ltd., India; [2]Indian 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 Tian[1], Han Cui[1], Lingxiao Xue[2]
[1]University of Tennessee Knoxville, United States; [2]Oak 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 Lim[3], Jung-Ik Ha[1]
[1]Seoul National University, Korea; [2]Samsun Electronics, Korea; [3]Seoul 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 Sarkar[1], Aditya Aman[2], Sandeep Anand[2]
[1]Indian Institute of Technology Kanpur, India; [2]Indian Institute of Technology Bombay, India

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 Gandomi[1], Leila Parsa[1], Keith Corzine[1], Vahid Dargahi[2]
[1]University of California Santa Cruz, United States; [2]University 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 Huang[1], Qingxuan Ma[1], Alex Q. Huang[1], Michael de Rooij[2]
[1]The University of Texas at Austin, United States; [2]Efficient 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 Shimada[1], Mizuki Nakahara[1], Takuya Ishigaki[2]
[1]Hitachi, Ltd., Japan; [2]Hitachi 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 Jia[1], Han Cui[1], Lingxiao Xue[2]
[1]University of Tennessee Knoxville, United States; [2]Oak 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 Chandwani[1], Saikat Dey[1], Ayan Mallik[1], Arun Sankar[2]
[1]Arizona State University, United States; [2]Mercedes-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 Wong[1], Guangqi Zhu[2], Birger Pahl[2], Subhashish Bhattacharya[1]
[1]North Carolina State University, United States; [2]Eaton, United States

2038 | Control Techniques for a Current-Mode-Controlled Merged-Energy-Buffer-Based Two-Stage Electrolytic-Free Offline LED Driver
Maida Farooq[1], Firehiwot Gurara[1], Mausamjeet Khatua[1], Danish Shahzad[1], Saad Pervaiz[2], Khurram K. Afridi[1]
[1]Cornell University, United States; [2]Texas Instruments, United States

1862 | Asymmetric Cascaded Transformer Multilevel AC-DC Converter
Bruna S. Gehrke[1], Cursino B. Jacobina[1], Nayara B. de Freitas[2], Italo R.F.M.P. da Silva[3], Reuben P.R. Sousa[1]
[1]Federal University of Campina Grande, Brazil; [2]INESC TEC, Portugal; [3]Federal 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 Dadkhah[1], Carl N.M. Ho[1], Ken K.M. Siu[2], River Tin Ho Li[3]
[1]University of Manitoba, Canada; [2]University of North Texas, United States; [3]Hong 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. Monteiro[1], Cursino B. Jacobina[1], Filipe A.C. Bahia[2], Reuben P.R. Sousa[1]
[1]Federal University of Campina Grande, Brazil; [2]Federal University of Bahia, Brazil

1215 | A Three-Phase Voltage Doubler Topology Consisted of Small Number of Switching Devices with Low Switching Frequency
Mizuki Nakahara[1], Hirooki Tokoi[1], Hideto Takada[2], Hironori Oohashi[2]
[1]Hitachi, Ltd., Japan; [2]Hitachi 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 Huang[1]
[1]The University of Texas at Austin, United States; [2]SharkNinja 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 Chen[1], Xinbo Ruan[1], Ying Li[2]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]University 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. Souza[1], Diego Acevedo-Bueno[1], Montiê A. Vitorino[1], Edison R.C. da Silva[1], Jens Friebe[2], Antonio M.N. Lima[1]
[1]Federal University of Campina Grande, Brazil; [2]Leibniz Universität Hannover, Germany

1705 | Multilevel Converter Based on Series and Parallel Connections Using High-Frequency Transformer
Filipe V. Rocha[1], Cursino B. Jacobina[1], Nady Rocha[2]
[1]Federal University of Campina Grande, Brazil; [2]Federal University of Paraíba, Brazil

1717 | Multilevel Converter Based on Series and Parallel Connections Using Floating Capacitor
Filipe V. Rocha[1], Cursino B. Jacobina[1], Nady Rocha[2], Antonio de Paula Dias Queiroz[3]
[1]Federal University of Campina Grande, Brazil; [2]Federal University of Paraíba, Brazil; [3]Federal 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 Luo[1], Khalegh Mozaffari[2], Brad Lehman[1], Mahshid Amirabadi[1]
[1]Northeastern University, United States; [2]Enphase 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 Mir[1], Bhim Singh[1], Abdul Hamid Bhat[2]
[1]Indian Institute of Technology Delhi, India; [2]National 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. Marinus[1], Reuben P.R. Jacobina[2], Nady Rocha[3], Alexandre C. Oliveira[2], Cursino B. Jacobina[2], Leonardo C. Pontes[1]
[1]Federal Institute of Education, Science and Technology of Ceará, Brazil; [2]Federal University of Campina Grande, Brazil; [3]Federal 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. Júnior[1], Cursino Jacobina[1], Edgard L.L. Fabricio[2]
[1]Federal University of Campina Grande, Brazil; [2]Federal Institute of Paraíba, Brazil

2100 | A Compact Design Using GaN Semiconductor Devices for a Flying Capacitor Five-Level Inverter
Majid Farhangi[1], Yam P. Siwakoti[1], Reza Barzegarkhoo[1], Saad Ul Hasan[1], Dylan Lu[1], Dan Rogers[2]
[1]University of Technology Sydney, Australia; [2]University 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 Lacerda[1], Cursino B. Jacobina[1], Edgard L.L. Fabricio[2], Jean Torelli Cardoso[1]
[1]Federal University of Campina Grande, Brazil; [2]Federal Institute of Paraíba, Brazil

1870 | A Seven-Level Inverter with Natural Balance and Boosting Capability
Ronnan de B. Cardoso[1], Edison Roberto C. da Silva[2,3], Leonardo R. Limongi[1], André Elias L. da Costa[2]
[1]Federal University of Pernambuco, Brazil; [2]Federal University of Campina Grande, Brazil;
[3]Federal 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. Foti[1], A. Testa[1], S. De Caro[1], G. Scelba[2], A. Cusumano[2]
[1]University of Messina, Italy; [2]University of Catania, Italy

2237 | AC-DC Single-Phase Multilevel Converters with Floating DC-Link and Reduced Controlled Switches
Ulisses G. Lima[1], Cursino B. Jacobina[2], Reuben P.R. Sousa[1], Rodrigo P. de Lacerda[1]
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. Silva[1], Filipe A.C. Bahia[1], Andre P.N. Tahim[1], Darlan A. Fernandes[2], Fabiano F. Costa[1]
[1]Federal University of Bahia, Brazil; [2]Federal 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 Ardashir[1], Mahdi Gasemi[1], Behrouz Rozmeh[1], Saeed Peyghami[2], Frede Blaabjerg[2]
[1]Islamic Azad University, Iran; [2]Aalborg University, Denmark

2097 | A Novel Single-Source Single-Stage Switched-Boost Five-Level (S5B5L) Inverter with Dynamic Voltage Boosting Feature

Majid Farhangi[1], Reza Barzegarkhoo[1], Yam P. Siwakoti[1], Dylan Lu[1], Sze Sing Lee[2]
[1]University of Technology Sydney, Australia; [2]Newcastle 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 Benedetto[1], A. Lidozzi[1], L. Solero[1], F. Crescimbini[1], P.J. Grbović[2]
[1]Roma Tre University, Italy; [2]University 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 Gheisarnejad[1], Mohammad Sharifzadeh[2], Mohammad-Hassan Khooban[1], Kamal Al-Haddad[2]
[1]Aarhus University, Denmark; [2]École de technologie supérieure, Canada

1467 | Convex Optimization-Based Vector Current Control Design for Grid-Connected Packed E-Cell Inverters

Mahdieh S. Sadabadi[1], Mohammad Sharifzadeh[2], Majid Mehrasa[3], Seddik Bacha[3], Kamal Al-Haddad[2]
[1]The University of Sheffield, United Kingdom; [2]École de Technologie Supérieure, Canada; [3]Université Grenoble Alpes, France

2253 | Hybrid Multilevel T-Type Inverter Exploiting a Nearest Level Modulation Technique

S. Foti[1], A. Testa[1], S. De Caro[1], T. Scimone[1], G. Scelba[2], G. Scarcella[2]
[1]University of Messina, Italy; [2]University 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 Noghani[1], Mostafa Abarzadeh[2], Alireza Javadi[3], Kamal Al-Haddad[1]
[1]École de technologie supérieure, Canada; [2]SmartD Technologies Inc., Canada; [3]SUEZ Water Technologies & Solutions, Canada

2009 | Splitting of Voltage Reference between Half-Bridge and Full-Bridge Sub-Modules in Hybrid MMC
Risabh Sarangi[1], Tanmoy Bhattacharya[2], Dheeman Chatterjee[2]
[1]Indian Institute of Technology Kanpur, India; [2]Indian Institute of Technology Kharagpur, India

1462 | Circulating Current Control in Arm Link Enhanced Modular Multilevel Converter for Low-Voltage and Variable Frequency Applications
Rodrigo Aguilar[1], Luca Tarisciotti[2], Javier Pereda[1]
[1]Pontificia Universidad Católica de Chile, Chile; [2]Universidad 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 Loncarski[1], Francesca Maiullari[2], Rinaldo Consoletti[2], Vito Giuseppe Monopoli[2], Francesco Cupertino[2]
[1]University of Bologna, Italy; [2]Politecnico 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 Khan[1], Usman Ali Khan[2], Shehab Ahmed[1]
[1]King Abdullah University of Science and Technology, Saudi Arabia; [2]Yonsei 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 Li[1], Zexi Zhou[1], Zhipeng Zhang[1], Guoen Cao[2], Yajing Zhang[3]
[1]Beijing Jiaotong University, China; [2]Chinese Academy of Science, China; [3]Beijing Information Science and Technology University, China

2359 | Dynamic Phasor Model of Multi-Converter Systems
Arash Nazari[1], Yaosuo Xue[2], Jayesh Kumar Motwani[1], Igor Cvetkovic[1], Dong Dong[1], Dushan Boroyevich[1]
[1]Virginia Polytechnic Institute and State University, United States; [2]Oak 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 Li[1], Shuxin Chen[1], Yi Tang[1], Yiming Zhang[2], Xin Zhang[3]
[1]Nanyang Technological University, Singapore; [2]Fuzhou University, China; [3]Zhejiang 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 Fritz[1], Maximilian Friedel[1], Rik W. De Doncker[1], Timothy A. Polom[2]
[1]RWTH Aachen University, Germany; [2]Silicon 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 Hong[1], Henry Shu-hung Chung[1], Alan Wai-Lun Lo[2], Huai Wang[3]
[1]City University of Hong Kong, China; [2]Chu Hai College of Higher Education, China; [3]Aalborg University, Denmark

1872 | Mode Analysis and Identification Scheme of Open-Circuit Fault in a Three-Phase DAB Converter

Sagar Kumar Rastogi[1], Suyash Sushilkumar Shah[1], Brij N. Singh[2], Subhashish Bhattacharya[1]
[1]North Carolina State University, United States; [2]John 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 Terlizzi[1], Stefano Bifaretti[1], Alessandro Lampasi[2]
[1]University of Rome "Tor Vergata", Italy; [2]ENEA, 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 Roy[1], Mansi Joisher[2], Alex J. Hanson[1]
[1]The University of Texas at Austin, United States; [2]National 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 Dutta[1], Minghui Lu[1], Branko Majmunovic[2], Rahul Mallik[1], Gab-Su Seo[3], Dragan Maksimović[2], Brian Johnson[1]
[1]University of Washington, United States; [2]University of Colorado, United States; [3]National Renewable Energy Laboratory, United States

1982 | Input AC Voltage Sensorless Control Method for Single-Phase PFC Converter Using Frequency Estimator

Seunghoon Baek[1], Chun-Gi Yun[2], Younghoon Cho[3]
[1]Virginia Polytechnic Institute and State University, United States; [2]Korea Electrical Manufacturers Association, Korea; [3]Konkuk 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 Suthar[1], V. Inder Kumar[1], Faleh Alskran[2], Dragan Maksimović[1]
[1]University of Colorado Boulder, United States; [2]Advanced Energy Industries, Inc., United States

Session F05: Power Converter Stability

1735 | An Approach for Modeling and Stability Analysis of Single-Phase Microgrids
Nima Amouzegar Ashtiani[1], S. Ali Khajehoddin[1], Masoud Karimi-Ghartemani[2]
[1]University of Alberta, Canada; [2]Mississippi 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 Yu[1], Han Deng[1], Yi Tang[1], Yang Qi[2], Xiong Liu[3]
[1]Nanyang Technological University, Singapore; [2]Northwestern Polytechnical University, China; [3]Jinan University, China

1077 | Stability Analysis and Improvement of Three-Phase Grid-Tied Power Converters through the Generalized Phase Portraits Method
Jiale Yu[1], Yi Tang[1], Jingyang Fang[2], Hongchang Li[3]
[1]Nanyang Technological University, Singapore; [2]Duke University, United States; [3]Xinjiang 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 Schanen[1], Herve Chazal[1], Pericle Zanchetta[2,3], Caio Fronseca de Freitas[4]
[1]Université Grenoble Alpes, France; [2]University of Nottingham, United Kingdom; [3]University of Pavia, Italy; [4]Centrale 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. Julian[1], Giovanna Oriti[2]
[1]Consultant, United States; [2]Naval Postgraduate School, United States

1856 | Electric Near Field Emission from a 1Mhz Power Converter for Electric Vehicles
Yanwen Lai[1], Juntao Yao[1], Shuo Wang[1], Zheng Luo[2], Yiming Li[2]
[1]University of Florida, United States; [2]Monolithic 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 Li[1], Weidong Xiao[1], Sinan Li[1], Jimmy Chih-Hsien Peng[2]
[1]The University of Sydney, Australia; [2]National University of Singapore, Singapore

Session F08: Design and Control of Power Converters

2199 | Switching Losses Minimized Harmonic Elimination for Two-Level Inverters
Kehu Yang[1], Suna Pan[1], Huawei Li[2]
[1]China University of Mining and Technology, China; [2]Beijing 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 Dehem[2], Charif Karimi[1], Tanguy Phulpin[1], Daniel Sadarnac[1]
[1]CentraleSupélec, France, France; [2]EnerSys, 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 Song[1], Subham Sahoo[1], Yongheng Yang[2], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Zhejiang 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 Zhao[1], Zheming Jin[2], Xiongfei Wang[1]
[1]Aalborg University, Denmark; [2]Beijing 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 Wang[1], Rui Ling[1], Dongxue Li[2]
[1]Chongqing University, China; [2]Vicor Corporation, United States

Session F10: Control Aspects of Grid-Connected Converters

1070 | Dynamic Performance Limitation and Enhancement of Grid-Forming Converters
Han Deng[1], Jingyang Fang[2], Yang Qi[3], Vincent Debusschere[4], Yi Tang[1]
[1]Nanyang Technological University, Singapore; [2]University of Kaiserslautern, Germany; [3]Northwestern Polytechnical University; [4]Grenoble 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 Dargahi[1], Arash Khoshkbar Sadigh[2]
[1]University of Washington, United States; [2]The 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 Men[1], Yuhua Du[1], Xiaonan Lu[1], Jianzhe Liu[2], Feng Qiu[2]
[1]Temple University, United States; [2]Argonne National Laboratory, United States

2162 | Shipboard Power Conversion System to Meet MIL-STD-1399 Limits for Pulsed Power Loads
Giovanna Oriti[1], Alexander L. Julian[2], Daniel P. DeToma[3]
[1]Naval Postgraduate School, United States; [2]Consultant, United States; [3]US 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 Mathew[1], Abhishek Awasthi[1], Praveen Jain[1], Shahbaj S. Dhillon[2], Majid Pahlevani[1]
[1]Queen's University, Canada; [2]Voltsafe 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 Zhang[1], Shuang Wang[1], Xinbo Ruan[1], Ming Yan[2], Donghua Wu[2]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]Shaanxi 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 Liu[1], Ezequiel Rodriguez[1], Glen G. Farivar[1], Josep Pou[1], Salvador Ceballos[2], Christopher D. Townsend[3], Ramon Leyva[4]
[1]Nanyang Technological University, Singapore; [2]Basque Research and Technology Alliance, Spain; [3]University of Western Australia, Australia; [4]Universitat Rovira i Virgili, Spain

1209 | Quasi-Reference PWM for 3-Level Voltage Source Inverters
Anatolii Tcai[1], Thiwanka Wijekoon[1], Jun-Hyung Jung[2], Marco Liserre[2]
[1]Huawei Technologies Düsseldorf GmbH, Germany; [2]Christian-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 Darbas[1], Jean-Christophe Olivier[2], Nicolas Ginot[1], Frédéric Poitiers[1]
[1]IETR, France; [2]IREENA, 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 Xu[1], Liang Qin[1], Yi Zhang[2], Kaipei Liu[1], Frede Blaabjerg[2]
[1]Wuhan University, China; [2]Aalborg University, Denmark

2341 | Power Device Losses in Two-Level Converters with Direct Current Controllers for Grid Connected Applications

Jose Ortiz Gonzalez[1], Diego Pérez-Estévez[2], Ruizhu Wu[1], Jesús Doval-Gandoy[2], Phil Mawby[1], Olayiwola Alatise[1]
[1]University of Warwick, United Kingdom; [2]University of Vigo, Spain

2194 | Real-Time Simulation Framework for Hardware-in-the-Loop Testing of Multi-Port Autonomous Reconfigurable Solar power plant (MARS)

Zerui Dong[1], Suman Debnath[2], Wei Li[3], Qianxue Xia[4], Phani R.V. Marthi[2], Sudipta Chakraborty[1]
[1]OPAL-RT Corporation, United States; [2]Oak Ridge National Laboratory, United States; [3]OPAL-RT Technologies, Inc., Canada; [4]Georgia 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. Piedra[1], Pablo García[2], Ramy Georgious[1], Geber Villa[2], Mhret Berhe Gebremariam[2]
[1]ENFASYS, Spain; [2]University 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 Yao[1], Harish S. Krishnamoorthy[1], Harshit Soni[2], Amitava Das[2]
[1]University of Houston, United States; [2]Tagore 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 Suryanarayana[1], Maziar Mobarrez[1], Jacob Miscio[1], Xiaoqing Song[1], Arun Kadavelugu[1], Silvio Colombi[2]
[1]ABB, United States; [2]ABB, Switzerland

2481 | Minimization of DC-Link Capacitance for a DC-Link Based Variable Speed Constant Frequency Aircraft Power System
Goutham Selvaraj[1], Kaushik Rajashekara[1], Krishna Raj Ramachandran Potti[2]
[1]University of Houston, United States; [2]Indian 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 Tarisciotti[1], Luca Papini[2], Constanza Ahumada[3], Paolo Bolognesi[2]
[1]University Andres Bello, Chile; [2]University of Pisa, Italy; [3]University 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 Cecati[1], Marco Liserre[1], Yicheng Liao[2], Xiongfei Wang[2], Frede Blaabjerg[2]
[1]Christian-Albrechts-Universität zu Kiel, Germany; [2]Aalborg 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 Torrisi[1], Sebastiano Messina[1], Mario Cacciato[2]
[1]STMicroelectronics, Italy; [2]University 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 Lu[1], Rahul Mallik[1], Brian Johnson[1], Sairaj Dhople[2]
[1]University of Washington, United States; [2]University 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 Chen[1], Fred Wang[1,2]
[1]The University of Tennessee Knoxville, United States; [2]Oak 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 Zeng[1], Ali Maswood[1], Josep Pou[1], Xin Zhang[2], Changjiang Sun[1], Zhan Li[1], Suvajit Mukherjee[2], Amit Kumar Gupta[2], Jiaxin Dong[1]
[1]Nanyang Technology University, Singapore; [2]Zhejiang University, China; [3]Rolls-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 Li[1], Linqian Cheng[1], Liqun He[1], Chudi Lin[1], Cheng Wang[2], Zhongkui Zhu[1]
[1]Soochow University, China; [2]Nanjing 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 Cao[1], Chaoyu Dong[1,2], Xiaodan Yu[1], Yunfei Mu[1], Qian Xiao[1], Hongjie Jia[1]
[1]Tianjin University, China; [2]Imperial College London, United Kingdom

1275 | Region-Based Stability Analysis on DC MGs with Consensus-Based Secondary Control and Communication Delay
Yuhua Du[1], Yuxi Men[1], Lizhi Ding[1], Xiaonan Lu[1], Bo Chen[2], Jianzhe Liu[2]
[1]Temple University, United States; [2]Argonne 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 Fan[1], Jun Wang[2], Yu Rong[1], Vladimir Mitrovic[1], Jianghui Yu[1], Slavko Mocevic[1], Rolando Burgos[1], Dushan Boroyevich[1]
[1]Virginia Polytechnic Institute and State University, United States; [2]University 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 Deng[1], Rui Ling[1], Dongxue Li[2]
[1]Chongqing University, China; [2]Vicor 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 Yang[1], Zeyu Min[1], Yongchang Zhang[1], Zeting Wang[1], Dong Jiang[2]
[1]North China University of Technology, China; [2]Huazhong 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 Umetani[1], Kota Shimomura[1], Kenta Yamada[1], Taichi Kawakami[2], Ishihara Masataka[1], Eiji Hiraki[1]
[1]Okayama University, Japan; [2]Osaka 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 Tarisciotti[1], Giampaolo Buticchi[2], Giovanni De Carne[3], Yang Jiajun[2], Chunyang Gu[2], Patrick Wheeler[4]
[1]University Andres Bello, Chile; [2]University of Nottingham Ningbo, China; [3]Karlsruhe Institute of Technology, Germany; [4]University 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 Wang[1], Daying Sun[1], Xiang Zhang[1], Wenhua Gu[1], Sang Gui[2]
[1]Nanjing University of Science and Technology, China; [2]Wuxi 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 Crespo[1], Pablo García[2], Konstantin Edl[3], Ramy Georgious[4], Cristian Blanco[2], Igor Cantero[1]
[1]Cegasa, Spain; [2]University of Oviedo, Spain; [3]IsarAerospace Technologies GmbH, Germany; [4]ENFASYS, 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 Zhang[1], Xiongfei Wang[1], Qianwen Xu[2]
[1]Aalborg University, Denmark; [2]KTH 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 Lin[1], Bo Wen[1], Rolando Burgos[1], John Noon[2]
[1]Virginia Polytechnic Institute and State University, United States; [2]Moog Inc., United States

2265 | Comparison of Anti-Windup Alternatives for Parallel Controllers
Cristina González Moral[1], Diego Fernández Laborda[2], Juan M. Guerrero Muñoz[2], Carlos Rivas[1], David Diaz Reigosa[2]
[1]Electrotécnica Industrial y Naval S.L., Spain; [2]University of Oviedo, Spain

2039 | Adaptive Voltage Positioning Design of Single Stage 48/1V Sigma Converter for Fast Transient Response
Xin Lou[1], Qiang Li[1], Mohamed H. Ahmed[2]
[1]Virginia Polytechnic Institute and State University, United States; [2]Texas Instruments, United States

Session F26: Power Converter EMI I

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. Venkatramanan[1], V. Nimesh[2], Brian Johnson[2], Sairaj Dhople[1]
[1]University of Minnesota, United States; [2]University 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. Júnior[1], Cursino Jacobina[1], Edgard L.L. Fabricio[2]
[1]Federal University of Campina Grande, Brazil; [2]Federal 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 Rahimi[1], Hossein Khoun Jahan[2], Saeed Peyghami[3], Ding Lei[1], Frede Blaabjerg[3], Pooya Davari[3]
[1]Shandong University, China; [2]Azarbaijan Regional Electric Company, Iran; [3]Aalborg 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 Broeck[1], Timothy A. Polom[2], Rik De Doncker[3]
[1]FEV Europe GmbH, Germany; [2]Silicon Austria Labs GmbH, Austria; [3]RWTH Aachen University, Germany

2102 | Fault Detection and Management of the Three-Phase 4-Leg Voltage Source Inverter
Mi Tang[1], Pericle Zanchetta[1], M. di Benedetto[2], A. Lidozzi[2], L. Solero[2]
[1]University of Nottingham, United Kingdom; [2]Roma 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 Davoodi[1], Saeed Peyghami[1], Yongheng Yang[2], Tomislav Dragičević[3], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Zhejiang University, China; [3]Technical University of Denmark, Denmark

1298 | Reliability of Wind Turbine Power Modules Using High-Resolution Wind Data Reconstruction: A Digital Twin Concept
Nikolaos Iosifidis[1], Yanghao Zhong[1], Borong Hu[2], Biyun Chen[3], Li Ran[1], Subhash Lakshminarayana[1], Chunjiang Jia[4], Paul McKeever[4], Chong Ng[4]
[1]University of Warwick, United Kingdom; [2]University of Cambridge, United Kingdom; [3]Guangxi University, China; [4]Offshore 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. Singh[1], Ramakrishnan Raja[1], Tomy Sebastian[1], Kaushik Rajashekara[2]
[1]Halla Mechatronics, United States; [2]University 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 Carbonieri[1], Wen L. Soong[2], Amin Mahmoudi[3], Nicola Bianchi[1]
[1]University of Padova, Italy; [2]University of Adelaide, Australia; [3]Flinders University, Australia

1165 | Optimization of a Line-Start Motor for Centrifugal Loads within Premium Efficiency According to IEC Standard
Diego Troncon[1], Luigi Alberti[1], Leone Donazzan[2], Mauro Daneluzzi[2], Massimo Trova[2]
[1]University of Padova, Italy; [2]Orange1 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. Nishanth[1], Joachim Van Verdeghem[2], Eric L. Severson[1]
[1]University of Wisconsin Madison, United States; [2]Université catholique de Louvain, Belgium

2085 | Investigation of Asymmetric Axial-Flux Hybrid Excited Electrodynamic Wheels for Maglev Transportation
Wei Qin[1], Ma Yuhua[2], Lv Gang[1], Wang Fuyao[1], Song Chengrui[1], Zhang Jielong[1]
[1]Beijing Jiaotong University, China; [2]Taiyuan 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 Nakazawa[1], Masatsugu Takemoto[2], Satoshi Ogasawara[1], Koji Orikawa[2]
[1]Hokkaido University, Japan; [2]Okayama 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 Riquelme[1], Werner Jara[1], Carlos Madariaga[2], Juan Tapia[2], Gerd Bramerdorfer[3], Javier Riedemann[4]
[1]Pontificia Universidad Católica de Valparaiso, Chile; [2]University of Concepcion, Chile; [3]Johannes Kepler University Linz, Austria; [4]The 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 Islam[2], Iqbal Husain[1]
[1]North Carolina State University, United States; [2]Halla 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 Liu[1], Yew Chuan Chong[2], Melanie Michon[2], James Goss[2], David Gerada[1], Zeyuan Xu[1], Chris Gerada[1], He Zhang[3]
[1]University of Nottingham, United Kingdom; [2]Motor Design Ltd., United Kingdom; [3]University of Nottingham Ningbo, China

2464 | Approaches for Improving Lumped Parameter Thermal Networks for Outer Rotor SPM Machines
Daniel Wöckinger[1], Gerd Bramerdorfer[1], Silvio Vaschetto[2], Andrea Cavagnino[2], Alberto Tenconi[2], Wolfgang Amrhein[1], Frank Jeske[3]
[1]Johannes Kepler University Linz, Austria; [2]Politecnico di Torino, Italy; [3]ebm-papst St. Georgen GmbH & Co. KG, Germany

2182 | Electromagnetic and Thermal Evaluation of Surface-Mounted PM Vernier Machines
Mostafa Ahmadi Darmani[1], Silvio Vaschetto[1], Andrea Cavagnino[1], Mircea Popescu[2]
[1]Politecnico di Torino, Italy; [2]Motor Design Ltd., United Kingdom

2183 | Comparison of Superposition Equivalent Loading Methods for Induction Machine Temperature Tests
Silvio Vaschetto[1], Emmanuel Agamloh[2], Federica Graffeo[1], Andrea Cavagnino[1]
[1]Politecnico di Torino, Italy; [2]Baylor 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 Simpson[1], Jakob Jung[2], Axel Helm[2], Phil Mellor[1]
[1]University of Bristol, United Kingdom; [2]Additive 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 Ibrahim[1], Sumeet Singh[2], Dwaipayan Barman[2], Fabrice Bernier[1], Jean-Michel Lamarre[1], Serge Grenier[3], Pragasen Pillay[2]
[1]National Research Council of Canada, Canada; [2]Concordia University, Canada; [3]Rio 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 Simizu[1], Kevin Byerly[1], Kyle Schneider[1], Heonyoung Kim[2], Mark Nations[2], Sneha Narasimhan[2], Richard Beddingfield[2], Subhashish Bhattacharya[2], Michael E. McHenry[1]
[1]Carnegie Mellon University, United States; [2]North 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 Hoole[1], Nick Simpson[1], Philip H. Mellor[1], Abdeljalil Daanoune[2]
[1]University of Bristol, United Kingdom; [2]hofer 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 Das[1], Md Ehsanul Haque[1], Anik Chowdhury[1], Yilmaz Sozer[1], David Colavincenzo[2], Fernando Venegas[2], Jeffrey Geither[2]
[1]The University of Akron, United States; [2]Bendix 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 Ozawa[1], Yusuke Fujii[1], Akira Chiba[1], Hiroya Sugimoto[2], Haruhiko Suzuki[3], Hannes Bleuler[4]
[1]Tokyo Institute of Technology, Japan; [2]Tokyo Denki University, Japan; [3]Fukushima College, Japan; [4]EPFL, 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 Chowdhury[1], Shuvajit Das[1], Teppei Tsuda[2], Naoto Saito[2], Subrata Saha[2], Yilmaz Sozer[1]
[1]The University of Akron, United States; [2]Aisin 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 Bianchini[1], Ambra Torreggiani[1], Matteo Davoli[2], Alberto Bellini[3], Ludovico Ortombina[4], Nicola Bianchi[4]
[1]University of Modena and Reggio Emilia, Italy; [2]Raw Power srl, Italy; [3]University of Bologna, Italy; [4]University 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 Gmyrek[1], Andrea Cavagnino[2]
[1]Lodz University of Technology, Poland; [2]Politecnico 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 Chambers[1], Nick Baker[1], Mike Galbraith[2], Edward Spooner[2]
[1]Newcastle University, United Kingdom; [2]Fountain 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 Bandarkar[1], Muntasir Islam[1], Senol Sancar[1], Lavanya Vadamodala[1], Md Ehsanul Haque[1], Yilmaz Sozer[1], Reginald Garcia[2]
[1]The University of Akron, United States; [2]Future Motors, United States

2263 | Influence of Constructive Parameters on the Performance of an Axial-Flux Induction Machine with Solid and Magnetically Anisotropic Rotor
Carlos Madariaga[1], Juan Tapia[1], Nicolás Reyes[1], Werner Jara[2], Michele Degano[3]
[1]University of Concepcion, Chile; [2]Pontificia Universidad Católica de Valparaiso, Chile; [3]University of Nottingham, United Kingdom

2191 | A Comparison of Cryogenic-Cooled and Superconducting Electrical Machines
Marco Biasion[1], João F. P. Fernandes[2], Paulo José da Costa Branco[2], Silvio Vaschetto[1], Andrea Cavagnino[1], Alberto Tenconi[1]
[1]Politecnico di Torino, Italy; [2]Universidade 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 Chattopadhyay[1], Md Sariful Islam[2], Rajib Mikail[3], Iqbal Husain[1]
[1]North Carolina State University, United States; [2]Halla Mechatronics, United States; [3]ABB, United States

2264 | Frequency-Domain Analysis and Design of Thomson-Coil Actuators
Bruno Lequesne[1], Tyler Holp[2], Steve Schmalz[2], Michael Slepian[2], Hongbin Wang[2]
[1]E-Motors Consulting, LLC, United States; [2]Eaton, United States

2193 | Design Optimization Procedure of Air-Cored Resonant Induction Machines
Zhao Jin[1], Matteo F. Iacchetti[1], Alexander C. Smith[1], Rajesh P. Deodhar[2], Yoshiyuki Komi[3], Ahmad Anad Abduallah[2], Chiaki Umemura[3]
[1]The University of Manchester, United Kingdom; [2]IMRA Europe SAS UK Research Centre, United Kingdom; [3]Aisin Seki Co., Ltd., Japan

2367 | Loss Minimization Control of an Electronic Pole Changing 4-Pole/2-Pole Induction Motor
Taohid Latif[1], Mohamed Zubair M. Jaffar[2], Iqbal Husain[1]
[1]North Carolina State University, United States; [2]FEV 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
[1]Newcastle University, United Kingdom; [2]University 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 Liang[1], Z.Q. Zhu[1], J.H. Feng[2], S.Y. Guo[2], Y.F. Li[2], A.F. Zhao[2], J.W. Hou[2]
[1]The University of Sheffield, United Kingdom; [2]CRRC Zhuzhou Institute Co. Ltd., China

1494 | Optimization of IM Rotor Bars Inclination Angle Using Analytical Model in Free FEA Software
Thanh Tung To[1], Emad Roshandel[2], Amin Mahmoudi[2], Zhi Cao[2], Solmaz Kahourzade[1]
[1]University of South Australia, Australia; [2]Flinders University, Australia

1510 | 2D Subdomain Model of the Ladder Linear Induction Machine with considering Saturation Effect
Emad Roshandel[1], Amin Mahmoudi[1], Solmaz Kahourzade[2]
[1]Flinders University, Australia; [2]University 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 Wang[1], Kyung-Hun Shin[1], Yuki Hidaka[2], Shota Kondo[2], Hideaki Arita[2], Kazumasa Ito[2]
[1]Mitsubishi Electric Research Laboratories, United States; [2]Mitsubishi Electric Corporation, Japan

1684 | Hybrid Approach for the Modeling of Magnetic Force Excitations in Multipole Wind Turbine Generators considering Air Gap Imperfections
Alexander Kern[1], Christoph Mülder[1], Kay Hameyer[2], Jianning Dong[1]
[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 Wang[1], Joshua Taylor[2], Berker Bilgin[2]
[1]Huazhong University of Science and Technology, China; [2]McMaster University, Canada

1204 | Space-Vector State Dynamic Model of the Synchronous Reluctance Motor considering Self, Cross-Saturation and Iron Losses
Angelo Accetta[1], Maurizio Cirrincione[2], Marcello Pucci[1], Antonino Sferlazza[3]
[1]CNR-INM, Italy; [2]University of the South Pacific, Italy; [3]University 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 Yogal[1], Christian Lehrmann[1], Markus Henke[2]
[1]Physikalisch-Technische Bundesanstalt, Germany; [2]Technical 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 Ma[1], Ayman EL-Refaie[1], Alireza Fatemi[2], Thomas Nehl[2]
[1]Marquette University, United States; [2]General Motors, United States

2211 | Time-Efficient Multi-Physics Optimization Approaches for the Design of Synchronous Reluctance Motors
Christophe De Gréef[1], Virginie Kluyskens[1], François Henrotte[1,2], Christophe Versèle[3], Christophe Geuzaine[2], Bruno Dehez[1]
[1]Université catholique de Louvain, Belgium; [2]Université de Liège, Belgium; [3]Alstom 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. Palangar[1], Wen L. Soong[2], A. Mahmoudi[1]
[1]Flinders University, Australia; [2]University 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 Xu[1], Zhenzhen Wang[1], Weili Li[2], Yang Zhan[1], Haisen Zhao[1], Yingli Luo[1]
[1]North China Electric Power University, China; [2]Beijing Jiaotong University, China

1081 | Inter-Turn Short Circuit Fault Identification of Salient Pole Synchronous Generators by Descriptive Paradigm
Hossein Ehya[1], Arne Nysveen[1], Jose A. Antonino-Daviu[2], Bilal Akin[3]
[1]Norwegian University of Science and Technology, Norway; [2]Universitat Politecnica de Valencia, Spain; [3]The 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 Perez[1], Werner Jara[1], Carlos Madariaga[2], Juan Tapia[2], Gerd Bramerdorfer[3], Javier Riedemann[4], Ilya Petrov[5], Juha Pyrhönen[5]
[1]Pontificia Universidad Católica de Valparaiso, Chile; [2]University of Concepcion, Chile; [3]Johannes Kepler University Linz, Austria; [4]The University of Sheffield, United Kingdom; [5]Lappeenranta 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 Zhang[1], Rui Nie[1], Jikai Si[1], Chun Gan[2], Yihua Hu[3]
[1]Zhengzhou University, China; [2]Huazhong University of Science and Technology, China; [3]University 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 Kiyota[1], Haruka Isogai[2], Kenji Amei[2], Takahisa Ohji[2]
[1]Tokyo Institute of Technology, Japan; [2]University of Toyama, Japan

2532 | Analysis and Benchmarking of Radial Flux Cycloidal Magnetic Gears with Reduced Permanent Magnet Piece Count Using Consequent Poles
Matthew Johnson[1], Shima Hasanpour[2], Matthew C. Gardner[3], Hamid A. Toliyat[2]
[1]U.S. Army Research Laboratory, United States; [2]Texas A&M University, United States; [3]The 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 Escobar[1], Gonzalo Sánchez[1], Werner Jara[1], Carlos Madariaga[2], Juan Tapia[2], Michele Degano[3], Javier Riedemann[4]
[1]Pontificia Universidad Católica de Valparaiso, Chile; [2]University of Concepcion, Chile; [3]University of Nottingham, United Kingdom; [4]The University of Sheffield, United Kingdom

2013 | Design Optimization and Experimental Study of Coreless Axial-Flux PM Machines with Wave Winding PCB Stators
Peng Han[1], Damien Lawhorn[1], Yaser Chulaee[1], Donovin Lewis[1], Greg Heins[2], Dan M. Ionel[1]
[1]University of Kentucky, United States; [2]Regal 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 Naghavi[1], Shrikesh Sheshaprasad[1], Matthew Gardner[2], Aghamarshana Meduri[1], HeonYong Kang[1], Hamid Toliyat[1]
[1]Texas A&M University, United States; [2]The 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 Aiso[1], Kan Akatsu[2], Yasuaki Aoyama[3]
[1]Shibaura Institute of Technology, Japan; [2]Yokohama National University, Japan; [3]Hitachi, 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 Han[1], Murat G. Kesgin[1], Dan M. Ionel[1], Rohan Gosalia[2], Nakul Shah[2], Charles J. Flynn[2], Chandra S. Goli[3], Somasundaram Essakiappan[3], Madhav Manjrekar[3]
[1]University of Kentucky, United States; [2]QM Power, Inc., United States[3]University 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-Ramirez[1], Roque A. Osornio-Rios[1], Jose Antonino-Daviu[2]
[1]Universidad Autonoma de Queretaro, Mexico; [2]Universitat Politecnica de Valencia, Spain

1302 | Analytical and Experimental Investigations of Magnetostriction Influence on Strain Measurement in Switched Reluctance Machines
Yifei Cai[1], Haruki Sobue[1], Candra Adi Wigna[1], Akira Chiba[1], Kunihiro Senda[2], Souichiro Yoshizaki[3]
[1]Tokyo Institute of Technology, Japan; [2]JFE Techno-Research Corporation, Japan; [3]JFE 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 Lee[1], In-Jun Yang[2], Si-Woo Song[2], Won-Ho Kim[1], Ik-sang Jang[3]
[1]Gachon University, Korea; [2]Hanyang University, Korea; [3]Hyundai 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 Zapico[1], David Diaz Reigosa[1], Hyeon Jun Lee[2], Muhammad Saad Rafaq[2], Sang Bin Lee[2], Fernando Briz del Blanco[1]
[1]University of Oviedo, Spain; [2]Korea 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 Okazaki[1], Kan Akatsu[2], Kan Yang[2]
[1]Mitsubishi Electric Co., Ltd., Japan; [2]Yokohama National University, Japan

Session G22: Modeling of Electric Machines – 3

1097 | Analytical Modeling and Design Optimization of a Vernier Permanent Magnet Motor
Bingnan Wang[1], Lei Zhou[1,2], Hongyu Wang[1], Chungwei Lin[1]
[1]Mitsubishi Electric Research Laboratories, United States; [2]The 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-Φand 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 Zhang[1], Yi Liu[1], Wei Xu[1], Jose Rodriguez[2]
[1]Huazhong University of Science and Technology, China; [2]Universidad Andres Bello, Chile

1646 | Development and Evaluation of a Power Hardware-in-the-Loop (PHIL) Emulator Testbench for Aerospace Applications
He Song[1], John Noon[1], Igor Cvetkovic[1], Bo Wen[1], Srdjan Srdic[2], Gernot Pammer[2], Dushan Boroyevich[1], Rolando Burgos[1]
[1]Virginia Polytechnic Institute and State University, United States; [2]EGSTON 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 Tavernier[1], Christophe Espanet[1], Gael Andrieux[2]
[1]Moving Magnet Technologies, France; [2]Compact 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 Kim[1], Su-Yong Kim[2], In-Jun Yang[1], Si-Woo Song[1], Ju Lee[1], Won-Ho Kim[3]
[1]Hanyang University, Korea; [2]Korea Electronics Technology Institute, Korea; [3]Gachon 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 Han[1], Yibin Zhang[1], Murat G. Kesgin[1], Greg Heins[2], Dean Patterson[2], Mark Thiele[2], Dan M. Ionel[1]
[1]University of Kentucky, United States; [2]Regal 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 Chu[1], Rukmi Dutta[1], John Fletcher[1], Howard Lovatt[2], M.F. Rahman[1]
[1]University of New South Wales, Australia; [2]CSIRO, 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 Cao[1], Dakai Hu[2], Yue Cao[1]
[1]Oregon State University, United States; [2]The MathWorks, Inc., United States

2186 | Torque-Sensorless Identification of IPMSM Torque Map
Hyung-June Cho[1], Joohyun Lee[1], Yong-Cheol Kwon[2], Seung-Ki Sul[1]
[1]Seoul National University, Korea; [2]PLECKO 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 Begh[1], Petros Karamanakos[1], Tobias Geyer[2]
[1]Tampere University, Finland; [2]ABB System Drives, Switzerland

1136 | A Computationally Efficient Robust Direct Model Predictive Control for Medium Voltage Induction Motor Drives
Andrei Tregubov[1], Petros Karamanakos[1], Ludovico Ortombina[2]
[1]Tampere University, Finland; [2]University of Padova, Italy

1553 | High Frequency Signal Injection Sensorless Control of Finite-Control-Set Model Predictive Control with Deadbeat Solution
Ximeng Wu[1], Z.Q. Zhu[1], Nuno M.A. Freire[2]
[1]The University of Sheffield, United Kingdom; [2]Siemens Gamesa Renewable Energy A/S, Denmark

2375 | A Direct Model Predictive Control Strategy for High-Performance Synchronous Reluctance Motor Drives
Jacopo Riccio[1], Petros Karamanakos[2], Shafiq Odhano[3], Mi Tang[1], Mauro Di Nardo[1], Pericle Zanchetta[1,4]
[1]University of Nottingham, United Kingdom; [2]Tampere University, Finland; [3]Newcastle University, United Kingdom; [4]Università 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 Krause[1], Antonio Di Gioia[2], Ian P. Brown[1]
[1]Illinois Institute of Technology, United States; [2]IEMA 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 Lee[1], Hanju Kim[1], Jigyun Jeong[1], Kibok Lee[2], Sang Bin Lee[1], Greg C. Stone[3]
[1]Korea University, Korea; [2]Incheon National University, Korea; [3]Iris 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 Lee[1], Yong-Cheol Kwon[2], Seung-Ki Sul[1]
[1]Seoul National University, Korea; [2]Plecko Co, Ltd., Korea

1755 | Design and Analysis of PLL Speed Estimator for Sensorless Rotor-Flux Oriented Control of Induction Motor Drives
Prasun Mishra[1], Cristian Lascu[1], Michael Møller Bech[1], Bjorn Rannestad[2], Stig Munk-Neilsen
[1]Aalborg University, Denmark; [2]KK 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 Wu[1], Z.Q. Zhu[1], Yang Chen[1], Zhanyuan Wu[2]
[1]The University of Sheffield, United Kingdom; [2]Siemens 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 Hu[1], Wenfei Yu[1], Jiaxing Lei[1], Zheng Wu[1], Wei Hua[2], Yinfeng Hu[2]
[1]Southeast University - Nanjing, China; [2]Southeast 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 Biason[1], Sandro Calligaro[2], Mattia Iurich[1], Roberto Petrella[1], Amir Shahdadi[1]
[1]University of Udine, Italy; [2]Free 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 Maeda[1], Hiroaki Matsumori[1], Takashi Kosaka[1], Nobuyuki Matsui[1], Hiroki Iwai[2], Teppei Tsuda[2], Subrata Saha[2]
[1]Nagoya Institute of Technology, Japan; [2]Aisin 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 Pescetto[1], Andres Sierra-Gonzalez[2], Elena Trancho[2], Gianmario Pellegrino[1]
[1]Politecnico di Torino, Italy; [2]Basque Research and Technology Alliance, Spain

2381 | Control of Dual Three-Phase IPMSM Drive with Cascaded DC-Link Capacitors for Third Generation EV
Andres Sierra-Gonzalez[1], Paolo Pescetto[2], Elena Trancho[1], Edorta Ibarra[3], Gianmario Pellegrino[2], Fernando Alvarez-Gonzalez[1]
[1]Basque Research and Technology Alliance, Spain; [2]Politecnico di Torino, Italy; [3]University of the Basque Country, Spain

2261 | A Novel Low-Speed Direct-Drive PMSM Control Strategy Based on a Two-DOF Structure
Kun Cai[1], Jie Hu[1], Mingjin Hu[1], Danfeng Sun[2], Huajun Zhou[2], Kai Liu[1], Hao Hua[3], Wei Hua[1]
[1]Southeast University, China; [2]Shanghai Aerospace Control Technology Institute, China; [3]Shanghai Jiao Tong University, China

2445 | Integrated High-Frequency SiC Based Modular Multi Three-Phase PMSM Drive for Automotive Range Extender
Nicola Bianchi[1], Sandro Calligaro[2], Giorgio Maldini[3], Mattia Marson[4], Mattia Iurich[5], Roberto Petrella[5]
[1]University of Padova, Italy; [2]Free University of Bozen, Italy; [3]Metasystem s.p.a., Italy; [4]Koala Electronics s.r.l., Italy; [5]University of Udine, Italy

Session H08: Electric Drives

2368 | Selection of Rotor Position Sensor Resolution for Variable Frequency Drives Utilizing Fixed-Position-Based Speed Estimation
Luigi Danilo Tornello[1], Giacomo Scelba[1], Giulio De Donato[2], Fabio Giulii Capponi[2], Giuseppe Scarcella[1], Mark Harbaugh[3]
[1]University of Catania, Italy; [2]Sapienza University of Rome, Italy; [3]Rockwell 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 Guo[1], Tao Yang[1], Seang Shen Yeoh[1], Serhiy Bozhko[1], Patrick Wheeler[1], Ahmed M. Diab[2]
[1]University of Nottingham, United Kingdom; [2]University of Nottingham Ningbo, China

2249 | Performance Analysis of a Fault Isolation System for Fault-Tolerant Voltage-Fed PWM Motor Drives
Luigi Danilo Tornello[1], Giacomo Scelba[1], Andrea Spampinato[2], Gianluigi Forte[2]
[1]University of Catania, Italy; [2]STMicroelectronics, 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 Kong[1], Qian Wang[2], Guorong Zhu[1], Haoran Wang[2], Huai Wang[2]
[1]Wuhan University of Technology, China; [2]Aalborg 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. Soares[1], Ayslan C.N. Maia[2], Cursino B. Jacobina[1], Nayara B. de Freitas[3], Nady Rocha[4], Antonio M.N. Lima[1]
[1]Federal University of Campina Grande, Brazil; [2]Federal Institute of Education, Science and Technology of Ceará, Brazil; [3]INESC TEC, Portugal; [4]Federal 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 Mizukoshi[1], Hitoshi Haga[1], Eiichi Sakasegawa[2]
[1]Nagaoka University of Technology, Japan; [2]National 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 Nagataki[1], Keiichiro Kondo[1], Osamu Yamazaki[2], Kazuaki Yuki[2], Yosuke Nakazawa[2]
[1]Waseda University, Japan; [2]Toshiba 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

Session H10: PM Motor Drives – 1

1408 | Improved Controller Optimization of Flux-Weakening Strategy for Salient Permanent-Magnet Synchronous Motor Based on Genetic Algorithm
Moustafa Magdi Ismail[1,2], Wei Xu[2], Yi Liu[2], Abdul Khalique Junejo[3], Mohamed G. Hussien[4]
[1]Minia University, Egypt; [2]Huazhong University of Science and Technology, China;
[3]Quaid-e-Awam University of Engineering, Science and Technology, Pakistan; [4]Tanta 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 Fernandez[1], David Reigosa[1], Yonghyun Park[2], Sangbin Lee[3], Fernando Briz[1]
[1]University of Oviedo, Spain; [2]Electree Co. Ltd., Korea; [3]Korea 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 Accetta[1], Maurizio Cirrincione[2], Filippo D’Ippolito[3], Marcello Pucci[1], Antonino Sferlazza[3]
[1]CNR-INM, Italy; [2]University of the South Pacific, Fiji; [3]University 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. Petit[1], Bulent Sarlioglu[2]
[1]Miller Electric Mfg., LLC, United States; [2]University of Wisconsin Madison, United States

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 Chen[1], Xiaonan Gao[1], Peter Stolze[2], Ralph Kennel[1]
[1]Technical University of Munich, Germany; [2]MAN 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 Lin[1], Po-Huan Chou[2], Chi-Jun Wu[1], Shih-Chin Yang[1]
[1]National Taiwan University, Taiwan; [2]Industrial 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 Song[1], Wenxi Yao[1], Kevin Lee[2]
[1]Zhejiang University, China; [2]Eaton, United States

2354 | Phase Current Sensorless Control of Switched Reluctance Machines Using Dynamic Interleaving
Md Ehsanul Haque[1], Anik Chowdhury[1], Okan Boler[1], Shuvajit Das[1], Yilmaz Sozer[1], Fernando Venegas[2], David Colavincenzo[2]
[1]The University of Akron, United States; [2]Bendix 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 Mao[1], Jianqiu Li[1], Xu Han[2], Weiguo Liu[2], Zunyan Hu[1], Liangfei Xu[1], Minggao Ouyang[1]
[1]Tsinghua University, China; [2]Northwestern 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 Montero[1], Markus Vogelsberger[2], Thomas Wolbank[1]
[1]Technical University of Vienna, Austria; [2]Bombardier 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 Shim[1], Jun Lee[2], Jung-Ik Ha[1]
[1]Seoul National University, Korea; [2]Samsung Electronics, Korea

1344 | A Novel SPWM-Based Common-Mode Voltage Elimination Modulation Method for Dual Three-Phase Motors
Yang Huang[1], Ximu Zhang[1], Jared Walden[1], Hua Bai[1], Fanning Jin[2], Xiaodong Shi[2], Bing Cheng[2]
[1]University of Tennessee Knoxville, United States; [2]Mercedes-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 Secrest[1], Haisen Zhao[2,4], Osama A. Mohammed[2]
[1]BorgWarner Inc., United States; [2]Florida International University, United States; [3]Ain Shams University, Egypt; [4]North 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 Hara[1], Shun Taniguchi[1], Toshiyuki Ajima[1], Masanori Sawahata[1], Masahiro Hori[1], Tsukagoshi Takaya[2], Katsuhiro Hoshino[2]
[1]Hitachi, Ltd., Japan; [2]Hitachi 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 Gude[1], River Chen[1], Sam Li[1], Yongqiang Lang[2]
[1]Delta Electronics Inc., Taiwan; [2]Delta Electronics Inc., China

1588 | An Energy Recovery Scheme for RCD Snubber in the Series Configuration of IGBTs
Mostafa Zarghani[1], Saeed Peyghami[2], Francesco Iannuzzo[2], Frede Blaabjerg[2], Shahriyar Kaboli[1]
[1]Sharif University of Technology, Iran; [2]Aalborg 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 Xia[1], Ze Li[2], Yuanbo Guo[2], Xiaohua Zhang[2]
[1]Zhejiang University, China; [2]Dalian University of Technology, China

2037 | A Stable and Robust DC Power System for More Electric Aircraft
Galina Mirzaeva[1], Dmitry Miller[1], Graham Goodwin[1], Patrick Wheeler[2]
[1]The University of Newcastle, Australia; [2]University 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 Hao[1], Chandra Namuduri[1], Chengwu Duan[2], Suresh Gopalakrishnan[1], Norman Bucknor[1]
[1]General Motors, United States; [2]General Motors, China

1704 | Iron Losses Impact on High-Speed Drives
Emilio Carfagna[1], Emilio Lorenzani[1], Karthik Debbadi[2], Sante Pugliese[2], Marco Liserre[2]
[1]University of Modena and Reggio Emilia, Italy; [2]Christian-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

Topic I: Power Semiconductor Devices

Session I01: 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 Emon[1], Mustafeez Ul Hassan[1], Abdul Basit Mirza[1], Zhao Yuan[2], Fang Luo[1]
[1]Stony Brook University, United States; [2]University of Arkansas, United States

1367 | Design and Analysis of a PCB-Embedded 1.2 kV SiC Half-Bridge Module
Jack Knoll[1], Gibong Son[1], Christina DiMarino[1], Qiang Li[1], Hannes Stahr[2], Mike Morianz[2]
[1]Virginia Polytechnic Institute and State University, United States; [2]Austria 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 Rajagopal[1], Christina DiMarino[1], Rolando Burgos[1], Taha Moaz[1], Igor Cvetkovic[1], Dushan Boroyevich[1], Olivier Mathieu[2]
[1]Virginia Polytechnic Institute and State University, United States; [2]Rogers 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 I02: 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 Renz[1], Oliver James Vavasour[1], Vishal Ajit Shah[1], Vasantha Pathirana[2], Tanya Trajkovic[2], Yeganeh Bonyadi[3], Ruizhu Wu[1], Jose Angel Ortiz-Gonzalez[1], Xiaoyun Rong[1], Guy William Clarke Baker[1], Philip Mawby[1], Peter Michael Gammon[1]
[1]University of Warwick, United Kingdom; [2]Cambridge Microelectronics Ltd., United Kingdom; [3]Lyra Electronics Ltd., United Kingdom

2406 | Static and Dynamic Characterization of 650 V GaN E-HEMTs in Room and Cryogenic Environments
Mahmoud Mehrabankhomartash[1], Shiyuan Yin[1], Alfonso J. Cruz[1], Lukas Graber[1], Maryam Saeedifard[1], Simon Evans[2], Florian Kapaun[3], Ivan Revel[2], Gerhard Steiner[3], Ludovic Ybanez[2], Chanyeop Park[4]
[1]Georgia Institute of Technology, United States; [2]Airbus, France; [3]Airbus, Germany; [4]Mississippi State University, United States

1827 | Performance Evaluation of Future T-Type PFC Rectifier and Inverter Systems with Monolithic Bidirectional 600V GaN Switches
F. Vollmaier[1], N. Nain[2], J. Huber[2], J.W. Kolar[2], K.K. Leong[3], B. Pandya[3]
[1]Silicon Austria Labs GmbH, Austria; [2]ETH Zürich, Switzerland; [3]Infineon 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 Byerly[1], Satoru Simizu[1], Michael E. McHenry[1], Paul R. Ohodnicki[2], R. Byron Beddingfield[3], Subhashish Bhattacharya[3], Geraldo Nojima[4]
[1]Carnegie Mellon University, United States; [2]University of Pittsburgh, United States; [3]North Carolina State University, United States; [4]Eaton, United States

2409 | Characterization of Inductor Magnetic Cores for Cryogenic Applications
Shiyuan Yin[1], Mahmoud Mehrabankhomartash[1], Alfonso J. Cruz[1], Lukas Graber[1], Maryam Saeedifard[1], Simon Evans[2], Florian Kapaun[3], Ivan Revel[2], Gerhard Steiner[3], Ludovic Ybanez[2], Chanyeop Park[4]
[1]Georgia Institute of Technology, United States; [2]Airbus, France; [3]Airbus, Germany; [4]Mississippi State University, United States

1369 | A Novel Measurement Method for DC Superimposition Characteristics of Three-Phase Coupled Inductors with Powder Cores
Yamato Mishima[1], Tatsuya Aoki[1], Kazuya Matsuta[1], Jun Imaoka[1], Masayoshi Yamamoto[1], Kosuke Yoshimoto[2]
[1]Nagoya University, Japan; [2]Daido Steel Co., Ltd., Japan

1638 | Condition Monitoring for Capacitors in Modular Multilevel Converter Based on High-Frequency Transient Analysis
Hongjian Xia[1], Yi Zhang[2], Huai Wang[2], Minyou Chen[1], Wei Lai[1], Dan Luo[1], Yulong Hu[1]
[1]Chongqing University, China; [2]Aalborg University, Denmark

Session I04: 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 I05: 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 Wang[1], Yang He[1], Junming Zhang[1], Shuai Shao[1], Han Li[2], Cheng Luo[2]
[1]Zhejiang University, China; [2]Eaton, 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 Katada[1], Katsuhiro Hata[1], Yoshitaka Yamauchi[1], Ting-Wei Wang[1,2], Ryuzo Morikawa[1], Cheng-Hsuan Wu[1], Toru Sai[1], Po-Hung Chen[2], Makoto Takamiya[1]
[1]The University of Tokyo, Japan; [2]National 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 Palmer[1], Edward Shelton[2], Mohammad Miri[1], Carissa King[1], Dan Rogers[2]
[1]Simon Fraser University, Canada; [2]University 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 Salvo[1], Mario Pulvirenti[1], Angelo Giuseppe Sciacca[1], Giacomo Scelba[2], Mario Cacciato[2]
[1]STMicroelectronics, Italy; [2]University of Catania, Italy

Session I07: Magnetics – 1

1476 | A Novel Magnetic Integrated Unit for a Full-Soft-Switching Full- Bridge Converter
Cheng Deng[1], Li Tan[1], Andrés Escobar-Mejia[2]
[1]Xiangtan University, China; [2]Universidad Tecnológica de Pereira, Colombia

2239 | Symmetric Four-Phase Inverse Coupled Inductors for GaN-Based Interleaving Four-Phase Point-of-Load Converters
Longyang Yu[1], Wei Mu[1], Chengzi Yang[1], Lei Zhu[1], Zhiyuan Qi[1], Laili Wang[1], Yilong Yao[1], Yuquan Su[2], Chi Zhang[2]
[1]Xi'an Jiaotong University, China; [2]MiSiliconn 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 Deng[1], Zhou You[1], Andrés Escobar-Mejia[2]
[1]Xiangtan University, China; [2]Universidad Tecnológica de Pereira, Colombia

1477 | A Passive Integration Unit for Electronic Ballast with Multiresonant Converter
Cheng Deng[1], Zhilin Zhou[1], Andrés Escobar-Mejia[2]
[1]Xiangtan University, China; [2]Universidad Tecnológica de Pereira, Colombia

Session I08: 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 I09: 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 Kieu[1], Donghan Lee[1], Sewan Choi[1], Sangjin Kim[2]
[1]Seoul National University of Science and Technology, Korea; [2]Hyundai 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. Benipal[1], Jesse Brown[1], Franz Koeck[2], Anna Zaniewski[1], Mohammad Faizan Ahmad[1], Robert Nemanich[2]
[1]Advent Diamond, Inc., United States; [2]Arizona State University, United States

1544 | Analysis on Static Current Sharing of N-Paralleled Silicon Carbide MOSFETs
Yang He[1], Xun Wang[1], Junming Zhang[1], Shuai Shao[1], Han Li[2], Cheng Luo[2]
[1]Zhejiang University, China; [2]Eaton, 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 Shintani[2], Takashi Sato[3]
[1]ROHM Co., Ltd., Japan; [2]Nara Institute of Science and Technology, Japan; [3]Kyoto University, Japan

2051 | Circuit-Semiconductor Dynamic Coupling Analysis for PiN Diode Reverse Recovery
Ruiwen Chen[1], Zhi Yang[1], Xiaoli Tian[2], Mingyang Wang[1], Yu Pan[3], Sideng Hu[1]
[1]Zhejiang University, China; [2]Chinese Academy of Sciences, China;
[3]Shanghai 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 Mu[1], Binyu Wang[1], Shenghe Wang[2], Fengtao Yang[1], Dingkun Ma[1], Laili Wang[1]
[1]Xi'an Jiaotong University, China; [2]State Grid Anhui Electric Power Co., Ltd., China

1375 | Thermal Management Strategy for IGBT Modules in PV Systems Based on the Benefit-Cost Ratio
Cheng Qian[1], Xiong Du[1], Rui Du[1], Jun Zhang[2]
[1]Chongqing University, China; [2]Hohai University, China

1774 | Multiscale Electrothermal Design of a Modular Multilevel Converter for Grid-Tied Applications
Xuhui Feng[1], Ramchandra Kotecha[1], Sreekant Narumanchi[1], Akanksha Singh[1], Barry Mather[1], Ke Wang[2], Boxue Hu[2], Jin Wang[2]
[1]National Renewable Energy Laboratory, United States; [2]The Ohio 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 Baker[1], Boran Fan[1], Jack Knoll[1], Rolando Burgos[1], Warren Chen[2]
[1]Virginia Polytechnic Institute and State University, United States; [2]Raytheon 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 Hou[1], Sreyam Sinha[1], Di Ni[1], Qing Ji[2], Arun Persaud[2], Peter Seidl[2], Thomas Schenkel[2], Amit Lal[1], Khurram K. Afridi[1]
[1]Cornell University, United States; [2]Lawrence 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 Rizzo[2], Giacomo Scelba[2], Giuseppe Longo[1], Filippo Scrimizzi[1], Giuseppe Ballarin[3]
[1]STMicroelectronics, Italy; [2]University of Catania, Italy; [3]Wurth Elektronik, Italy

2318 | Wireless Power Transfer System with Variable Mutual Inductance Control for Battery Charging
Ruibang Li[1], Chenxu Zhao[1], Yongbin Jiang[2], Min Wu[1], Shuting Feng[1], Laili Wang[1], Yunqing Pei[1], Hong Zhang[1]
[1]Xi'an Jiaotong University, China; [2]UNISOC (Shanghai) Technologies Co., Ltd., China

1012 | Inverter Phase Current Balancing for Wireless Power Transfer Systems Based on Parallel Resonant Networks
Yiming Zhang[1], Zhiwei Shen[1], Xin Li[2], Shuxin Chen[2], Yi Tang[2]
[1]Fuzhou University, China; [2]Nanyang 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 Sinha[1], Ashish Kumar[2], Khurram K. Afridi[1]
[1]Cornell University, United States; [2]Texas 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 Zhang[1], Shaoyu Cheng[2], Yilong Wang[3], Hassan H. Eldeeb[4], Guorui Xu[2], Haisen Zhao[2]
[1]North China Institute of Aerospace Engineering, China; [2]North China Electric Power University, China; [3]Beijing Information Science and Technology University, China; [4]BorgWarner Noblesville Technical Center, United States

144 | Medium Voltage to Low Voltage Contactless Power Transformation for Data Centers
Guangqi Zhu[1], Birger Pahl[1], Richard J. Fons[1], Isaac Wong[2], Subhashish Bhattacharya[2], Byron Beddingfield[2]
[1]Eaton, United States; [2]North 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 Chen[1], Han Peng[1], Zhijie Feng[1], Kai Gao[2], Shaojing Wang[2], Peng Xu[2]
[1]Huazhong University of Science and Technology, China; [2]State 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 Wu[1], Xu Yang[1], Kangping Wang[1], Jiwen Wei[1], Zhiyuan Qi[1], Wenjie Chen[1], Qiaoliang Chen[2]
[1]Xi'an Jiaotong University, China; [2]Longteng Semiconductor Co., Ltd., China

1332 | Film Capacitors ESL Extraction Based on SiC MOSFET Switching Transient Process
Jianfeng Niu[1], Zejun He[2], Yun Lei[1], Mingyang Wang[1], Jing Zhou[1], Sideng Hu[1]
[1]Zhejiang University, China; [2]Ningbo 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. Hussein[1], Abbas A. Fardoun[2]
[1]Prince Mohammad Bin Fahd University, Saudi Arabia; [2]Al-Marref University, Lebanon

1381 | An Extended Kalman Filter with Exponential Thermoelectric Measurement Model for Sensorless Surface Temperature Estimation of Li-Ion Batteries
Mahroo Sajid[1], Ali Wadi[1], Mamoun Abdel-Hafez[1], Ala A. Hussein[2]
[1]American University of Sharjah, United Arab Emirates; [2]Prince 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 Rong[1], Zhiyu Shen[2], Boran Fan[1], Vladimir Mitrovic[1], Jianghui Yu[1], Slavko Mocevic[1], Jun Wang[3], Dushan Boroyevich[1], Rolando Burgos[1]
[1]Virginia Polytechnic Institute and State University, United States; [2]Delta Electronics (America) Ltd., United States; [3]University of Nebraska Lincoln, United States

1105 | Analysis and Design of a Latching Current Limiter Based on a SiC N-MOSFET
Abraham López[1], Pablo F. Miaja[1], Manuel Arias[1], Arturo Fernández[2]
[1]University of Oviedo, Spain; [2]European Space Agency, The Netherlands

1898 | Design and Development of Modular Hybrid DC Breaker Scheme for DC Distribution Systems
D.K.J.S. Jayamaha[1], Ken K.M. Siu[2], Carl N.M. Ho[1], A.D. Rajapakse[1]
[1]University of Manitoba, Canada; [2]University 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 Che[1], Jonathan Z. Bird[1], Alex Hagmuller[2], Md Emrad Hossain[1]
[1]Portland State University, United States; [2]Aquaharmonics 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 Ruddy[1], Yi Chen Mazumdar[2], Jason Yunhe Guan[3]
[1]University of Auckland, New Zealand; [2]Georgia Institute of Technology, United States; [3]Fisher 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

A01 | Photovoltaic Systems
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 Ul, *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, USA*

Xibo Yuan, *The University of Bristol, UK*

B11 | Control of DC Microgrids

Subhashish Bhattacharya, *North Carolina State University, USA*

Luis 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*

F18 | Power Converter Modeling and Control – 2
Tianqi 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 I
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*

F25 | Modeling and Control in Power Electronic Systems
Jun Wang, *University of Nebraska-Lincoln, USA*

F26 | Power Converter EMI I
Hang Dai, *University of Wisconsin-Madison, USA*

F27 | Converter Power Quality I
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*

I01 | Power Module and Integration - In Memory of Bram Ferreira
Adam Skorek, *Université du Québec à Trois Rivières, Canada*

I02 | WBG and UWBG Devices
Jose Ortiz Gonzalez, *University of Warwick, UK*

I03 | Passive Components
Hengzhao Yang, *ShanghaiTech University, China*

I04 | Gate Drivers – 1
Tanya Gachovska, *Solantro Semiconductors Corp.*

I05 | Gate Drivers – 2
Zheyu Zhang, *Clemson University, USA*

I06 | Gate Drivers – 3
Patrick Palmer, *Simon Fraser University, Canada*

I07 | Magnetics – 1
Shuo Wang, *University of Florida, USA*

I08 | Magnetics – 2
Shuo Wang, *University of Florida, USA*

I09 | Magnetics – 3
Christina DiMarino, *Center for Power Electronics Systems,Virginia Tech, USA*

I10 | Application of Power Modules
Yarui Peng, *University of Arkansas, USA*

I11 | Semiconductor Devices
Francesco Iannuzzo, *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

OPAL-RT TECHNOLOGIES

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

STMicroelectronics

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

GeneSiC™ SEMICONDUCTOR

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.

Hardware Competition

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

ECCE 2022

IEEE ENERGY CONVERSION CONGRESS & EXPO — Detroit, Michigan, USA Oct. 9-13

IMPORTANT DATES

January 15, 2022
Digest submission

May 1, 2022
Author notification

July 1, 2022
Final papers with
IEEE copyright forms

IEEE

IAS IEEE INDUSTRY APPLICATIONS SOCIETY — Linking Research to Practice

pels IEEE POWER ELECTRONICS SOCIETY — Powering a Sustainable Future

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

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
- 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

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
- 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.

www.ieee-ecce.org/2022 — **Detroit, Michigan, USA – October 9–13, 2022**

ECCE 2022

IEEE ENERGY CONVERSION CONGRESS & EXPO Detroit, Michigan, USA Oct. 9-13

IMPORTANT DATES

February 11, 2022
Tutorial proposal due

April 8, 2022
Notification of acceptance

July 1, 2022
Full tutorials materials due

Call for Tutorials

IEEE

IAS IEEE INDUSTRY APPLICATIONS SOCIETY Linking Research to Practice

pels IEEE POWER ELECTRONICS SOCIETY Powering a Sustainable Future

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:

A. Industry led or co-hosted lectures;
B. Interactive instructor-audience approaches, including hands-on demonstrations and practices;
C. Application focused session on tools or methods for the practicing engineer.
D. ECCE 2022 regionally oriented topics at the host city, e.g. transportation electrification;
E. Collaborative cross-disciplinary topics and tutorial teams are welcome;
F. Topics that engage the audience in formats that serves to communicate with the attendees.

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;
c) Tutorial topics or teams presented previously in immediate past ECCE or other major IAS/PELS conferences;
d) Tutorials that narrowly focus on presenter's own research works that are already publicly available
e) Solicitation of a particular product or service.

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
- 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

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
- 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

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

www.ieee-ecce.org/2022 Detroit, Michigan, USA – October 9–13, 2022

Tutorial Proposal Form

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.

ECCE 2022

IEEE ENERGY CONVERSION CONGRESS & EXPO Detroit, Michigan, USA Oct. 9-13

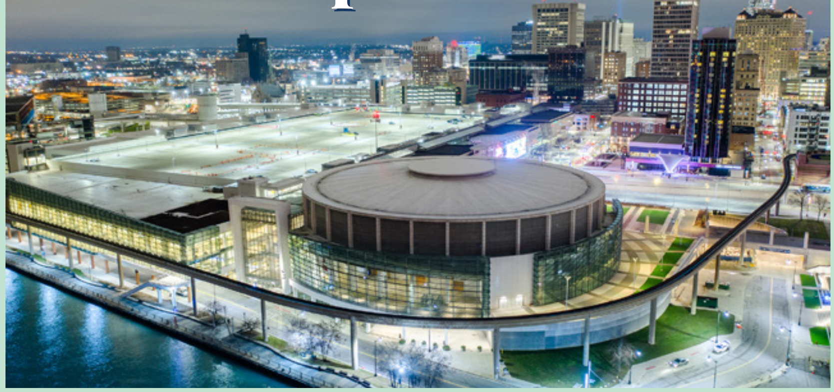
IMPORTANT DATES

April 1, 2022
Special session proposal due

May 20, 2022
Notification of acceptance

July 1, 2022
Final session plan due

Call for Special Sessions



IEEE

IAS IEEE INDUSTRY APPLICATIONS SOCIETY Linking Research to Practice

pels IEEE POWER ELECTRONICS SOCIETY Powering a Sustainable Future

General Chair
Emmanuel Agamloh
Baylor University, USA

Special Session Co-Chairs
Yue Cao
Oregon State University, USA

Sara Roggia
MagniX, USA

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 cross-disciplinary 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, trains, ships
- Energy storage systems, including real or virtual storage
- Charging stations, vehicle to grid
- Additive manufacturing
- Renewable energy integration
- Smart grids, micro-grids, nano-grids
- Resiliency in energy systems
- Smart and energy efficient buildings
- Energy conversion for information technology
- Big data and machine learning in energy conversion
- Cybersecurity in energy conversion
- Design automation and optimization

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
- Thermal management, advanced cooling technologies
- Wireless power transfer
- High voltage power conversion, including insulation technologies
- Reliability, diagnostics, prognostics, and health management

Others

- Advanced testing and validation, including demo
- Standards development
- Education and career development
- 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.

www.ieee-ecce.org/2022 Detroit, Michigan, USA – October 9–13, 2022

IEEE ENERGY CONVERSION CONGRESS & EXPO Detroit, Michigan, USA Oct. 9-13

Special Session Proposal Form

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 ☐ 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 ☐ 2x100 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

2022

Detroit, Michigan, USA Oct. 9-13

ECCE

IEEE ENERGY CONVERSION CONGRESS & EXPO

http://www.ieee-ecce.org/2022