

# TABLE OF CONTENTS

Scroll to the title and select a **Blue** link to open a paper. After viewing the paper, use the bookmarks to the left to return to the beginning of the Table of Contents.

---

## Monday, October 2

### Session 1: Power Conversion for Solar Photovoltaic Systems I

Chair(s): Ranjit Mahanty, Yongheng Yang

- [Single-Stage Three-Phase Grid-Connected Photovoltaic System with Maximum Power Tracking and Active and Reactive Power Control based on Nonlinear Control](#) ..... 1  
Pablo R. Rivera, Michael L. McIntyre, Mohammad Mohebbi and Joseph Latham  
University of Louisville, United States

- [A Single Phase Doubly Grounded, PV Inverter using Coupled Inductor with Integrated Magnetics and Active Power Decoupling Technique](#) ..... 8  
Yinglai Xia, Jinia Roy and Raja Ayyanar  
Texas Instruments, United States; Arizona State University, United States

- [A ZVT Cell for High-Frequency Quasi-Resonant Converters in ON-OFF Mode for Solar Applications](#) ..... 15  
Hossein Mousavian, Alireza Bakhshai and Praveen Jain  
Queen's University, Canada

- [Sliding Mode Control of a Single Phase Transformer-less PV Inverter with Active Power Decoupling](#) ..... 23  
Jinia Roy, Yinglai Xia and Raja Ayyanar  
Arizona State University, United States; Texas Instruments, United States

### Session 2: Hybrid AC/DC Microgrids

Chair(s): Jinjun Liu, Meiqin Mao

- [Adaptive Active Power Sharing Techniques for DC and AC Voltage Control in a Hybrid DC/AC Microgrid](#) ..... 30  
Ángel Navarro-Rodríguez, Pablo García, Ramy Georgious and Jorge García  
University of Oviedo, Spain

- [Modulation and Control Method for Bidirectional Isolated AC/DC Matrix based Converter in Hybrid AC/DC Microgrid](#) ..... 37  
Fanxiu Fang and Yun Wei Li  
University of Alberta, Canada

- [Fault Ride-Through Capability of Hybrid AC/DC Microgrids during AC and DC Network Faults](#) ..... 44  
Lasantha Meegahapola, Inam Ullah Nutkani, Brendan McGrath and Donald Grahame Holmes  
RMIT University, Australia

- [An Effective DC Microgrid Operation Using a Line Impedance Regulator](#) ..... 52  
Fatih Cingoz, Awab Ali, Ali Elrayyah, Yilmaz Sozer and J. Alexis De Abreu-Garcia  
University of Akron, United States; Qatar Environment Research Institute, Qatar

## **Session 3: Dynamic Performance of Power Converters for Renewable Energy**

**Chair(s): Hui Li, Adel Nasiri**

<b>Robust <math>H_\infty</math> DC Link Control Design for High-Power Density Converters with High-Order Filter in PV Systems .....</b>	<b>58</b>
---	-----------

Nima Amouzegar Ashtiani, S. Mohsen Azizi and S. Ali Khajehoddin  
University of Alberta, Canada; Michigan Technological University, United States; Concordia University, Canada

<b>Grid Voltage Harmonic Damping Method for SPC based Power Converters with Multiple Virtual Admittance Control .....</b>	<b>64</b>
---	-----------

Andres Tarrasó, Jose Ignacio Candela, Joan Rocabert and Pedro Rodriguez  
Technical University of Catalonia, Spain; Universidad de Loyola, Spain

<b>Adaptive Control of Grid-Connected Inverters based on Real-Time Measurements of Grid Impedance: DQ-Domain Approach .....</b>	<b>69</b>
---	-----------

R. Luhtala, T. Messo, T. Reinikka, J. Sihvo, T. Roinila and M. Vilkko  
Tampere University of Technology, Finland

<b>Improve the Robustness of Digitally-Controlled LCL-Filtered Inverters against Grid Impedance Variation with a Lag Compensator .....</b>	<b>76</b>
--	-----------

Yuying He, Xuehua Wang and Xinbo Ruan  
Huazhong University of Science and Technology, China

## **Session 4: Applications of MMC**

**Chair(s): Maryam Saeedifard, Vito Giuseppe Monopoli**

<b>An MMC-based Topology using DHB Power Channels for Load Balancing in 50 Hz Railway Applications .....</b>	<b>83</b>
--	-----------

Andreas Zafeiropoulos, Antonios Antonopoulos and Jan R. Svensson  
ABB Corporate Research, Sweden

<b>Communication Network Latency Compensation in Modular Multilevel Converters .....</b>	<b>91</b>
--	-----------

Tomás P. Corrêa, Emilio J. Bueno and Francisco J. Rodriguez  
University of Alcalá, Spain

<b>Analysis and Mitigation of AC Coupling Effects on Overhead Line of Modular Multilevel Converter (MMC) based HVDC Transmission System .....</b>	<b>97</b>
---	-----------

Joon-Hee Lee, Jae-Jung Jung and Seung-Ki Sul  
Seoul National University, Korea

<b>A Novel Pilot Protection Scheme for MMC-HVDC Transmission Lines .....</b>	<b>105</b>
--	------------

Lianying Ning, Xiaodong Zheng, Nengling Tai, Wentao Huang, Jinyi Chen and Zhongyu Wu  
Shanghai Jiao Tong University, China; Shanghai Pudong Electric Power Corporation, China; MISO, United States

## **Session 5: Inductive Power Transfer for EV Charging**

**Chair(s): Suman Debnath, Daniel Ludois**

<b>An Analytical Method to Calculate Winding Resistance for Planar Coil with Ferrite Plate and Litz Wire in Inductive Power Transfer .....</b>	<b>111</b>
--	------------

Ming Lu and Khai D.T. Ngo  
Virginia Polytechnic Institute and State University, United States

**Comparative Evaluation of Front and Back End PFC IPT Systems for a Contactless Battery Charger ..... 118**

Ander Avila, Asier Garcia-Bediaga, Ugaitz Iruretagoyena, Irma Villar and Alejandro Rujas  
IK4-Ikerlan Technology Research Centre, Spain

**Field Attenuation around Inductive-Power-Transfer Coils with Dual-Side-Controlled Converter ..... 126**

Ming Lu and Khai D.T. Ngo  
Virginia Polytechnic Institute and State University, United States

**Power Factor Correction Focusing on Magnetic Coupling of Parallel-connected Wires for  
Inductive Power Transfer System ..... 133**

Keita Furukawa, Keisuke Kusaka and Jun-ichi Itoh  
Nagaoka University of Technology, Japan

**Session 6: Single-Phase DC/AC Converters I**

Chair(s): Adam Skorek, Feng Gao

**Mode Selection Strategy for Multi-Mode Power Converters to Minimize its Differential Power ..... 141**

R. Ramos, I. Zubitur, D. Serrano, J.A. Oliver, P. Alou and J.A. Cobos  
Universidad Politécnica de Madrid, Spain

**Investigation of Single-Phase Multilevel Inverter based on Series/Parallel-Connected H-Bridges ... 148**

Antonio de P.D. Queiroz, Cursino B. Jacobina, Ayslan C.N. Maia, Victor F.M.B. Melo and Ivan da Silva  
Federal University of Campina Grande, Brazil; Federal Institute of Paraíba, Brazil; Federal Institute of  
Alagoas, Brazil; Federal Institute of Pernambuco, Brazil

**Design and Implementation of a DC-AC Inverter with Zero-Voltage-Switching ..... 156**

Hsin-Ju Liu, Tsorng-Juu Liang, Kuan-Ho Liu and Kai-Hui Chen  
National Cheng Kung University, Taiwan

**A Hybrid Two-Four Leg H-Bridge Inverter ..... 161**

Abinadabe S. Andrade and Edison R.C. da Silva  
Federal Institute of Paraíba, Brazil

**Session 7: Multi-Phase DC/AC Converters I**

Chair(s): David Diaz Reigosa, Marcello Pucci

**Critical-Mode-based Soft-Switching Modulation for Three-Phase Inverters ..... 167**

Zhengrong Huang, Zhengyang Liu, Fred C. Lee, Qiang Li and Furong Xiao  
Virginia Polytechnic Institute and State University, United States; Beijing Institute of Technology, China

**Implementing Synchronous DC Link Voltage Control with Phase Skipping on a Three-Phase  
Microinverter using Minimum DC Link Capacitance ..... 175**

S. Milad Tayebi, Siddhesh Shinde, Michael Pepper, Haibing Hu and Issa Batarseh  
University of Central Florida, United States

**Differential-Mode and Zero Sequence Circulating Current Reduction for Paralleled Inverters  
with Modified Zero-CM PWM Algorithm ..... 183**

Zewei Shen, Dong Jiang, Jianan Chen and Ronghai Qu  
Huazhong University of Science and Technology, China

**MPC-SVM Method with Subdivision Strategy for Current Ripples Reduction and Neutral-Point Voltage Balance in Three-Level Inverter ..... 191**

Hyun-Cheol Moon, June-Seok Lee, June-Hee Lee and Kyo-Beum Lee  
Ajou University, Korea; Korea Railroad Research Institute, Korea

**Session 8: DC/DC Converters I**

**Chair(s): Philip Krein, Santanu Mishra**

**Experimental Verification of a Bidirectional Chopper for Battery Energy Storage Systems Capable of Reduction in Size and Weight of an Inductor ..... 197**

Haruna Ohnishi and Makoto Hagiwara  
Tokyo Institute of Technology, Japan

**Magnetic Structure of Close-Coupled Inductors to Improve the Thermal Handling Capability in Interleaved DC-DC Converter ..... 205**

Thai Hoang Chuong, Shota Kimura, Daigoro Ebisumoto, Mostafa Noah, Masataka Ishihara, Masayoshi Yamamoto, Jun Imaoka and Wilmar Martinez  
Shimane University, Japan; Okayama University, Japan; Nagoya University, Japan; Kyushu University, Japan; Toyota Technological Institute, Japan

**Integrated Switched Coupled-Inductor Boost-Flyback Converter ..... 211**

Xinping Ding, Dailing Yu, Yingjie Song and Bicui Xue  
Qingdao University of Technology, China; Jinan University, China

**Energy Efficient Visible Light Communication Transmitter based on the Split of the Power ..... 217**

Juan Rodriguez, Daniel G. Aller, Diego G. Lamar and Javier Sebastian  
University of Oviedo, Spain

**Session 9: Modeling and Control of Resonant Converters**

**Chair(s): Gerry Moschopoulos, Rivas-davila Juan**

**Resonant LLC Bus Conversion using Homopolarity Width Control ..... 225**

Mehdi Mohammadi and Martin Ordóñez  
University of British Columbia, Canada

**Dual-Loop Controller for LLC Resonant Converters using an Average Equivalent Circuit ..... 230**

Franco Degioanni, Ignacio Galiano Zurbriggen and Martin Ordóñez  
University of British Columbia, Canada

**Modeling Resonant Converters in a Rotating Coordinate ..... 237**

Yi-Hsun Hsieh and Fred C. Lee  
Virginia Polytechnic Institute and State University, United States

**Closed-Loop Control of Impedance Control Network Resonant DC-DC Converter ..... 244**

Jie Lu, Ashish Kumar and Khurram K. Afridi  
University of Colorado-Boulder, United States

**Session 10: Modeling and Control of Power Factor Correction Converters**

**Chair(s): Aleksandar Prodic, Huai Wang**

**A Discontinuous Boost Power Factor Correction Conduction Loss Model ..... 251**

Yanqi Yu, Wilson Eberle and Fariborz Musavi  
University of British Columbia, Canada; Washington State University, United States

<b>Digital Control of an Interleaved BCM Boost PFC Converter with Fast Transient Response at Low Input Voltage .....</b>	<b>257</b>
Robert T. Ryan, John G. Hayes, Richard Morrison and Diarmuid Hogan University College Cork, Ireland; Excelsys Technologies, Ireland	
<b>New Modulated Carrier Control Method for Power Factor Correction Rectifier .....</b>	<b>265</b>
Jintae Kim, Dong-Wook Yoo and Chung-Yuen Won Sungkyunkwan University, Korea; Korea Electrotechnology Research Institute, Korea	
<b>Efficiency Evaluation of Three-Phase SiC Power Factor Correction Rectifier with Different Controllers .....</b>	<b>272</b>
Alireza Kouchaki and Morten Nyman University of Southern Denmark, Denmark	
<b>Session 11: Induction Machines I</b>	
<b>Chair(s): Andrea Cavagnino, Renato Lyra</b>	
<b>Induction Machine Design for Dynamic Loss Minimization along Driving Cycles for Traction Applications .....</b>	<b>278</b>
Yuying Shi and Robert D. Lorenz University of Wisconsin-Madison, United States	
<b>Impact of Core Material Grades on Performance of Variable Speed Induction Motors Fed by Inverters .....</b>	<b>286</b>
Katsumi Yamazaki, Koki Tanaka and Motomichi Ohto Chiba Institute of Technology, Japan; Yaskawa Motor Corp., Japan	
<b>Electrical Monitoring of Mechanical Defects in Induction Motor Driven V-Belt-Pulley Speed Reduction Couplings .....</b>	<b>293</b>
Tae-June Kang, Chanseung Yang, Yonghyun Park, Sang Bin Lee and Mike Teska Korea University, Korea; SKF Condition Monitoring Center, United States	
<b>A Simple Method for Determining Equivalent Circuit Parameters of Double-Cage Induction Motors from No-Load and Locked-Rotor Tests .....</b>	<b>301</b>
Shu Yamamoto, Hideaki Hirahara, Akira Tanaka and Takahiro Ara Polytechnic University, Japan	
<b>Session 12: Axial Flux Machines</b>	
<b>Chair(s): Akira Chiba, Giulio De Donato</b>	
<b>An Axial Flux-Focusing Magnetically Geared Motor .....</b>	<b>307</b>
M. Bahrami Kouhshahi, J.Z. Bird, V. Acharya, K. Li, M. Calvin and W. Williams Portland State University, United States; University of North Carolina at Charlotte, United States	
<b>Design of a Novel Interior Permanent Magnet Axial Flux Machine .....</b>	<b>314</b>
Burak Tekgun, Tausif Husain, Shuvajit Das, Yilmaz Sozer and Marv Hamdan University of Akron, United States; Bendix Commercial Vehicle Systems, United States	
<b>A Comparative Study of Coreless and Conventional Axial Flux Permanent Magnet Synchronous Machines Designed for Low and High Speed Operation .....</b>	<b>321</b>
Narges Taran, Vandana Rallabandi, Dan M. Ionel and Greg Heins University of Kentucky, United States; Regal Beloit Corporation, Australia	

**Comparison of Dual Structure Axial Flux-Switching Permanent Magnet Machines ..... 328**

Ju Hyung Kim, Mingda Liu, Hao Ding and Bulent Sarlioglu

University of Wisconsin-Madison, United States

**Session 13: Control of Electric Drives I****Chair(s): Roberto Petrella, Hinkkanen Marko****Optimal Torque Control of Synchronous Motor Drives: Plug-and-Play Method ..... 334**

Hafiz Asad Ali Awan, Zhanfeng Song, Seppo E. Saarakkala and Marko Hinkkanen

Aalto University, Finland; Tianjin University School of Electrical and Information Engineering, China

**Self-Commissioning Technique for High Bandwidth Servo Motor Drives ..... 342**

Yen-Shin Lai and Min-Hsien Ho

National Taipei University of Technology, Taiwan

**A Geometrical Linearization Approach for Salient-Pole PMSM Optimal Voltage/Current Constrained Control over Whole Speed Range ..... 350**

Li Yang, Rui Gao, Wensong Yu and Iqbal Husain

North Carolina State University, United States

**Algebraic Weighting Factor Selection for Predictive Torque and Flux Control ..... 357**

Tobias Geyer

ABB Corporate Research, Switzerland

**Session 14: Diagnostics and Fault Tolerant Systems in Drives****Chair(s): Giacomo Scelba, Antonio J. Marques Cardoso****Faulted Phase Location Identification for Adjustable Speed Drives in High Resistance Grounding System ..... 365**

Jiangang Hu, Lixiang Wei, Jeffrey McGuire and Zhijun Liu

Rockwell Automation Inc., United States

**Fault Analysis in an Inverter-Fed Nine-Phase Induction Machine ..... 371**

Tamires Santos de Souza, Rodrigo Rodrigues Bastos and Braz J. Cardoso Filho

Federal University of Minas Gerais, Brazil

**Fault Detection and Tolerant Capability of Parallel Connected Permanent Magnet Machines under Stator Turn Fault ..... 379**

Shih-Chin Yang, Yu-Liang Hsu, Po-Huan Chou, Cheng-Xin Liu, Guan-Ren Chen and Kang Li

National Taiwan University, Taiwan; Feng Chia University, Taiwan; Industrial Technology Research Institute, Taiwan

**Comparison of Open-Phase Fault Detection for Permanent Magnet Machine Drives using Different Fault Signals ..... 385**

Shih-Chin Yang, Yu-Liang Hsu, Po-Huan Chou, Da-Ren Jian and Guan-Ren Chen

National Taiwan University, Taiwan; Feng Chia University, Taiwan; Industrial Technology Research Institute, Taiwan

## **Session 15: GaN Switching Performance**

**Chair(s): Enrico Santi, Muhammad Nawaz**

### **Analysis of Oscillation in Bridge Structure based on GaN Devices and Ferrite Bead**

**Suppression Method ..... 391**

Fangwei Zhao, Yan Li, Qing Tang and Lu Wang  
Beijing Jiaotong University, China

### **Switching Transient Analysis for Normally-Off GaN Transistors with p-GaN Gate in a**

**Phase-Leg Circuit ..... 399**

Ruiliang Xie, Guangzhao Xu, Xu Yang, Hanxing Wang, Mofan Tian, Yidong Tian, Feng Zhang, Wenjie Chen, Laili Wang and Kevin J. Chen  
Xi'an Jiaotong University, China; Hong Kong University of Science and Technology, Hong Kong

### **Optimization of the Balance between the Gate-Drain Capacitance and the Common Source**

**Inductance for Preventing the Oscillatory False Triggering of Fast Switching GaN-FETs ..... 405**

Ryunosuke Matsumoto, Kazuhiro Umetani and Eiji Hiraki  
Okayama University, Japan

### **Static and Dynamic Characterization of a GaN-on-GaN 600 V, 2 A Vertical Transistor ..... 413**

Amy Romero, Christina DiMarino, Rolando Burgos, Ray Li, Mary Chen, Yu Cao and Rongming Chu  
Virginia Polytechnic Institute and State University, United States; HRL Laboratories LLC, United States

## **Session 16: Magnetics I**

**Chair(s): David Perreault, Ruxi Wang**

### **Medium Frequency Transformer Leakage Inductance Modeling and Experimental Verification ..... 419**

Marko Mogorovic and Drazen Dujic  
EPFL, Switzerland

### **Continuum Modeling of Inductor Hysteresis and Eddy Current Loss Effects in Resonant Circuits ..... 425**

Jason Pries, Lixin Tang and Tim Burress  
Oak Ridge National Laboratory, United States

### **Characterization of Magnetoresistors for Contactless Current Sensing in Power**

**Electronic Applications ..... 433**

Shahriar Jalal Nibir, Hossein Niakan and Babak Parkhideh  
University of North Carolina at Charlotte, United States

### **Trapezoidal Characterization of Magnetic Materials with a Novel Dual Voltage Test Circuit ..... 439**

Richard Beddingfield, Paras Vora, David Storelli and Subhashish Bhattacharya  
North Carolina State University, United States

## **Session 17: Power Conversion for Solar Photovoltaic Systems II**

**Chair(s): Pedro Rodriguez, Lixiang Wei**

### **Three-Phase DC-DC PWM Boost Converter for Renewable Energy Applications ..... 447**

Adel Ali Abosnina and Gerry Moschopoulos  
Western University, Canada

**Power Command Compensation Structure to Improve the Dynamic Performance for Single Phase Transformer-Less Photovoltaic Inverters with Dynamic Power Decoupling ..... 455**

Yinglai Xia, Ziwei Yu and Raja Ayyanar

Texas Instruments, United States; Arizona State University, United States

**A Novel Model Predictive Control for Single-Phase Grid-Connected Photovoltaic Inverters ..... 461**

Esmaeil Zangeneh Bighash, Seyed Mohammad Sadeghzadeh, Esmaeil Ebrahimzadeh, Yongheng Yang and Frede Blaabjerg

Shahed University, Iran; Aalborg University, Denmark

**Power Pulsation Decoupling for a Two-Stage Single-Phase Photovoltaic Inverter with Film Capacitor ..... 468**

Jianwu Zeng, Meixian Zhuo, Hao Cheng, Taesic Kim, Vincent Winstead and Liangcai Wu

Minnesota State University, United States; Growatt New Energy Technology Co. Ltd., China; Texas A&M University-Kingsville, United States

**Differential Power Processing of Photovoltaic Systems for High Energy Capture and Reduced Cost ..... 475**

Mohamed Badawy and Yilmaz Sozer

San Jose State University, United States; University of Akron, United States

**Session 18: Power Converter Topologies for Renewable Energy**

**Chair(s): Mohammad B. Shadmand, Tiefu Zhao**

**Soft-Switching Isolated Tri-Port Converter for Integration of PV, Storage and Single-Phase AC Grid .... 482**

Nishant Bilakanti, Liran Zheng, Rajendra Prasad Kandula, Karthik Kandasamy and Deepak Divan

Georgia Institute of Technology, United States

**Power-Loss Analysis in 3-Level TNPC Inverters: Modulation Effects ..... 490**

Emanuel Serban, Cosmin Poniche and Martin Ordóñez

Schneider Electric, Canada; University of British Columbia, Canada

**Modeling and Design for Integrated Coupled Inductors in Interleaved Three-Level DC/DC Converters ..... 498**

Ruiyang Qin and Fred C. Lee

Delta Products Corporation, United States; Virginia Polytechnic Institute and State University, United States

**Design Considerations of a Full-Bridge Modular Multilevel Converter under Variable DC Link Voltage ..... 504**

Ahmed Allu, Milijana Odavic and Kais Atallah

University of Sheffield, United Kingdom

**Geometry Optimization and Characterization of Three-Phase Medium Frequency Transformer for 10kVA Isolated DC-DC Converter ..... 511**

Youngsil Lee, Gaurang Vakil, Alan J. Watson and Patrick W. Wheeler

University of Nottingham, United Kingdom

**Session 19: Renewable Impacts in Industrial Microgrids**

**Chair(s): Marco Liserre, Giovanna Oriti**

**High-Speed Algorithm for Renewable Energy based Microgrid Fault Detection and Protective Coordination ..... 519**

Hashim A. Al Hassan, Qiang Fu, Vijay Bhavaraju, Yi Yang and Brandon M. Grainger

University of Pittsburgh, United States; Eaton, United States

<b>Increasing the Robustness of Islanded CERTS Microgrids with PV Microsources and Gensets during Dynamic Overload Conditions .....</b>	<b>526</b>
Zhe Chen, Mitch Marks and T.M. Jahns University of Wisconsin-Madison, United States	
<b>A Wind Energy Battery Charging System with Dynamic Current Limitation .....</b>	<b>534</b>
Guilherme de C. Farias, João V.M. Caracas, José G. de Matos and Luiz A. de S. Ribeiro Enova Energia, Brazil; Universidade Federal do Maranhão, Brazil	
<b>A Fast Fault Protection based on Direction of Bus-Side Capacitor Discharge Current for a High-Surety Power Supply .....</b>	<b>542</b>
Haijin Li, Min Chen, Boping Yang, Frede Blaabjerg and Dehong Xu Zhejiang University, China; Aalborg University, Denmark	
<b>A First Approach for the Energy Management System in DC Micro-Grids with Integrated RES of Smart Ships .....</b>	<b>550</b>
Angelo Accetta and Marcello Pucci ISSIA-CNR, Italy	
<b>Session 20: Control Aspects of Electrified Vehicles</b>	
Chair(s): Jin Ye, Ian Brown	
<b>Control Strategies for a High Frequency DC-DC Converter for Electrified Vehicles .....</b>	<b>558</b>
Xin Jing, Brian A. Welchko, Constantin Stancu and Peter J. Savagian General Motors Company, United States	
<b>Maximum Efficiency Control Strategy of PM Traction Machine Drives in GM Hybrid and Electric Vehicles .....</b>	<b>566</b>
Brian Gallert, Gilsu Choi, Kibok Lee, Xin Jing and Yochan Son General Motors Company, United States	
<b>Optimal Performance of a Full Scale Li-Ion Battery and Li-Ion Capacitor Hybrid Energy Storage System for a Plug-In Hybrid Vehicle .....</b>	<b>572</b>
Phillip Kollmeyer, Mackenzie Wootton, John Reimers, Tyler Stiene, Ephrem Chemali, Megan Wood and Ali Emadi McMaster University, Canada	
<b>Hybrid Balancing in a Modular Battery Management System for Electric-Drive Vehicles .....</b>	<b>578</b>
Fan Zhang, M. Muneeb Ur Rehman, Regan Zane and Dragan Maksimovic University of Colorado-Boulder, United States; Utah State University, United States	
<b>Development of Compact Power Control Unit for HEVs .....</b>	<b>584</b>
Shinya Yano, Yasushi Nakayama, Hiroshi Kobayashi, Seiki Hiramatsu, Motoru Yoshida, Kohei Onda, Komei Hayashi and Koji Yamazaki Mitsubishi Electric Corp., Japan	
<b>Session 21: Multi-Phase DC/AC Converters II</b>	
Chair(s): Parag Kshirsagar, Grahame Holmes	
<b>A Three-Phase Grid-Connected Inverter Equipped with a Shunt Instantaneous Reactive Power Compensator .....</b>	<b>589</b>
Kazuto Takagi and Hideaki Fujita Tokyo Institute of Technology, Japan	

**A New Three-Level Three-Phase Boost PWM Inverter ..... 597**

Yam P. Siwakoti, Stephan Liese, Jian Guo Zhu and Frede Blaabjerg

University of Technology Sydney, Australia; Fraunhofer-Institute for Solar Energy Systems, Germany; Aalborg University, Denmark

**A Sine-Like Hysteresis Current Control Method in Application of Three-Phase Voltage Source Converter ..... 603**Hongyan Zhao, Yan Li, Trillion Q. Zheng, Xianjin Huang, Fangwei Zhao, Haobo Guo and Zhenning Zi  
Beijing Jiaotong University, China; State Grid Electric Power Research Institute, China**Evaluation of Modulation Techniques to Eliminate Neutral Point Oscillation of the Four Pole NPC Converter ..... 610**

Meng-jiang Tsai and Po-tai Cheng

National Tsing Hua University, Taiwan

**Y-Connected Topologies Composed of Three Three-Leg Converters with Two-Level and Three-Level Legs ..... 617**Rodrigo P. de Lacerda, Edgard L.L. Fabricio, Cursino B. Jacobina, Marício B.R. Correa and Ivan da Silva  
Federal University of Campina Grande, Brazil; Federal Institute of Paraíba, Brazil**Session 22: Single-Phase DC/AC Converters II****Chair(s): Madhav Manjrekar, Vladimir Blasko****Loss Reduction of 13.56 MHz Inverter based on Frequency Multiplying Method ..... 625**

Koji Orikawa, Satoshi Ogasawara and Jun-ichi Itoh

Hokkaido University, Japan; Nagaoka University of Technology, Japan

**A Bridge Modular Switched-Capacitor-based Multilevel Inverter ..... 632**

Liangzong He, Chen Cheng, Jixiao Nai and Wenxiang Chen

Xiamen University, China

**Pulse Energy Modulation for a Single-Phase Bridge Inverter with Power Decoupling Capability ..... 637**

Shuang Xu, Liuchen Chang and Riming Shao

University of New Brunswick, Canada

**A High Control Bandwidth Design Method for Aalborg Inverter under the Weak Grid Condition ... 645**

Weimin Wu, Cong Zou, Houqing Wang, Min Huang, Frede Blaabjerg and Henry Shu-Hung Chung

Shanghai Maritime University, China; Aalborg University, Denmark; City University of Hong Kong, Hong Kong

**A Comprehensive Analysis of DC-Link Current for Single Phase H-Bridge Inverter Under Harmonic Output Currents ..... 652**

Tao Wang and Shuai Lu

Chongqing University, China

**Session 23: Power Quality Control****Chair(s): Zheng Wang, Tsorng-Juu Liang****Single-Phase AC-DC-AC Topology for Grid Voltage Compensation ..... 659**

Nayara B. de Freitas, Cursino B. Jacobina and Rodrigo P. de Lacerda

Federal University of Campina Grande, Brazil

<b>Single-Phase AC-DC-AC Multilevel Converter for Grid Overvoltage based on an H-Bridge Connected in Series to the Five-Leg Converter .....</b>	<b>667</b>
Antonio de P.D. Queiroz, Cursino B. Jacobina, Ayslan C.N. Maia, Victor F.M.B. Melo, Nayara B. de Freitas and Gregory A. de A. Carlos	
Federal University of Campina Grande, Brazil; Federal Institute of Paraíba, Brazil; Federal Institute of Alagoas, Brazil; Federal Institute of Pernambuco, Brazil	
<b>Effects of DC-Link Filter on Harmonic and Interharmonic Generation in Three-phase Adjustable Speed Drive Systems .....</b>	<b>675</b>
Hamid Soltani, Pooya Davari, Dinesh Kumar, Firuz Zare and Frede Blaabjerg	
Aalborg University, Denmark; Danfoss Drives A/S, Denmark; University of Queensland, Australia	
<b>Control System for Shunt Active Power Filters with Adaptive Voltage Saturation .....</b>	<b>682</b>
Albino Amerise, Michele Mengoni, Luca Zarri, Angelo Tani, Giovanni Serra and Domenico Casadei	
University of Bologna, Italy	
<b>Research on Improved Hybrid Power Quality Conditioner for VV Co-Phase Railway Power Supply System .....</b>	<b>688</b>
Chenmeng Zhang, Jianming Li, Xishan Wen, Baichao Chen, Jiaxin Yuan, Wenli Fei and Mangmang Chen	
State Grid Sichuan Electric Power Research Institute, China; Wuhan University, China; Southwest Electric Power Design Institute, China	
<b>Session 24: Modeling and Control of Multilevel Converters</b>	
<b>Chair(s): Yongdong Li, Vito Giuseppe Monopoli</b>	
<b>A Distributed Control Technique for the Multilevel Cascaded Converter .....</b>	<b>693</b>
Ping-heng Wu, Yu-chen Su and Po-tai Cheng	
National Tsing Hua University, Taiwan	
<b>A Capacitor Voltage Balancing Method for a Three Phase Modular Multilevel DC-DC Converter ....</b>	<b>701</b>
Mingming Jiang, Shuai Shao, Kuang Sheng and Junming Zhang	
Zhejiang University, China	
<b>Modeling and Suppression of Circulating Currents for Multi-Paralleled Three-Level T-Type Inverters .....</b>	<b>708</b>
Zicheng Zhang, Alian Chen, Xiangyang Xing, Ke Li, Chunshui Du and Chenghui Zhang	
Shandong University, China	
<b>GA Optimized SHE PWM Hybrid Cascaded H-Bridge Multilevel Inverter with Capacitor Voltage Balancing .....</b>	<b>714</b>
Abhinandan Routray, R.K. Singh and R. Mahanty	
Indian Institute of Technology, India	
<b>Resilient Two Dimensional Redundancy based Fault-Tolerant Controller Array for Modular Multi-Level Converters .....</b>	<b>722</b>
Ali Azidehak, Rajat Agarwal, Nima Yousefpoor, Alexander G. Dean and Subhashish Bhattacharya	
North Carolina State University, United States	

## **Session 25: Switched Reluctance Machines**

**Chair(s): Davide Barater, Iqbal Husain**

<b>A Fast Control-Integrated and Multiphysics-based Multi-Objective Design Optimization of Switched Reluctance Machines .....</b>	<b>730</b>
---	------------

Sufei Li, Shen Zhang, Chen Jiang, J. Rhett Mayor, Thomas G. Habetler and Ronald G. Harley  
Georgia Institute of Technology, United States; University of KwaZulu-Natal, South Africa

<b>Acoustic Noise Mitigation for High Pole Count Switched Reluctance Machines through Skewing Method with Multiphysics FEA Simulations .....</b>	<b>738</b>
--	------------

Yusuf Yasa, Mohammed Elamin, Yilmaz Sozer, John Kutz, Joshua S. Tylenda and Ronnie L. Wright  
University of Akron, United States; DCS Corporation, United States; US Army, United States

<b>Investigation of Torque Ripple in Switched Reluctance Machines with Errors in Current and Position Sensing .....</b>	<b>745</b>
---	------------

Cong Ma, Rakesh Mitra, Prerit Pramod and Rakib Islam  
Nexteer Automotive Corp., United States

<b>Comparison of Current Waveforms for Noise Reduction in Switched Reluctance Motors .....</b>	<b>752</b>
--	------------

Jihad Furqani, Masachika Kawa, Kyohei Kiyota, and Akira Chiba  
Tokyo Institute of Technology, Japan

<b>Simultaneous Optimization of Geometry and Firing Angles of In-Wheel Switched Reluctance Motor ...</b>	<b>760</b>
--	------------

Bahareh Anvari and Hamid A. Toliat  
Texas A&M University, United States

## **Session 26: Induction Machines II**

**Chair(s): Renato Lyra, Nicola Bianchi**

<b>Induction Machine Efficiency Measurement using a Variable Frequency Drive Source .....</b>	<b>768</b>
---	------------

Emmanuel Agamloh, Andrea Cavagnino and Silvio Vaschetto  
Advanced Energy Corp., United States; Politecnico di Torino, Italy

<b>Frequency, Load, and Flux Impacts on Induction Machine Copper and Core Losses in the qd0-Frame .....</b>	<b>776</b>
---	------------

Yiqi Liu and Ali M. Bazzi  
University of Connecticut, United States

<b>Induction Machine Rapid Performance Tests .....</b>	<b>782</b>
--	------------

Maher Al-Badri, Pragasen Pillay and Pierre Angers  
Concordia University, Canada; Hydro-Quebec, Canada

<b>Nonintrusive Efficiency Estimation for Large Power and High Voltage Induction Motors .....</b>	<b>786</b>
---	------------

Haisen Zhao, Pengyu Li, Geng Chen, Yilong Wang, Yang Zhan, Guorui Xu and Xiaofang Liu  
North China Electric Power University, China

<b>Separation of Slip- and High-Frequency Flux Densities and its Application in Rotor Iron Loss Fine Analysis of Induction Motors .....</b>	<b>794</b>
---	------------

Haisen Zhao, Bing Li, Wang Yilong Yang Zhan, Guorui Xu and Dong Dong Zhang  
North China Electric Power University, China; Xian Jiaotong University, China

## **Session 27: Medium Voltage Drives and High Power Drives**

**Chair(s): Navid Zargari, Shih-Chin Yang**

**Assessment of Medium Voltage SiC MOSFET Advantages in Medium Voltage Drive Application ..... 801**

Hanning Tang and Alex Q. Huang

North Carolina State University, United States

**High-Speed Medium Voltage (MV) Drive Applications Enabled by Series Connection of 1.7 kV  
SiC MOSFET Devices ..... 808**

Kasunaidu Vechalapu, Samir Hazra, Utkarsh Raheja, Abhay Negi and Subhashish Bhattacharya

North Carolina State University, United States

**Integrated Motor Drive Design for Weight Optimization ..... 816**

Benjamin Cheong, Paolo Giangrande, Michael Galea, Pericle Zanchetta and Patrick Wheeler

University of Nottingham, United Kingdom

**DC Current Balance with Common-Mode Voltage Reduction for Parallel Current Source Converters ... 824**

Li Ding and Yun Wei Li

University of Alberta, Canada

**Position Sensorless Control of a Permanent Magnet Linear Motor Connected through a Long Cable ... 830**

Hussain A. Hussain and Hamid A. Toliyat

Texas A&M University, United States

## **Session 28: Sensorless Drives I**

**Chair(s): Fernando Briz, Abraham Gebregergis**

**Sensorless Speed Measurement for n-Phase Induction Machines under Open-Phase Fault by  
Means of Rotor Slot Harmonics ..... 836**

Alejandro G. Yepes, Jesús Doval-Gandoy, Fernando Baneira and Hamid Toliyat

University of Vigo, Spain; Texas A&M University, United States

**Analysis on the Position Estimation Error in Position-Sensorless Operation using Pulsating  
Square Wave Signal Injection ..... 844**

Chae-Eun Hwang, Younggi Lee and Seung-Ki Sul

Seoul National University, Korea

**Enhanced Methodology for Injection-based Real-Time Parameter Estimation to Improve Back-  
EMF Self-Sensing in Induction Machine Deadbeat-Direct Torque and Flux Control Drives ..... 851**

Kang Wang, Robert D. Lorenz and Noor Aamir Baloch

University of Wisconsin-Madison, United States; Yaskawa Electric Corporation, Japan

**Compensation of Position Estimation Error for Precise Position-Sensorless Control of IPMSM  
based on High-Frequency Pulsating Voltage Injection ..... 859**

Younggi Lee, Yong-Cheol Kwon, Seung-Ki Sul, Noor Aamir Baloch and Shinya Morimoto

Seoul National University, Korea; Yaskawa Electric Corporation, Japan

**Full Torque-Range Low-Speed Sensorless Drive for Heavily Saturated IPMSMs by Manipulation  
of Convergence Point ..... 865**

Yong-Cheol Kwon, Joohyun Lee and Seung-Ki Sul

Seoul National University, Korea

## **Session 29: Magnetics II**

**Chair(s): Shashank Krishnamurthy, Shuo Wang**

<b>A High-Reliable Magnetic Design Method for Three-Phase Coupled Inductor used in Interleaved Multi-Phase Boost Converters .....</b>	<b>873</b>
---	------------

Jun Imaoka, Kenkichiyo Okamoto, Masahito Shoyama, Mostafa Noah, Shota Kimura and Masayoshi Yamamoto  
Kyushu University, Japan; Shimane University, Japan

<b>Design and Additive Manufacturing of Multi-Permeability Magnetic Cores .....</b>	<b>881</b>
---	------------

L. Liu, C. Ding, S. Lu, T. Ge, Y. Yan, Y. Mei, K.D.T. Ngo and G-Q. Lu  
Virginia Polytechnic Institute and State University, United States; Tianjin University, China

<b>Influence of Switching Frequency and Saturation of the Magnetic Material on the Volume of Common-Mode Inductors used in Power Converter EMI Filters .....</b>	<b>887</b>
--	------------

Bilel Zaidi, Arnaud Videt and Nadir Idrir  
University of Lille, France

<b>Variable Inductor Modeling Revisited: The Analytical Approach .....</b>	<b>895</b>
--	------------

J. Marcos Alonso, Marina Perdigão, Marco A. Dalla Costa, Shu Zhang and Yijie Wang  
University of Oviedo, Spain; University of Coimbra, Portugal; Federal University of Santa Maria, Brazil; Harbin Institute of Technology, China

<b>Winding and Air Gap Configurations for Power Inductors to Reduce Near Magnetic Field Emission ....</b>	<b>903</b>
---	------------

Huan Zhang, Shuo Wang and Qinghai Wang  
University of Florida, United States; Huawei Technologies Co., Ltd., China

## **Session 30: SiC Converter Applications**

**Chair(s): Jean-Luc Schanen, Yuxiang Shi**

<b>Impact of Next-Generation 1700V SiC MOSFETs in a 125kW PV Converter .....</b>	<b>911</b>
--	------------

Jon Zhang, Fenton L. Rees, Brett Hull, Jeffrey B. Casady, Scott Allen and John W. Palmour  
Wolfspeed, a Cree Company, United States; F.L. Rees and Associates, United States

<b>Operation of Planar and Trench SiC MOSFETs in a 10kW DC/DC-Converter Analyzing the Impact of the Body Diode .....</b>	<b>917</b>
--	------------

Abdullah Eial Awwad and Sibylle Dieckerhoff  
Technical University of Berlin, Germany

<b>High Efficiency Power Converter with SiC Power MOSFETs for Pulsed Power Application .....</b>	<b>925</b>
--	------------

Ruxi Wang, Juan Sabate, Xiaohu Liu and Krishna Mainali  
GE Global Research Center, United States; Busek Co., Inc., United States

<b>Influence of SiC Technology in a Railway Traction DC-DC Converter Design Evolution .....</b>	<b>931</b>
---	------------

Alejandro Rujas, Víctor M. López, Asier García-Bediaga, Aloña Berasategi and Txomin Nieva  
IK4-Ikerlan. Power Electronics Area, Spain; CAF Power and Automotion, Spain

<b>Design of a 250 kW, 1200 V SiC MOSFET-based Three-Phase Inverter by Considering a Subsystem Level Design Optimization Approach .....</b>	<b>939</b>
---	------------

Ajith H. Wijenayake, Kraig J. Olejniczak, David Simco, Stephen Minden, Matthew Feurtado, Brandon Passmore, Ty McNutt, Alex Lostetter and Daniel Martin  
Wolfspeed, A Cree Company, United States

## **Session 31: Wireless Power Transfer I**

**Chair(s): Huang-jen Chiu, Yaow-Ming Chen**

**Tunable Impedance Matching Network based on Phase-Switched Impedance Modulation ..... 947**

Alexander S. Jurkov, Aaron Radomski and David J. Perreault

Massachusetts Institute of Technology, United States; MKS Instruments Inc., United States

**Design 13.56MHz 10 kW Resonant Inverter using GaN HEMT for Wireless Power Transfer Systems .... 955**

Nguyen Kien Trung and Kan Akatsu

Shibaura Institute of Technology, Japan

**An Optimized Frequency and Phase Shift Control Strategy for Constant Current Charging and Zero Voltage Switching Operation in Series-Series Compensated Wireless Power Transmission .... 961**

Yongbin Jiang, Junwen Liu, Xiufang Hu, Laili Wang, Yue Wang and Gaidi Ning

Xi'an Jiaotong University, China

**High-Power-Transfer-Density Capacitive Wireless Power Transfer System for Electric Vehicle Charging ..... 967**

Sreyam Sinha, Brandon Regensburger, Kate Doubleday, Ashish Kumar, Saad Pervaiz and Khurram K. Afridi  
University of Colorado-Boulder, United States

**Modeling and Analysis of Wireless Power Transfer System with Constant-Voltage Source and Constant-Current Load ..... 975**

Yiming Zhang, Zhengming Zhao and Ye Jiang

Missouri University of Science and Technology, United States; Tsinghua University, China

## **Session 32: Energy Storage Systems**

**Chair(s): Rashmi Prasad, Dazhong Gu**

**An Online LiFePO<sub>4</sub> Battery Impedance Estimation Method for Grid-Tied Residential Energy Storage Systems ..... 980**

Andres Salazar, Carlos Restrepo, Yabiao Gao, Javad Mohammadpour Velni and Antonio Ginart  
Sonnen Inc., United States; University of Georgia, United States; Smart Wires, Inc., United States

**An Improved Voltage Balance Strategy for Renewable Generation Energy Storage System ..... 987**

Muxin Han, Fu Jiang, Heng Li, Rong Zhou, Zhiwu Huang and Jun Peng

Central South University, China

**Design Recommendations for Energy Systems: A UK Domestic Study ..... 992**

Konstantina Panagiotou, Christian Klumpner, Mark Sumner and Pat Wheeler

University of Nottingham, United Kingdom

**A Decentralized SOC Balancing Method in Cascaded H-Bridge based Storage Modules ..... 1000**

Guangze Shi, Yao Sun, Wenbin Yuan, Hua Han, Mei Su and Xiaochao Hou

Central South University, China

**Cloud-based Battery Condition Monitoring Platform for Large-Scale Lithium-Ion Battery Energy Storage Systems using Internet-of-Things (IoT) ..... 1004**

Amit Adhikaree, Taesic Kim, Jitendra Vagdoda, Ason Ochoa, Patrick J. Hernandez and Young Lee

Texas A&M University-Kingsville, United States

<b>Environmental Tests and Evaluations of Variable 18650 Cylindrical Li-Ion Cells for Space Cell's Qualification Establishment .....</b>	<b>1010</b>
Jonghoon Kim, P.-Y. Lee, C.-O Youn, Woonki Na and Minho Jang Chungnam National University, Korea; California State University-Fresno, United States; Korea Aerospace Research Institute, Korea	
<b>A Hybrid Vanadium Redox/Lithium-Ion Energy Storage System for Off-Grid Renewable Power ...</b>	<b>1016</b>
Leong Kit Gan, Jorn Reniers and David Howey University of Oxford, United Kingdom	
<b>Electrical Circuit Modeling of Lithium-Sulfur Batteries during Discharging State .....</b>	<b>1024</b>
Daniel-Ioan Stroe, Vaclav Knap, Maciej Swierczynski and Erik Schatz Aalborg University, Denmark	
<b>Supercapacitor to Provide Ancillary Services to the Grid .....</b>	<b>1030</b>
V. Gevorgian, E. Muljadi, Yusheng Luo, M. Mohanpurkar, R. Hovsepian and V. Koritarov National Renewable Energy Laboratory, United States; Idaho National Laboratory, United States; Argonne National Laboratory, United States	
<b>Cascaded Multilevel qZSI Powered Single-Phase Induction Motor for Water Pump Application ....</b>	<b>1037</b>
Syed Rahman, Mohammad Meraj, Atif Iqbal, Mohd Tariq, Ali I. Maswood, Lazhar Ben-Brahim and Rashid Alammari Qatar University, Qatar; Nanyang Technological University, Singapore; Aligarh Muslim University, India	
<b>Session 33: AC/AC Converters</b>	
<b>Chair(s): Yam Siwakoti, Luca Zarri</b>	
<b>Single-Phase Trans-Z-Source AC-AC Converter with Safe-Commutation Strategy .....</b>	<b>1043</b>
Jixiao Nai, Liangzong He and Yuzi Lin Xiamen University, China	
<b>A Post-Fault Strategy to Control the AC-AC Modular Multilevel Converter under Input-Side Line-to-Ground Fault .....</b>	<b>1050</b>
Qichen Yang and Maryam Saeedifard Georgia Institute of Technology, United States	
<b>Single-Phase Universal Active Power Filter with Five-Leg AC/DC/AC Converter .....</b>	<b>1057</b>
Phelipe L.S. Rodrigues, Cursino B. Jacobina, Nayara B. de Freitas and Mauricio B.R. Correa Federal University of Campina Grande, Brazil	
<b>Modulation and Control Strategy for a Single-Phase to Three-Phase Indirect Matrix Converter Drives .....</b>	<b>1065</b>
Yeongsu Bak, June-Seok Lee and Kyo-Beum Lee Ajou University, Korea; Korea Railroad Research Institute, Korea	
<b>Switched Capacitor Impedance Matrix Converter .....</b>	<b>1071</b>
M. Raghuram, Avneet K. Chauhan and Santosh K. Singh Indian Institute of Technology, India	
<b>A Modular Three-Phase AC-AC Converter with Small Number of Film Capacitors for High-Voltage High-Current Applications .....</b>	<b>1076</b>
Ehsan Afshari and Mahshid Amirabadi Northeastern University, United States	

<b>Control Scheme of the Modular Multilevel Matrix Converter using Space Vector Modulation for Wide Frequency Range Operation .....</b>	<b>1084</b>
Yushi Miura, Takuya Fujikawa, Tomoaki Yoshida and Toshifumi Ise Osaka University, Japan	
<b>Investigations on the Family of Center-Point-Clamped AC-AC Direct Power Converters .....</b>	<b>1092</b>
Pankaj Kumar Bhowmik and Madhav Manjrekar University of North Carolina-Charlotte, United States	
<b>Session 34: Reliability, Diagnostics and Fault Analysis of Power Electronics</b>	
<b>Chair(s): Wei Qiao, Huai Wang</b>	
<b>Diagnosis of Open-Circuit Faults for Six-Level Hybrid Inverters .....</b>	<b>1099</b>
Quoc Anh Le, Ngoc Dat Dao and Dong-Choon Lee Can Tho University, Viet Nam; Yeungnam University, Korea	
<b>Design of Power Converter in DFIG Wind Turbine with Enhanced System-Level Reliability .....</b>	<b>1105</b>
Dao Zhou, Guanguan Zhang and Frede Blaabjerg Aalborg University, Denmark; Central South University, China	
<b>Comparative Study on the Crowbar Protection Topologies for a DFIG Wind Turbine .....</b>	<b>1112</b>
Andreas Giannakis, Efthymios Koroniotis and Athanasios Karlis Democritus University of Thrace, Greece	
<b>Photovoltaic Condition Monitoring using Real-Time Adaptive Parameter Identification .....</b>	<b>1119</b>
Jason Poon, Palak Jain, Costas Spanos, Sanjib Kumar Panda and Seth R. Sanders University of California-Berkeley, United States; National University of Singapore, Singapore	
<b>A Fast Fault Diagnosis Method for Submodule Failures in Modular Multilevel Converters .....</b>	<b>1125</b>
Kunshan Xu, Shaojun Xie, Ye Yan, Zhao Zhang, Binfeng Zhang and Qiang Qian Nanjing University of Aeronautics and Astronautics, China	
<b>On Self-Healing of Grid-Tied PV Inverters Considering Current Sensor Inaccuracy and Aging Degradation .....</b>	<b>1131</b>
Mehrdad Biglarbegian, Hamidreza Jafarian and Babak Parkhideh University of North Carolina at Charlotte, United States	
<b>Fault Tolerant Control Method for Interleaved DC-DC Converters under Open and Short Circuit Switch Faults .....</b>	<b>1137</b>
Elham Pazouki, Jose Alexis De Abreu-Garcia and Yilmaz Sozer University of Akron, United States	
<b>A General Fault Diagnosis Strategy for Modular DC-DC Converter System .....</b>	<b>1143</b>
Hanyu Wang, Xuejun Pei, Yuhuan Wu and Yong Kang Huazhong University of Science and Technology, China	
<b>Monitoring Transistor Degradation in Power Electronic Converters using Saturation-Region Resistance .....</b>	<b>1148</b>
Lei Ren, Chunying Gong and Xin Chen Nanjing University of Aeronautics and Astronautics, China	

## **Session 35: AC Electrical Machines: Innovative Design Studies**

**Chair(s): Phillip Kollmeyer, Zi-Qiang Zhu**

<b>Principles and Characteristics of an Ultralightweight Electromagnetic Resonance Coupling Machine With a Cage Rotor .....</b>	<b>1154</b>
Kazuto Sakai, Kenta Takijima and Kazuki Nihei Toyo University, Japan	
<b>Investigation on the Frequency Effects on Iron Losses in Laminations .....</b>	<b>1161</b>
Omar Bottesi, Sandro Calligaro and Luigi Alberti Free University of Bozen-Bolzano, Italy; University of Padova, Italy	
<b>The Effect of Modulating Ring Design on Induction Machine with Integrated Magnetic Gear Torque .....</b>	<b>1169</b>
Dalia Zaky Abdelhamid and Andrew M. Knight University of Calgary, Canada	
<b>Practical Considerations on the Off-Line Measurements of PMSM and SyRM Inductances .....</b>	<b>1175</b>
Andrea Cavagnino, Silvio Vaschetto and Emmanuel Agamloh Politecnico di Torino, Italy; Advanced Energy, United States	
<b>Decoupled Current Control with Novel Anti-Windup for PMSM Drives .....</b>	<b>1183</b>
Kahyun Lee, Jung-Ik Ha and Dwarakanath Simili Seoul National University, Korea; General Motors, United States	
<b>Foil Conductor Concentrated Coil Windings for Modular Permanent Magnet AC Machines .....</b>	<b>1191</b>
Michael Rios, Giri Venkataraman and Annette Muetze University of Wisconsin-Madison, United States; Graz University of Technology, Austria	
<b>Synchronous Machine Field Excitation Utilizing a Single Phase Matrix Converter Excited Rotary Transformer .....</b>	<b>1197</b>
Jianyang Liu and Thomas A. Lipo University of Wisconsin-Madison, United States	
<b>Session 36: Axial and Transversal Flux Machines</b>	
<b>Chair(s): Akira Chiba, Ayman El-Refaie</b>	
<b>Mechanical and Thermal Performance of Transverse Flux Machines .....</b>	<b>1205</b>
Iftekhar Hasan, Tausif Husain, Yilmaz Sozer, Iqbal Husain and Eduard Muljadi University of Akron, United States; North Carolina State University, United States; National Renewable Energy Laboratory, United States	
<b>Maximum Torque Output Control of Hybrid Permanent Magnet Axial Field Flux-Switching Memory Machine .....</b>	<b>1212</b>
Gongde Yang, Mingyao Lin, Nian Li, Xinghe Fu and Kai Liu Southeast University, China	
<b>Design Considerations and Performance Improvement of a Dual-Stator PM Vernier Motor with Axial-Flux Loop .....</b>	<b>1220</b>
Fei Zhao, Liyi Li, Chunhua Liu and Byung-il Kwon Harbin Institute of Technology, China; City University of Hong Kong, Hong Kong; Hanyang University, Korea	

<b>Design, Analysis and Prototyping of a Flux Switching Transverse Flux Machine with Ferrite Magnets .....</b>	<b>1227</b>
Zhao Wan and Iqbal Husain North Carolina State University, United States	
<b>MAGNUS – An Ultra-high Specific Torque PM Axial Flux Type Motor with Flux Focusing and Modulation .....</b>	<b>1234</b>
Vandana Rallabandi, Narges Taran, Dan M. Ionel and Ion G. Boldea University of Kentucky, United States; Univerisitatea Politehnica Timisoara, Romania	
<b>Three-Part Hybrid Rotor PM Machine with Variable Magnetization State .....</b>	<b>1240</b>
Dheeraj Bobba, Timothy A. Burress, Jason Pries and Bulent Sarlioglu University of Wisconsin-Madison, United States; Oak Ridge National Laboratory, United States	
<b>Designing the First Stage of a Series Connected Multistage Coaxial Magnetic Gearbox for a Wind Turbine Demonstrator .....</b>	<b>1247</b>
K. Li, J. Wright, S. Modaresahmadi, D. Som, W. Williams and J.Z. Bird University of North Carolina at Charlotte, United States; Portland State University, United States	
<b>A Comprehensive Review of Permanent Magnet Transverse Flux Machines for Direct Drive Applications .....</b>	<b>1255</b>
Tausif Husain, Iftekhar Hasan, Yilmaz Sozer, Iqbal Husain and Eduard Muljadi University of Akron, United States; North Carolina State University, United States; National Renewable Energy Laboratory, United States	
<b>Session 37: Utility Converters and Power Electronics Transformers</b>	
<b>Chair(s): Fred Wang, Jinwei He</b>	
<b>A Novel Current Control Strategy for a Back-to-Back HVDC Applications under Unbalanced Operation Conditions .....</b>	<b>1263</b>
Mohammed Alharbi, Faris E. Alfaris and Subhashish Bhattacharya North Carolina State University, United States	
<b>Voltage Balancing of Modular Smart Transformers based on Dual Active Bridges .....</b>	<b>1270</b>
Sante Pugliese, Markus Andresen, Rosa Mastrommauro, Giampaolo Buticchi, Silvio Stasi and Marco Liserre Polytechnic of Bari, Italy; Christian-Albrechts-Universität zu Kiel, Germany; University of Florence, Italy	
<b>Three-Port Energy Router for Universal and Flexible Power Management in Future Smart Distribution Grids .....</b>	<b>1276</b>
L. Tarisciotti, P. Zanchetta, S. Pipolo and S. Bifaretti University of Nottingham, United Kingdom; University of Rome Tor Vergata, Italy	
<b>Design and Implementation of a Series Resonant Solid State Transformer .....</b>	<b>1282</b>
Mohammad Rashidi, Mohamad Sabbah, Abedalsalam Bani-Ahmed, Adel Nasiri and Mohammad Hasan Balali University of Wisconsin-Milwaukee, United States	
<b>Design and Implementation of a 7.2kV Single Stage AC-AC Solid State Transformer based on Current Source Series Resonant Converter and 15 kV SiC MOSFET .....</b>	<b>1288</b>
Qianlai Zhu, Li Wang, Dong Chen, Lili Zhang and Alex Q. Huang North Carolina State University, United States	

**Research on an Improved Hybrid Unified Power Flow Controller ..... 1296**

Baichao Chen, Wenli Fei, Jiaxin Yuan and Cuihua Tian  
Wuhan University, China

**Session 38: Motor Drives I**

**Chair(s): Fabio Giulii Capponi, Radu Bojoi**

**Two-Phase Open-End Winding Induction Motor Drive using Improved Current Source Inverter ... 1304**

Louelson A.L. de A.C. Costa, Montiê A. Vitorino, Edgar R. Braga-Filho, Maurício B.R. Corrêa  
and Darlan A. Fernandes  
Federal University of Campina Grande, Brazil; Federal University of Paraiba, Brazil

**An Extended Analytical Approach for Obtaining the Steady-State Periodic Solutions of SPWM Single-Phase Inverters ..... 1311**

Xu Cheng, Yanfeng Chen, Xi Chen, Bo Zhang and Dongyuan Qiu  
South China University of Technology, China

**Reliability Analysis and Life Testing of Semiconductor Devices for In-Wheel Motor Drive System .. 1317**

Chao Ji, Geoffrey Owen, Simon T.M. Brockway and Chris Hilton  
Protean Electric Ltd., United Kingdom

**Comparison of Operating Modes for a Brushless Doubly Fed Reluctance Motor Drive ..... 1323**

Ronald S. Rebeiro and Andrew M. Knight  
University of Calgary, Canada

**Sensorless Direct Torque Control of Induction Motors with Fault-Tolerant Extended Kalman Filtering ..... 1331**

Xin Wang  
Southern Illinois University, United States

**A Modulated Model Predictive Control Scheme for the Brushless Doubly-Fed Induction Machine ..... 1338**

Xuan Li, Tao Peng, Hanbing Dan, Guanguan Zhang, Weiyi Tang and Pat Wheeler  
Central South University, China; University of Nottingham, United Kingdom

**Session 39: Switching Devices I**

**Chair(s): Tanya Gachovska, Jun Wang**

**Comparative Assessment of 3.3kV/400A SiC MOSFET and Si IGBT Power Modules ..... 1343**

Claudiu Ionita, Muhammad Nawaz, Kalle Ilves, and Francesco Iannuzzo  
ABB Corporate Research, Sweden; Aalborg University, Denmark

**Characterization and Performance Evaluation of State-of-the-Art 3.3 kV 30 A Full-SiC MOSFETs ..... 1350**

Alinaghi Marzoughi, Rolando Burgos and Dushan Boroyevich  
Virginia Polytechnic Institute and State University, United States

**Research on an Improved DC-Side Snubber for Suppressing the Turn-Off Overvoltage and Oscillation in High Speed SiC MOSFET Application ..... 1358**

Mei Liang, Yan Li, Qian Chen, Yi Lu, Haihong Yu, Trillion Q. Zheng, Haobo Guo and Fangwei Zhao  
Beijing Jiaotong University, China; State Grid Zhejiang Electric Power Corporation, China

**A Modified Equivalent Circuit based Electro-Thermal Model for Integrated POL Power Modules ..... 1366**

Wenbo Liu, Sam Webb, Yan-Fei Liu, Laili Wang and Doug Malcolm  
Queen's University, Canada; Sumida Technologies Inc., Canada

<b>Investigation of Cascode Structure GaN Devices in ZCS Region of LLC Resonant Converter .....</b>	<b>1374</b>
Junlin Xiang, Xiaoyong Ren, Yakun Wang and Yue Zhang	
Nanjing University of Aeronautics and Astronautics, China	
<b>Design of High-Speed H-Bridge Converter using Discrete SiC MOSFETs for Solid-State Transformer Applications .....</b>	<b>1379</b>
Dong Dong, Mohammed Agamy, Gary Mandrusiak and Qin Chen	
GE Global Research, United States	
<b>Role of Parasitic Capacitances in Power MOSFET Turn-On Switching Speed Limits: A SiC Case Study .....</b>	<b>1387</b>
Davide Cittanti, Francesco Iannuzzo, Eckart Hoene and Kirill Klein	
Politecnico di Torino, Italy; Aalborg University, Denmark; Fraunhofer IZM, Germany	
<b>Analysis of False Turn-On Phenomenon of GaN HEMT with Parasitic Inductances for Propose Novel Design Method Focusing on Peak Gate Voltage .....</b>	<b>1395</b>
Seiya Ishiwaki, Toshihiro Iwaki, Yusuke Sugihara and Kimihiro Nanamori and Masayoshi Yamamoto	
Shimane University, Japan; Nagoya University, Japan	
<b>Gate Driver Design Considerations for Silicon Carbide MOSFETs including Series Connected Devices .....</b>	<b>1402</b>
Samir Hazra, Kasunaidu Vechalapu, Sachin Madhusoodhanan, Subhashish Bhattacharya and Kamalesh Hatua	
North Carolina State University, United States; Indian Institute of Technology Madras, United States	
<b>Session 40: Electric Vehicle Energy Management</b>	
<b>Chair(s): Kevin Bai, Anand Sathyan</b>	
<b>A Novel Dynamic Demand Control of an Electric Vehicle Integrated in a Solar Nanogrid with Energy Storage .....</b>	<b>1410</b>
Adamantios Bampoulas and Athanasios Karlis	
Democritus University of Thrace, Greece	
<b>Stackelberg Game based Energy and Reserve Management for a Fast Electric Vehicle Charging Station .....</b>	<b>1417</b>
Tianyang Zhao, Xuwei Pan, Shuhan Yao and Peng Wang	
Nanyang Technology University, Singapore; Harbin Institute of Technology, China	
<b>Multi-Time Scale Forecast for Schedulable Capacity of EVs based on Big Data and Machine Learning .....</b>	<b>1425</b>
Meiqin Mao, Yangyang Wang, You Yue and Liuchen Chang	
Hefei University of Technology, China	
<b>Three-Port Bidirectional CLLC Resonant Converter based Onboard Charger for PEV Hybrid Energy Management System .....</b>	<b>1432</b>
Xiaoying Lu and Haoyu Wang	
ShanghaiTech University, China	
<b>V2G Bi-directional Battery Charger with Flexible AC/DC Converter .....</b>	<b>1439</b>
Yaguang Liu, Wenxing Zhong, Haoyuan Weng, Zheqing Li, Min Chen, Changsheng Hu and Dehong Xu	
Zhejiang University, China	

## **Session 41: Sensing and Control for Power Converters**

**Chair(s): Tsai-Fu Wu, Amir Yaznadi**

<b>An Experimental Method for Extracting Stray Inductance of Bus Bars without High Bandwidth Current Measurement .....</b>	<b>1446</b>
Ye Jiang, Liqiang Yuan, Zhengming Zhao, Haitao Zhang, Rong Yi, Yali Ding and Wei Gu <i>Tsinghua University, China; Rongxin Huiko Electric Technology Co., Ltd., China; Anshan Information Engineering School, China</i>	
<b>Comparative Evaluations on Three High Resolution Sampling Schemes for Digital Boundary Control .....</b>	<b>1451</b>
Yuanbin He, Chun-tak Lai, Shu-hung Chung and Weimin Wu <i>Hangzhou Dianzi University, China; City University of Hong Kong, Hong Kong; Shanghai Maritime University, China</i>	

<b>Closed-Loop Control of a Capacitive-Link Universal Converter with Minimum Number of Voltage Sensors .....</b>	<b>1457</b>
Masih Khodabandeh and Mahshid Amirabadi <i>Northeastern University, United States</i>	

<b>Wavelet-based Prognostic-Oriented Temperature Sensing with Sigma-Delta ADCs in Power Applications .....</b>	<b>1465</b>
Giorgio Pietrini, Alessandro Soldati, Davide Barater and Carlo Concari <i>University of Parma, Italy</i>	

## **Session 42: Modelling and Control of MMC**

**Chair(s): Yongdong Li, Tzung-Lin Lee**

<b>Delta-Sigma Modulators for Modular Multilevel Converters .....</b>	<b>1473</b>
Hao Jiang and Giri Venkataraman <i>University of Wisconsin-Madison, United States</i>	

<b>Hybrid Asymmetric Cascaded Multilevel Inverters based on Three- and Nine-Level H-Bridges .....</b>	<b>1479</b>
Filipe A. da C. Bahia, Cursino B. Jacobina, Nady Rocha, Italo Roger F.M.P. da Silva, Reuben P.R. de Sousa <i>Federal University of Campina Grande, Brazil; Federal University of the Paraíba, Brazil; Federal Rural University of Pernambuco, Brazil</i>	

<b>Comparative Study of PES Net and SyCCo Bus: Communication Protocols for Modular Multilevel Converter .....</b>	<b>1487</b>
Hao Tu and Srdjan Lukic <i>North Carolina State University, United States</i>	

<b>Asymmetric Cascaded H-Bridge Topology with 25-Level Output Voltage based on Modular Multilevel DSCC Inverters .....</b>	<b>1493</b>
Filipe A. da C. Bahia, Cursino B. Jacobina, Nady Rocha, Italo Roger F.M.P. da Silva <i>Federal University of Campina Grande, Brazil; Federal University of the Paraíba, Brazil; Federal Rural University of Pernambuco, Brazil</i>	

<b>System-on-Chip Implementation of Embedded Real-Time Simulator for Modular Multilevel Converters .....</b>	<b>1500</b>
Mattia Ricco, Marius Gheorghe, Laszlo Mathe and Remus Teodorescu <i>Aalborg University, Denmark</i>	

<b>A Novel Frequency Domain Control Method for Modular Multilevel Converters under Non-Sinusoidal Supply Conditions .....</b>	<b>1506</b>
Rostan Rodrigues, Jun Li and Herbert L. Ginn III ABB Inc., United States; University of South Carolina, United States	
<b>Modeling and Design of the Modular Multilevel Converter with Parametric and Model-Form Uncertainty Quantification .....</b>	<b>1513</b>
Niloofar Rashidi Mehrabadi, Rolando Burgos, Dushan Boroyevich and Christopher Roy Virginia Polytechnic Institute and State University, United States	
<b>Decoupled <math>\alpha\beta</math> Model of Modular Multilevel Converter (MMCs) .....</b>	<b>1521</b>
Yi-Hsun Hsieh and Fred C. Lee Virginia Polytechnic Institute and State University, United States	
<b>Damping Analysis for Transients of Modular Multilevel Converter .....</b>	<b>1527</b>
Haihao Jiang and Boon-Teck Ooi McGill University, Canada	
<b>Session 43: Control in Microgrids</b>	
<b>Chair(s): Xiaonan Lu, Thomas Podlesak</b>	
<b>Variable Structure Robust Voltage Regulator Design for Microgrid Master-Slave Control .....</b>	<b>1532</b>
Tong Yao and Raja Ayyanar Arizona State University, United States	
<b>Stability Improvement of Current Control by Voltage Feedforward considering a Large Synchronous Inductance of Diesel Generator .....</b>	<b>1540</b>
Jongmin Jo and Hanju Cha Chungnam National University, Korea	
<b>Method to Reduce the Circulating Current of Paralleled Inverters with Different Capacities .....</b>	<b>1545</b>
Xiang Li, Jiawei Chen and Jie Chen Chongqing University, China; Nanjing University of Aeronautics and Astronautics, China	
<b>Novel Hybrid Energy Storage Control for a Single Phase Energy Management System in a Remote Islanded Microgrid .....</b>	<b>1552</b>
Giovanna Oriti, Alexander L. Julian, Norma Anglani and Gabriel D. Hernandez Naval Postgraduate School, United States; Power Engineering, United States; University of Pavia, Italy; United States Navy, United States	
<b>Dynamic Composite Load Signature Detection and Classification using Supervised Learning over Disturbance Data .....</b>	<b>1560</b>
Kelly Tray, Phylicia Cicilio, Ted Brekken and Eduardo Cotilla-Sanchez Oregon State University, United States	
<b>A Highly Reconfigurable System Emulator for Testing AC Microgrids .....</b>	<b>1567</b>
Vijay A.S., Suryanarayana Doolla and Mukul C. Chandorkar Indian Institute of Technology Bombay, India	
<b>An Unsupervised Approach for Disaggregating Major Loads in Small Commercial Buildings .....</b>	<b>1575</b>
Saman Mostafavi, John Troxler and Robert W. Cox University of North Carolina at Charlotte, United States	

<b>Autonomous Control of Active Power Electronics Loads for Frequency Control of Islanded Microgrid .....</b>	<b>1582</b>
---	-------------

Guangqian Ding, Song Zhang, Jing Shan, Feng Gao and Xin Gu

University of Jinan, China; State Grid of China Technology College, China; State Grid Zaozhuang Power Supply Company, China; Shandong University, China

## **Tuesday, October 3**

### **Session 44: Harmonic Compensation Techniques for Microgrids**

**Chair(s): Dehong Mark Xu, Frede Blaabjerg**

<b>A Unified Selective Harmonic Compensation Strategy using DG-Interfacing Inverter in both Grid-Connected and Islanded Microgrid .....</b>	<b>1588</b>
---	-------------

Qicheng Huang and Kaushik Rajashekara

University of Houston, United States

<b>Active Suppression of Photovoltaic System Related Harmonics in a DC Micro Grid .....</b>	<b>1594</b>
---	-------------

R. Alsharif , M. Odavic and K. Atallah

University of Sheffield, United Kingdom

<b>A Novel Harmonic Current Sharing Control Strategy for Parallel-Connected Inverters .....</b>	<b>1602</b>
---	-------------

Yajuan Guan, Josep M. Guerrero, Mehdi Savaghebi, Juan C. Vasquez and Wei Feng

Aalborg University, Denmark; Tsinghua University, China

<b>Harmonic Current Control for LCL-Filtered VSCs Connected to Ultra-Weak Grids .....</b>	<b>1608</b>
---	-------------

Xiongfei Wang, Dongsheng Yang and Frede Blaabjerg

Aalborg University, Denmark

### **Session 45: Power Converters for HVDC Grids**

**Chair(s): Dianguo Xu, Brandon Grainger**

<b>Asymmetric Mixed Modular Multilevel Converter Topology in Bipolar HVDC Transmission Systems ...</b>	<b>1615</b>
--	-------------

Jae-Jung Jung, Joon-Hee Lee and Seung-Ki Sul

Seoul National University, Korea

<b>Dynamic Performance and Fault-Tolerant Capability of a TLC-MMC Hybrid DC-DC Converter for Interconnection of MVDC and HVDC Grids .....</b>	<b>1622</b>
---	-------------

Shenghui Cui, Nils Soltau and Rik W. De Doncker

RWTH Aachen University, Germany

<b>Efficient Modeling of Hybrid MMCs for HVDC Systems .....</b>	<b>1629</b>
---	-------------

Lei Zhang, Jiangchao Qin, Di Shi and Zhiwei Wang

Arizona State University, United States; GEIRI North America, United States

<b>A New Hybrid Modular Multilevel Converter with Increased Output Voltage Levels .....</b>	<b>1634</b>
---	-------------

Mahendra B. Ghat, Anshuman Shukla and Ebin Cherian Mathew

Indian Institute of Technology Bombay, India; Power Grid Corporation of India Ltd., India

## **Session 46: Solid State Transformers**

**Chair(s): Alex Huang, Rolando Burgos**

- A Switched-Winding Transformer with Low Quiescent Loss to Meet the Level VI Efficiency Standard at High Power Density .....** 1642

Weston D. Braun, Minjie Chen and David J. Perreault  
Massachusetts Institute of Technology, United States; Princeton University, United States

- A Winding Method of High Frequency High Voltage Transformer .....** 1649

Junpeng Ji, Xingxia Zhang, Wenjie Chen, Shaoliang An and Xu Yang  
Xi'an University of Technology, China; Xi'an Jiaotong University, China

- Comparison of Voltage Control Methods of CHB Converters for Power Routing in Smart Transformer .....** 1652

Vivek Raveendran, Giampaolo Buticchi, Marco Liserre and Alessandro Mercante  
Christian-Albrechts-Universität zu Kiel, Germany; Wärtsilä Italia S.p.A, Italy

- Generalized Average Modeling of DC Subsystem in Solid State Transformers .....** 1659

Jacob A. Mueller and Jonathan W. Kimball  
Missouri University of Science and Technology, United States

## **Session 47: Power Conversion for Solar Photovoltaic Systems III**

**Chair(s): Wuhua Li, Rajeev Kumar Singh**

- A Distributed Active and Reactive Power Control Strategy for Balancing Grid-tied Cascaded H-Bridge PV Inverter System .....** 1667

Hamidreza Jafarian, Namwon Kim and Babak Parkhideh  
University of North Carolina at Charlotte, United States

- Advanced Photovoltaic Inverter Control Development and Validation in a Controller-Hardware-in-the-Loop Test Bed .....** 1673

Kumaraguru Prabakar, Mariko Shirazi, Akanksha Singh and Sudipta Chakraborty  
National Renewable Energy Laboratory, United States

- DC Link Side Current Control of Inverters based on Integer Programming .....** 1680

O. Salari, A. Nazemi, A. Bakhshai, K. Hashtrudi Zaad and P. Jain  
Queen's University, Canada

- GaN-based High Gain Soft Switching Coupled-Inductor Boost Converter .....** 1687

Jinia Roy, Yinglai Xia and Raja Ayyanar  
Arizona State University, United States; Texas Instruments, United States

## **Session 48: Multi-Phase AC/DC Converters**

**Chair(s): Fernando Briz, Norma Anglani**

- Soft-Switching Parameter Design for an Isolated Three-Phase AC/DC Converter .....** 1694

Kazuma Suzuki, Wataru Kitagawa and Takaharu Takeshita  
Nagoya Institute of Technology, Japan

- Dynamic and Control Analysis of Modular Multi-Parallel Rectifiers (MMR) .....** 1701

Firuz Zare, Arindam Ghosh, Pooya Davari and Frede Blaabjerg  
University of Queensland, Australia; Curtin University, Australia; Aalborg University, Denmark

<b>A Reconfigurable Three- and Single-Phase AC/DC Non-Isolated Bi-Directional Converter for Multiple Worldwide Voltages .....</b>	<b>1708</b>
Daniel F. Opila, Eun Oh, Keith Kintzley and Jedediah Lomax United States Naval Academy, United States	
<b>High-Frequency Link AC/DC Converter using Matrix Converter with Soft-Switching Technique ....</b>	<b>1715</b>
Yuto Matsui, Kazuma Suzuki and Takaharu Takeshita Nagoya Institute of Technology, Japan	
<b>Session 49: DC/DC Converters II</b>	
<b>Chair(s): Dushan Borojevic, Grant Pitel</b>	
<b>A High Gain Non-Isolated Soft-Switching Bidirectional DC-DC Converter with PPS Control .....</b>	<b>1723</b>
Hyeonju Jeong, Minho Kwon and Sewan Choi Seoul National University of Science and Technology, Korea	
<b>An Investigation on Zero-Voltage-Switching Condition in Synchronous-Conduction-Mode Buck Converter .....</b>	<b>1728</b>
Chih-Shen Yeh, Xiaonan Zhao and Jih-Sheng Lai Virginia Polytechnic Institute and State University, United States	
<b>Single-Wing Resonant Multilevel Converter Featuring Reduced Number of Resonant Inductors ...</b>	<b>1733</b>
Boris Curuvija, Yanchao Li, Xiaofeng Lyu and Dong Cao North Dakota State University, United States	
<b>Dual Active Bridge with Triple Phase Shift by obtaining Soft Switching in all Operation Range .....</b>	<b>1739</b>
C. Calderon, A. Barrado, A. Rodriguez, A. Lazaro, C. Fernandez and P. Zumel Universidad Carlos III de Madrid, Spain	
<b>Session 50: Single-Phase Grid Connected Converters</b>	
<b>Chair(s): Diego G. Lamar, Andrea Formentini</b>	
<b>Trapezium Current Mode (TPCM) Boundary Operation for Single Phase Grid-Tied Inverter .....</b>	<b>1745</b>
JianTao Zhang, Rene A. Barrera-Cardenas, Takanori Isobe and Hiroshi Tadano University of Tsukuba, Japan	
<b>Leakage Current Suppression and Ripple Power Reduction for Transformer-less Single-Phase Photovoltaic Inverters .....</b>	<b>1753</b>
Xin Li, Zhongting Tang, Mei Su, Qi Zhu, Yonglu Liu and Yao Sun Central South University, China	
<b>ZVRT Capability of Minimized-LCL-Filter-based Single-Phase Grid-Tied Inverter with High-Speed Gate-Block .....</b>	<b>1757</b>
Satoshi Nagai, Keisuke Kusaka and Jun-ichi Itoh Nagaoka University of Technology, Japan	
<b>DC to Single-phase AC Grid-Tied Inverter using Buck Type Active Power Decoupling without Additional Magnetic Component .....</b>	<b>1765</b>
Jun-ichi Itoh, Tomokazu Sakuraba, Hiroki Watanabe and Nagisa Takaoka Nagaoka University of Technology, Japan	

## **Session 51: Sensorless Methods and State and Parameter Estimation**

**Chair(s): Yongsug Su, Maurizio Cirrincione**

<b>Online Equivalent Series Resistance Estimation Method for Condition Monitoring of DC-Link Capacitors .....</b>	<b>1773</b>
---	-------------

Sundararajan Prasanth, Mohamed Halick Mohamed, Sathik, Firman Sasongko, Tan Chuan Seng, Mohd Tariq and Rejeki Simanjorang  
Nanyang Technological University, Singapore; Rolls-Royce Singapore Pte. Ltd., Singapore

<b>A Novel Current Estimation Technique for Digital Controlled Switching Converters Operating in CCM and DCM .....</b>	<b>1781</b>
--	-------------

Rajat Channappanavar and Santanu Mishra  
Indian Institute of Technology Kanpur, India

<b>Distributed Balancing Control for Modular Multilevel Series/Parallel Converter with Capability of Sensorless Operation .....</b>	<b>1787</b>
---	-------------

Zhongxi Li, Ricardo Lizana, Angel V. Peterchev and Stefan M. Goetz  
Duke University, United States; Universidad Católica de la Santísima Concepción, Chile

<b>A Novel Approach to the Grid Inductance Estimation based on Second Order Generalized Integrators .....</b>	<b>1794</b>
---	-------------

Javier Moriano, Victor Bermejo, Emilio Bueno, Mario Rizo and Ana Rodriguez  
University of Alcalá, Spain; Gamesa Electric, Spain

## **Session 52: Modeling and Control of Modular Multilevel Converter**

**Chair(s): Hirofumi Akagi, Navid Zargari**

<b>Optimal Submodule Capacitor Sizing for Modular Multilevel Converters with Common Mode Voltage Injection and Circulating Current Control .....</b>	<b>1802</b>
--	-------------

Ziwei Ke, Jianyu Pan, Karun Potty, William Perdikakis, Arvind Shanmuganaatham, Muneer Al Sabbagh, Julia Zhang, Fang Luo, Jin Wang and Longya Xu  
Ohio State University, United States

<b>A New Insertion Index Selection Method to Control Modular Multilevel Converters .....</b>	<b>1809</b>
--	-------------

Mohammad Sleiman, Luc-André Gregoire, Handy Fortin-Blanchette, Hadi Kanaan and Kamal Al-Haddad  
École de Technologie Supérieure, Canada; OPAL-RT Technologies Inc., Canada; Saint-Joseph University, Lebanon

<b>A Modified Circulating Current Suppressing Strategy for Nearest Level Control based Modular Multilevel Converter .....</b>	<b>1817</b>
---	-------------

Xingxing Chen, Jinjun Liu, Shaodi Ouyang, Shuguang Song and Hongda Wu  
Xi'an Jiaotong University, China

<b>Independent Positive- and Negative-Sequence Control for MMC-SAPF with Unbalanced PCC Voltage .....</b>	<b>1823</b>
---	-------------

Chengjing Li, Ke Dai, Derong Lin, Chen Xu, Cai Chen and Ziwei Dai  
Huazhong University of Science and Technology, China; Rensselaer Polytechnic Institute, United States

## **Session 53: Large Synchronous Machines**

**Chair(s): Ayman El-Refaie, Mohammad Islam**

- Design of Field-Oriented-Control-based Brushless, Self-Excited Synchronous Field-Winding Machine with Combined Finite Element/Rectifier Model ..... 1830**

Abdi Zeynu and Heath Hofmann  
University of Michigan, United States

- Analysis of Magnetic Forces and Vibration in a Converter-Fed Synchronous Hydrogenerator ..... 1838**

Mostafa Valavi, Arne Nysveen, Roy Nilsen, Jean Le Besnerais and Emile Devillers  
Norwegian University of Science and Technology, Norway; EOMYS Engineering, France

- Performance Improvement of Simplified Synchronous Generators using an Active Power Filter .... 1845**

Al-Hussein Abu-Jalala, Tom Cox, Chris Gerada, Mohamed Rashed, Tahar Hamiti and Neil Brown  
University of Nottingham, United Kingdom; VEDECOM Institute, France; Cummins Power Generation, United Kingdom

- Reducing MMF Harmonics and Core Loss Effect of Non-Overlap Winding Wound Rotor**

- Synchronous Machine (WRSM) ..... 1850**

Karen S. Garner and Maarten J. Kamper  
Stellenbosch University, South Africa

## **Session 54: Synchronous Reluctance Machines I**

**Chair(s): Robert D. Lorenz, Dan Ionel**

- The Loss of Self-Excitation Capability in Stand-Alone Synchronous Reluctance Generators ..... 1857**

Maged Ibrahim and Pragasen Pillay  
Concordia University, Canada

- Reluctance Synchronous Wind Generator Design Optimisation in the Megawatt, Medium**

- Speed Range ..... 1864**

Eduan Howard and Maarten J. Kamper  
Stellenbosch University, South Africa

- Choice of Flux-Barriers Position in Synchronous Reluctance Machines ..... 1872**

Giacomo Bacco and Nicola Bianchi  
University of Padova, Italy

- Investigation of Torque Production and Torque Ripple Reduction Method for 6-Stator/7-Rotor-**

- Pole Variable Flux Reluctance Machines ..... 1880**

Beomseok Lee, Z.Q. Zhu and L.R. Huang  
University of Sheffield, United Kingdom

## **Session 55: Sensorless Drives II**

**Chair(s): Fabio Giulii Capponi, David Diaz Reigosa**

- Extending Low Speed Self-Sensing via Flux Tracking with Volt-Second Sensing ..... 1888**

Yang Xu, Yukai Wang, Ryo Iida and Robert D. Lorenz  
University of Wisconsin-Madison, United States; Toshiba Mitsubishi-Electric Industrial, Japan

- Pseudo-Sensorless Control of PMSM with Linear Hall-Effect Sensor ..... 1896**

Seung-Tae Lee, Young-Kyoun Kim and Jin Hur  
Incheon National University, Korea; Osan University, Korea

<b>Current Derivative Estimation by Using AMR Current Sensor and its Application in Sensorless Control of an IPMSM Drive .....</b>	<b>1901</b>
D.Q. Guan, D. Xiao, M.X. Bui and M.F. Rahman University of New South Wales, Australia	
<b>Sensorless Commissioning of Synchronous Reluctance Machines Augmented with High Frequency Voltage Injection .....</b>	<b>1909</b>
Paolo Pescetto and Gianmario Pellegrino Politecnico di Torino, Italy	
<b>Session 56: PM and IPM Motor Drives I</b>	
<b>Chair(s): Ramakrishnan Rajavenkitasubramony, Davide Barater</b>	
<b>Self-Adaptation of MTPA Tracking Controller for IPMSM and SynRM Drives based on On-Line Estimation of Loop Gain .....</b>	<b>1917</b>
Nicola Bedetti, Sandro Calligaro and Roberto Petrella Gefran S.p.A., Italy; Free University of Bozen, Italy; University of Udine, Italy	
<b>Control Method of PMSM Driving System with Small DC-Link Capacitor .....</b>	<b>1925</b>
Xi Xiao, Shubei Zhang, Youshuang Ding and Yuyang Song Tsinghua University, China	
<b>Enabling Driving Cycle Loss Reduction in Variable Flux PMSMs via Closed-Loop Magnetization State Control .....</b>	<b>1932</b>
Apoorva Athavale, Daniel J. Erato and Robert D. Lorenz University of Wisconsin-Madison, United States	
<b>Analysis and Design of IPMSM Drive System based on Visualization Technique in Discrete Time Domain .....</b>	<b>1940</b>
Haoyuan Li, Xing Zhang, Shuying Yang, Fei Li, Jian Yang and Pengpeng Cao Hefei University of Technology, China	
<b>Session 57: GaN Device and Gate Drive</b>	
<b>Chair(s): Daniel Costinett, Chenhao Nan</b>	
<b>Active Gate Current Control for Non-Insulating-Gate WBG Device .....</b>	<b>1947</b>
He Li, Yousef M. Abdullah, Chengcheng Yao, Xiaodan Wang and Jin Wang Ohio State University, United States	
<b>Crosstalk Suppression in a 650-V GaN FET Bridge-Leg Converter using 6.7-GHz Active Gate Driver .....</b>	<b>1955</b>
Jianjing Wang, Dawei Liu, Harry C.P. Dymond, Jeremy J.O. Dalton and Bernard H. Stark University of Bristol, United Kingdom	
<b>A 1-MHz Leakage-Compensating Bootstrap Driver for Normally-On Depletion-Mode GaN FET ...</b>	<b>1961</b>
Yoontaek Lee, Sangwoo Han and Jaeha Kim Seoul National University, Korea; Hongik University, Korea	
<b>Applications and Characterization of Four Quadrant GaN Switch .....</b>	<b>1967</b>
Utkarsh Raheja, Ghanshyamsinh Gohil, Kijeong Han, Sayan Acharya, B. Jayant Baliga, Subhashish Bhattacharya, Michelle Labreque, Peter Smith and Rakesh Lal North Carolina State University, United States; Transphorm Inc., United States	

## **Session 58: Wide Band Gap Device Reliability**

**Chair(s): Jerry Hudgins, Tanya Gachovska**

**Ron Increase in GaN HEMTs – Temperature or Trapping Effects .....** 1975

Jan Böcker, Carsten Kuring, Marvin Tannhäuser and Sibylle Dieckerhoff  
Technische Universität Berlin, Germany; Siemens AG, Germany

**Short-Circuit Ruggedness Assessment of a 1.2 kV/180 A SiC MOSFET Power Module .....** 1982

Claudiu Ionita, Muhammad Nawaz, Kalle Ilves, and Francesco Iannuzzo  
ABB Corporate Research, Sweden; Aalborg University, Denmark

**Prognosis of Enhance Mode Gallium Nitride High Electron Mobility Transistors using On-State Resistance as a Fault Precursor .....** 1988

Moinul Shahidul Haque and Seungdeog Choi  
University of Akron, United States

**E-Mode GaN HEMT Short Circuit Robustness and Degradation .....** 1995

He Li, Xiao Li, Xiaodan Wang, Jin Wang, Yazan Alsmadi, Liming Liu and Sandeep Bala  
Ohio State University, United States; Jordan University of Science and Technology, Jordan; ABB Corporate Research, United States

## **Session 59: Datacenters and Telecommunication Applications**

**Chair(s): Xinke Wu, Al-Thaddeus Avestruz**

**Single-Stage Isolated 48V-to-1.8V Point-of-Load Converter Utilizing an Impedance Control Network for Wide Input Range Operation .....** 2003

Ashish Kumar and Khurram K. Afridi  
University of Colorado-Boulder, United States

**Startup and Control of High Efficiency 48/1V Sigma Converter .....** 2010

Mohamed H. Ahmed, Chao Fei, Virginia Li, Fred C. Lee and Qiang Li  
Virginia Polytechnic Institute and State University, United States

**A Hybrid AC and DC Distribution Architecture in Data Centers .....** 2017

Alexander Barthelme, Xiwen Xu and Tiefu Zhao  
University of North Carolina at Charlotte, United States

**Unidirectional Single-Phase AC-DC-AC Three-Level and Two-Level Three-Leg Converters .....** 2023

Nustenil S.M.L. Marinus, Cursino B. Jacobina, Nady Rocha and Reuben P.R. de Sousa  
Federal University of Campina Grande, Brazil; Federal Institute of Ceará, Brazil; Federal University of Paraíba, Brazil

**Data Center Power Distribution System Reliability Analysis Tool based on Monte Carlo Next Event Simulation Method .....** 2031

Yang Lei and Alex Q. Huang  
North Carolina State University, United States

**Resonant Filter based Buck Converters with Tunable Capacitor .....** 2036

Ben Guo, Suman Dwari, Lee Yongduk, Joseph Mantese, Brian McCabe, Andy Ritter, Craig Nies, Shashank Priya, Khai Ngo, Lujie Zhang and Rolando Burgos  
United Technologies Research Center, United States; AVX Corp., United States; Virginia Polytechnic Institute and State University, United States

**An Enhanced Control Scheme for Uninterruptible Power Supply ..... 2043**

Jinghang Lu, Mehdi Savaghebi, Baoze Wei and Josep Guerrero  
Aalborg University, Denmark

**Session 60: Applications of Electric Traction and Propulsion**

Chair(s): Bulent Sarlioglu, Suman Debnath

**An Accurate Modeling Method for Electric Parameters Prediction of Contactless Slip Ring ..... 2051**

Guangming He, Qianhong Chen, Xin Chen and Pingping Xin  
Nanjing University of Aeronautics and Astronautics, China

**High Power Medium Frequency Power Electronic Traction Transformer based on Bidirectional Z-Source-Alike Impedance Network ..... 2057**

Hongbo Li, Zhixue Zhang and Jing Shang  
CRRC Zhuzhou Institute Co., Ltd., China

**Investigation of the RC-IGBT Application in High Speed Railway Converters ..... 2062**

Xianjin Huang, Dengwei Chang, and Trillion Q. Zheng  
Beijing Jiaotong University, China

**Battery Energy Storage System Integration to the More Electric Aircraft 270 V DC Power Distribution Bus using Peak Current Controlled Dual Active Bridge Converter ..... 2068**

Mohd Tariq, Ali I. Maswood, Chandana J. Gajanayake, Amit K. Gupta and Firman Sasongko  
Nanyang Technological University, Singapore; Rolls-Royce Singapore Pte. Ltd., Singapore

**Research on Excitation Control Method for the Three-Phase Brushless Asynchronous Excitation System of Wound-Field Synchronous Starter/Generators ..... 2074**

Zan Zhang, Weiguo Liu, Shuai Mao, Jichang Peng, Chenghao Sun, Tao Meng and Ningfei Jiao  
Northwestern Polytechnical University, China

**Optimal Gear Ratios Selection for a Nissan Leaf: A Case Study of InGear Transmission System ... 2079**

Ahmed S. Abdelrahman, Khalil S. Algarny and Mohamed Z. Youssef  
University of Ontario Institute of Technology, Canada

**A Novel Hybrid Approach towards Drive-Cycle based Design and Optimization of a Fractional Slot Concentrated Winding SPMSM for BEVs ..... 2086**

Philip Korta, Lakshmi Varaha Iyer, Chunyan Lai, Kaushik Mukherjee, Jimi Tjong and Narayan C. Kar  
University of Windsor, Canada

**Session 61: Multilevel Converters**

Chair(s): Sheldon Williamson, Pericle Zanchetta

**A Novel Voltage Balance Circuit for Three-Level Diode-Clamped Inverter with Small Inductor ..... 2093**

Dongdong Cui, Zhida Zhou, Bo Yang, Qiongxuan Ge and Cong Zhao  
Institute of Electrical Engineering, CAS, China; University of Chinese Academy of Sciences, China

**An Improved Phase-Shifted PWM Method for a Three-Phase Cascaded H-Bridge Multi-Level Inverter ..... 2100**

June-Seok Lee, Kyo-Beum Lee and Youngjong Ko  
Korea Railroad Research Institute, Korea; Ajou University, Korea; University of Kiel, Germany

<b>Performance Assessment of the 5-Level 3-Phase Back to Back E-Type Converter .....</b>	<b>2106</b>
Marco Di Benedetto, Alessandro Lidozzi, Luca Solero, Fabio Crescimbini and Petar J. Grbovic Roma Tre University, Italy; Huawei Technologies Dusseldorf GmbH, Germany	
<b>Modeling and Voltage Balancing Control for a Hybrid Stacked Five-Level Converter .....</b>	<b>2114</b>
Shuai Xu, Jianzhong Zhang and Xing Hu Southeast University, China	
<b>Flying Capacitor Resonant Pole Inverter Applying Five Voltage Levels .....</b>	<b>2121</b>
Sjef J. Settels, Jeroen van Duivenbode, Jorge L. Duarte and Elena A. Lomonova Eindhoven University of Technology, Netherlands	
<b>Single-Phase AC-DC-AC Multilevel Converter based on H-Bridges and Three-Leg Converters Connected in Series .....</b>	<b>2129</b>
Antonio de P.D. Queiroz, Cursino B. Jacobina, Nayara B. de Freitas, Ayslan C.N. Maia and Victor F.M.B. Melo Federal University of Campina Grande, Brazil; Federal Institute of Paraíba, Brazil; Federal Institute of Alagoas, Brazil; Federal Institute of Pernambuco, Brazil	
<b>Control Strategy for Modular Multilevel Matrix Converters at High Output Frequencies .....</b>	<b>2137</b>
Dennis Braeckle, Patrick Himmelmann, Mathias Schnarrenberger and Marc Hiller Karlsruhe Institute of Technology, Germany	
<b>Low-Voltage DC Input, High-Voltage Pulse Generator using Nano-Crystalline Transformer and Sequentially Charged MMC Sub-Modules, for Water Treatment Applications .....</b>	<b>2144</b>
M.A. Elgennedy, A.M. Massoud, D. Holliday, S. Ahmed and B. Williams University of Strathclyde, United Kingdom; Qatar University, Qatar; Texas A&M University at Qatar, Qatar	
<b>Analysis of a Three Phase Five-Level Dual Tapped Inductor Quasi Impedance Source-Nested Neutral Point Clamped Converter .....</b>	<b>2150</b>
Akinola A. Ajayi-Obe and Azeem Khan University of Cape Town, South Africa	
<b>Session 62: DC/AC Converters</b>	
<b>Chair(s): Sewan Choi, Carl Ho</b>	
<b>A Novel Wireless Control Strategy for Input-Series Output-Parallel Inverter System .....</b>	<b>2156</b>
Xiaojian Jiang, Xiaopeng Cao, Liangcai Shu, Guangfu Ning and Wu Chen Southeast University, China	
<b>Comparative Analysis of Cascaded Inverters based on 5-Level and 3-Level H-Bridges .....</b>	<b>2161</b>
Reuben P.R. Sousa, Cursino B. Jacobina, Filipe A.C. Bahia and Luciano M. Barros Universidade Federal de Campina Grande, Brazil; Universidade Federal de Sergipe, Brazil	
<b>Differential Power as a Metric to Optimize Power Converters and Architectures .....</b>	<b>2168</b>
José A. Cobos, Helena Cristóbal, Diego Serrano, Regina Ramos, Jesús A. Oliver and Pedro Alou Universidad Politécnica de Madrid, Spain	
<b>The Phase-Controlled Class-D ZVS Inverter with Current Protection .....</b>	<b>2176</b>
Yudai Nagata, Yuta Yamada, Yoshiki Fukumoto, Tatsuya Ikenari, Xiuqin Wei, Tadashi Suetsugu and Hiroo Sekiya Chiba University, Japan; DAIHEN Corp., Japan; Chiba Institute of Technology, Japan; Fukuoka University, Japan	

<b>Hybrid Open-End Multilevel Six-Phase Machine Drive System with Reduced Harmonic Distortion .....</b>	<b>2184</b>
Ivan da Silva, Cursino B. Jacobina, Ayslan C.N. Maia, Isaac S. de Freitas and Reuben P.R. Sousa Federal University of Campina Grande, Brazil; Federal Institute of Alagoas, Brazil; Federal University of Paraiba, Brazil	
<b>DVR based on Three-Phase Converter Cascaded by Transformers with Only Two Pairs of Windings .....</b>	<b>2192</b>
Joao Paulo R.A. Mello and Cursino B. Jacobina Federal University of Campina Grande, Brazil	
<b>Coupled Inductor Implementation Improves Performance of Output Feedback ZVT in Full Bridge Inverters .....</b>	<b>2200</b>
Yinglai Xia, Chenhao Nan, Siddharth Kulasekaran and Raja Ayyanar Texas Instruments, United States; Google Inc., United States; Intel Corp., United States; Arizona State University, United States	
<b>Hybrid Single-Phase Multilevel Inverter with DC Bypass .....</b>	<b>2207</b>
Liming Liu ABB Corporate Research Center, United States	
<b>Session 63: DC/DC Converters</b>	
<b>Chair(s): Wilson Eberle, Sudip Mazumder</b>	
<b>Isolated and Wide Input Ranged Boost Full Bridge DC-DC Converter with Low Loss Active Snubber .....</b>	<b>2213</b>
Satoshi Ikeda and Fujio Kurokawa Panasonic Co. Ltd., Japan; Nagasaki Institute of Applied Science, Japan	
<b>Multi-Port Isolated LLC Resonant Converter for Distributed Energy Generation with Energy Storage .....</b>	<b>2219</b>
Kevin Tomas-Manez, Zhe Zhang and Ziwei Ouyang Technical University of Denmark, Denmark	
<b>A New PWM Shoot-through Control Technique to Reduce Switching Losses in Impedance Source DC/DC Converters .....</b>	<b>2227</b>
Yuba Raj Kafle, Saad UI Hasan and Graham E. Town Macquarie University, Australia	
<b>An Isolated High-Voltage High-Frequency Pulsed Power Converter for Non-Thermal Plasma Ozone Generation .....</b>	<b>2232</b>
Changqi You, Mengqi Wang and Jin Ye University of Michigan-Dearborn, United States; San Francisco State University, United States	
<b>Evaluation of Isolated DC/DC Converter Topologies for Future HVDC Aerospace Microgrids .....</b>	<b>2238</b>
Luca Tarisciotti, Alessandro Costabeber, Chen Linglin, Adam Walker and Mikael Galea University of Nottingham, United Kingdom	
<b>High-Efficiency High-Bandwidth Switch-Linear Hybrid Envelope-Tracking Power Supply with Slew Rate Split-Band Method .....</b>	<b>2246</b>
Yang Leng, Xinbo Ruan, Qian Jin and Yazhou Wang Nanjing University of Aeronautics and Astronautics, China	

<b>Quadratic Gain Converter with Output Voltage Ripple Mitigation .....</b>	<b>2253</b>
Pedro Martin Garcia-Vite, Jesus Elias Valdez-Resendiz, Jonathan Carlos Mayo-Maldonado, Julio Cesar Rosas-Caro, Maria del Rosario Rivera-Espinosa and Antonio Valderrabano-Gonzalez <i>Instituto Tecnológico de Ciudad Madero, Mexico; Tecnológico de Monterrey, Mexico; Universidad Panamericana Guadalajara, Mexico</i>	
<b>High Efficient Multiple-Input Positive Buck-Boost Converter .....</b>	<b>2260</b>
Jeongtae Kim and Sungwoo Bae <i>Yeungnam University, Korea; Hanyang University, Korea</i>	
<b>Dual Bridge LLC Resonant Converter with Frequency Adaptive Phase-Shift Modulation Control for Wide Voltage Gain Range .....</b>	<b>2265</b>
S.M. Showbul Islam Shakib, Saad Mekhilef and Mutsuo Nakaoka <i>University of Malaya, Malaysia</i>	
<b>Multiple-input Soft-switching Ćuk Converter .....</b>	<b>2272</b>
Zhuoya Sun and Sungwoo Bae <i>Yeungnam University, Korea; Hanyang University, Korea</i>	
<b>Session 64: PV Applications</b>	
<b>Chair(s): Sonny Xue, Qin Lei</b>	
<b>Powerline Communications Strategy Enabling Fully Decentralized Control of AC-Stacked PV Inverters .....</b>	<b>2277</b>
Daniel Evans and Robert Cox <i>University of North Carolina at Charlotte, United States</i>	
<b>A Simultaneous Voltage and Frequency Control Scheme for Photovoltaic Distributed Generation Units in Small-Scale Power Systems .....</b>	<b>2285</b>
Hossein Saberi and Shahab Mehraeen <i>Louisiana State University, United States</i>	
<b>Performance and Mitigation Strategy of Distributed AC-Stacked PV Inverter Architecture under Grid Background Harmonics .....</b>	<b>2291</b>
Namwon Kim, Hamidreza Jafarian, Babak Parkhideh and Johan Enslin <i>University of North Carolina at Charlotte, United States; Clemson University, South Africa</i>	
<b>An Analog MPPT Controller without Multiplier for PV Applications based on Improved P&amp;O Method .....</b>	<b>2296</b>
Chenxi Wang, Min Chen, Xinghua Zhang and Mingzhi Gao <i>Zhejiang University, China</i>	
<b>An Integrated Single Inductor-Single Sensor based Photovoltaic Optimizer with an Optimal Current Point Tracking Strategy .....</b>	<b>2301</b>
Tianhua Zhu, Xinlu He, Tong Guan, Feng Wang, Hao Yi and Fang Zhuo <i>Xi'an Jiaotong University, China</i>	
<b>A Regulated Incremental Conductance (r-INC) MPPT Algorithm for Photovoltaic System .....</b>	<b>2305</b>
Thusitha Randima Wellawatta, Young-Tae Seo, Hong-Hee Lee and Sung-Jin Choi <i>University of Ulsan, Korea</i>	

**Dynamic Equivalent Circuit Modelling of Polycrystalline Silicon Photovoltaic Cells ..... 2310**

Olufemi I. Olayiwola and Paul S. Barendse  
University of Cape Town, South Africa

**Modular Cascaded Converter for MVDC-Connected Photovoltaic Systems ..... 2318**

Zheng Fan, Guangyao Qiao, Guangfu Ning and Liangcai Shu  
Global Energy Interconnection Research Institute, China; Southeast University, China

**An Efficient Ramp Rate and State of Charge Control for PV-Battery System Capacity Firming ..... 2323**

Amit Kumar Bhattacharjee, Issa Batarseh, Haibing Hu and Nasser Kutkut  
University of Central Florida, United States; Advanced Charging Technologies, United States

**Analysis of an Interleaved Current-Fed Capacitor-Less DC/AC Converter for PV Systems ..... 2330**

Yue Zhang, Zheng Wang and Ming Cheng  
Southeast University, China

**Session 65: EMI in Power Converters**

Chair(s): Khurram Afridi, Yaow-Ming Chen

**A Galvanic Isolated Voltage Probe for Noise Sources Identification in EMI / EMC Applications ..... 2336**

Zhuxian Xu, Chingchi Chen and Richard Kautz  
Ford Motor Company, United States

**Common Mode EMI Reduction Structure of EV/HEV Inverters for High-Speed Switching ..... 2341**

Akinori Okubo, Kraisorn Throngnumchai and Tetsuya Hayashi  
Nissan Motor Co., Ltd., Japan

**A Layout Method of Passive EMI Filter ..... 2346**

Junpeng Ji, Wenjie Chen, Xu Yang, Xingxia Zhang and Na Zhi  
Xi'an Jiaotong University, China; Xi'an University of Technology, China

**Magnetic Material Selection for EMI Filters ..... 2350**

Marcin Kacki, Marek S. Rylko, John G. Hayes and Charles R. Sullivan  
SMA Magnetics Sp. z o.o., Poland; University College Cork, Ireland; Dartmouth College, United States

**Session 66: Advances in Special Electrical Machines**

Chair(s): Greg Heins, Dan Ionel

**A High Voltage Pulsed Power Supply with Reduced Device Voltage Stress for Industrial Electrostatic Precipitators ..... 2357**

Ming Tang, Liangcai Shu, Guangyao Qiao, Guangfu Ning, Wu Chen, Xiaohui Qu and Baojian Ji  
Southeast University, China; Global Energy Interconnection Research Institute, China; Nanjing University of Technology, China

**Novel Reluctance Axis Shifted Machines with Hybrid Rotors ..... 2362**

Hui Yang, Ya Li, Heyun Lin, Z.Q. Zhu, Shukang Lyu, Haitao Wang, Shuhua Fang and Yunkai Huang  
Southeast University, China; University of Sheffield, United Kingdom

**Electromagnetic Design of an Ultra-High Speed Switched Reluctance Machine over 1 Million RPM .... 2368**

Cheng Gong and Thomas Habetler  
Georgia Institute of Technology, United States

<b>Research on the Influence of Rotor Poles Number on Performances of Rotor Permanent-Magnet Flux-Switching Machines .....</b>	<b>2374</b>
Peng Su, Wei Hua, Chuang Hou and Mingjin Hu Southeast University, China	
<b>Wirelessly Powered Coil-Type Robot with 1D Self-Actuation Capability .....</b>	<b>2382</b>
Jun Lee and Jung-Ik Ha Seoul National University, Korea	
<b>A Switched Elastance Electrostatic Machine Constructed from Sustainable Elements for Rotational Actuators .....</b>	<b>2389</b>
Graham Reitz, Bill Butrymowicz, Justin Reed, Baoyun Ge and Daniel C. Ludois C-Motive Technologies Inc., United States; University of Wisconsin-Madison, United States	
<b>A dq-Axis Framework for Electrostatic Synchronous Machines and Charge Oriented Control .....</b>	<b>2396</b>
Baoyun Ge, Aditya N. Ghule and Daniel C. Ludois University of Wisconsin-Madison, United States	
<b>Session 67: Induction and Permanent Magnet AC Machines</b>	
<b>Chair(s): Dong Jiang, Kyo-Beum Lee</b>	
<b>State-Space Space-Vector Model of the Induction Motor Including Magnetic Saturation and Iron Losses .....</b>	<b>2404</b>
Marcello Pucci ISSIA-CNR, Italy	
<b>The Rotor Copper and Iron Loss Analysis of the Inverter-Fed Induction Motor Considering Rotor Slip Frequency .....</b>	<b>2412</b>
Dongdong Zhang, Haisen Zhao and Thomas Wu Xian Jiaotong University, China; North China Electric Power University, China; University of Central Florida, United States	
<b>GA-based Off-Line Parameter Estimation of the Induction Motor Model Including Magnetic Saturation and Iron Losses .....</b>	<b>2420</b>
Angelo Accetta, Francesco Alonge, Maurizio Cirrincione, Filippo D'Ippolito, Marcello Pucci and Antonino Sferlazza ISSIA-CNR, Italy; University of Palermo, Italy; University of South Pacific, Fiji; CNRS, LAAS, France	
<b>Simplified Equivalent Model of PMSM with Inter-Turn Fault .....</b>	<b>2427</b>
Seung-Tae Lee and Jin Hur Incheon National University, Korea	
<b>Analysis of Cogging Torque and Torque Ripple according to Unevenly Magnetized Permanent Magnets Pattern in PMSM .....</b>	<b>2433</b>
Dong-ho Lee, Chae-lim Jeong and Jin Hur Incheon National University, Korea	
<b>Optimized Design of PMSM with Hybrid Type Permanent Magnet for Improving Performance and Reliability .....</b>	<b>2439</b>
Chae-Lim Jeong, Young-Kyoun Kim and Jin Hur Incheon National University, Korea; Osan University, Korea	

**Reluctance Magnetic Gear and Flux Switching Magnetic Gear for High Speed Motor System ..... 2445**

Kohei Aiso, Kan Akatsu and Yasuaki Aoyama

Shibaura Institute of Technology, Japan; Hitachi, Ltd., Japan

**Influence of Gear Ratio on Electromagnetic Performance and Geometries of Vernier Permanent Magnet Synchronous Machines ..... 2453**

Yue Liu and Z.Q. Zhu

University of Sheffield, United Kingdom

**A Family of Vernier Permanent Magnet Machines Utilizing an Alternating Rotor Leakage Flux Blocking Design ..... 2461**

Wenbo Liu and Thomas A. Lipo

University of Wisconsin-Madison, United States

**Session 68: Motor Drives II****Chair(s): Giovanna Oriti, Ziaur Rahman****A Novel Active Common-Noise Canceler Combining Feedforward and Feedback Control ..... 2469**

Shunsuke Ohara, Satoshi Ogasawara, Takemoto Masatsugu, Koji Orikawa and Yushin Yamamoto

Hokkaido University, Japan; Toshiba Mitsubishi-Electric Industrial Systems Corporation, Japan

**Harmonics Performance and System Stability Evaluation between 18-Pulse and LCL Filter Based Active Front End Converters under Weak Grid Condition ..... 2476**

Kevin Lee, Wenxi Yao, Daniel Carnovale and Yuxi Huang

Eaton Corporation, United States; Zhejiang University, China

**Harmonic Analysis of a Regulated DC Voltage Space Vector Modulation Technique for High Speed Electrical Drives ..... 2484**

Vito Giuseppe Monopoli, Pierluigi Sidella and Francesco Cupertino

Politecnico di Bari, Italy

**Distributed Speed Control for Multi-Three Phase Electrical Motors with Improved Power Sharing Capability ..... 2492**

A. Galassini, A. Costabeber, C. Gerada and A. Tessarolo

University of Nottingham, United Kingdom; University of Trieste, Italy

**Single-Stage Soft-Switching Solid-State Transformer for Bidirectional Motor Drives ..... 2498**

Liran Zheng, Rajendra Prasad Kandula, Karthik Kandasamy and Deepak Divan

Georgia Institute of Technology, United States

**Session 69: Switching Devices II****Chair(s): Ruxi Wang, Xiaoqing Song****Aging Precursors and Degradation Effects of SiC-MOSFET Module under Highly Accelerated Power Cycling Conditions ..... 2506**

Haoze Luo, Francesco Iannuzzo, Frede Blaabjerg, Marcello Turnaturi and Emilio Mattiuzzo

Aalborg University, Denmark; Vishay Semiconductor Italiana, Italy

**A Measurement Method to Extract the Transient Junction Temperature Profile of Power Semiconductors at Surge Conditions ..... 2512**

Yu Du, Rostan Rodrigues and Taosha Jiang

ABB Inc., United States

<b>Lifetime Extension of a Multi-Die SiC Power Module using Selective Gate Driving with Temperature Feed-Forward Compensation .....</b>	<b>2520</b>
Jeffrey Ewanchuk, Julio Brandelero and Stefan Mollov Mitsubishi Electric Research Centre Europe, France	
<b>Degradation of SiC MOSFETs with Gate Oxide Breakdown under Short Circuit and High Temperature Operation .....</b>	<b>2527</b>
Vamsi Mulpuri and Seungdeog Choi University of Akron, United States	
<b>The Effect of Load Properties on the Reliability of Machine Drives – The Temperature and Stress Analysis of Power Module Bond Wires .....</b>	<b>2533</b>
He Niu General Motors Co., United States	
<b>Power Cycling Test of a 650 V Discrete GaN-on-Si Power Device with a Laminated Packaging Embedding Technology .....</b>	<b>2540</b>
Sungyoung Song, Stig Munk-Nielsen, Christian Uhrenfeldt and Kjeld Pedersen Aalborg University, Denmark	
<b>Gate Driver Design for a High Power Density EV/HEV Traction Drive using Silicon Carbide MOSFET Six-Pack Power Modules .....</b>	<b>2546</b>
Rui Gao, Li Yang, Wensong Yu and Iqbal Husain North Carolina State University, United States	
<b>Isolation Design Considerations for Power Supply of Medium Voltage Silicon Carbide Gate Drivers .....</b>	<b>2552</b>
Tushar Batra, Ghanshyam Gohil, Arun Kumar Sesham, Nicholas Rodriguez and Subhashish Bhattacharya North Carolina State University, United States	
<b>An Intelligent Medium Voltage Gate Driver with Enhanced Short Circuit Protection Scheme for 10kV 4H-SiC MOSFETs .....</b>	<b>2560</b>
Ashish Kumar, Aishwarya Ravichandran, Shrishti Singh, Suyash Shah and Subhashish Bhattacharya North Carolina State University, United States	
<b>Impact of Gate Control on Short-Circuit Capability of SiC/Si based Hybrid Switch .....</b>	<b>2567</b>
Xi Jiang, Jun Wang, Zongjian Li, Linfeng Deng, Jiwu Lu, Xiaohao Wang, Cheng Zeng and Z. John Shen Hunan University, China	
<b>Session 70: Wireless Power Transfer</b>	
<b>Chair(s): Mark J Scott, Jin Wang</b>	
<b>A Phase-Shift Soft-Switching Control Strategy for Dual Active Wireless Power Transfer System ....</b>	<b>2573</b>
Fenghua Liu, Wanjun Lei, Tengbo Wang, Cheng Nie and Yue Wang Xi'an Jiaotong University, China	
<b>Modeling and Experimentation of Multi-Coil Switching Coupler for Wireless Power Transfer Systems .....</b>	<b>2579</b>
Pingan Tan, Chunxia Liu, Liangwei Ye and Tao Peng Xiangtan University, China	

<b>Analysis and Optimization of 3-Coil Magnetically Coupled Resonant Wireless Power Transfer System for Stable Power Transmission .....</b>	<b>2584</b>
Weiwei Ye, Lu Chen, Fuxin Liu, Xuling Chen and Xuehua Wang Nanjing University of Aeronautics and Astronautics, China; Huazhong University of Science and Technology, China	
<b>A Double-Frequency Superposition Methodology for High Efficiency and Oriented Power Distribution of MCR WPT System with Two Receivers .....</b>	<b>2590</b>
Yong Yang, Ze Ding, Fuxin Liu and Xuling Chen Nanjing University of Aeronautics and Astronautics, China	
<b>Resonant Converter with Coupling and Load Independent Resonance for Omnidirectional Wireless Power Transfer Application .....</b>	<b>2596</b>
Junjie Feng, Minfan Fu, Qiang Li and Fred C. Lee Virginia Polytechnic Institute and State University, United States	
<b>ANN-based Algorithm for Estimation and Compensation of Lateral Misalignment in Dynamic Wireless Power Transfer Systems for EV Charging .....</b>	<b>2602</b>
Reza Tavakoli and Zeljko Pantic Utah State University, United States	
<b>Comparative Evaluation of Secondary-Side ZVS-PWM Controlled GaN-HFET Resonant Converters for Inductive Power Transfer .....</b>	<b>2610</b>
Tomokazu Mishima and Eitaro Morita Kobe University, Japan	
<b>Session 71: DC and Hydrid AC/DC Systems</b>	
Chair(s): Meiqin Mao, Adel Nasiri	
<b>Coordinated Control and Optimization of DC Power Systems .....</b>	<b>2618</b>
Bhanu Babaiahgari, Md. Habib Ullah and Jae-Do Park University of Colorado-Denver, United States	
<b>Controller Design of DC Microgrids with Multiple Sources and Constant Power Loads .....</b>	<b>2625</b>
Luis Herrera, Benjamin Palmer, Xiu Yao and Bang-Hung Tsao Rochester Institute of Technology, United States; University of Cincinnati, United States; University at Buffalo, United States; University of Dayton Research Institute, United States	
<b>A Study on High-Efficiency Floating Multi-Terminal Power Flow Controller for Next-Generation DC Power Networks .....</b>	<b>2631</b>
Kenji Natori, Toru Tanaka, Yoshinori Takahashi and Yukihiko Sato Chiba University, Japan	
<b>Operational Cost Reduction Based on Distributed Adaptive Droop Control Technique in DC Microgrids .....</b>	<b>2638</b>
Mohamed Zaery, Emad M. Ahmed, Mohamed Orabi and Mohamed Youssef Aswan University, Egypt; University of Ontario Institute of Technology, Canada	
<b>Hurst Exponent-based Adaptive Detection of DC Arc Faults .....</b>	<b>2645</b>
Yousef Abdullah, Boxue Hu, Wei Zhou, Yafeng Wang, Jin Wang and Amin Emrani Ohio State University, United States; Ford Motor Company, United States	

## **Session 72: Applications of MMC**

**Chair(s): Dianguo Xu, Maryam Saeedifard**

**Impact of DC Fault in Multi-Terminal DC Grid on Connected AC System Stability ..... 2651**

Shuotong Zhang, Yalong Li and Fred Wang  
University of Tennessee, United States

**Analysis of Single-Phase-to-Ground Faults at the Valve-Side of HB-MMCs in Bipolar HVDC Systems ..... 2659**

Gen Li, Jun Liang, Fan Ma, Carlos E. Ugalde-Loo, Haifeng Liang and Hui Li  
Cardiff University, United Kingdom; Naval University of Engineering, China; North China Electric Power University, China; Beijing Information Science & Technology University, China

**Feedback Linearization Applicable to the State-Space Modelling of an HVDC Terminal based on Modular Multilevel Converter ..... 2666**

Diego A. Montoya-Acevedo, Julian C. Buitrago-Herrera and Andres Escobar-Mejia  
Universidad Tecnológica de Pereira, Columbia

**Simulation of Modular Multilevel Converter and DC Grids on FPGA with Sub-Microsecond Time-Step ..... 2673**

Hui Pang, Fei Zhang, Hailong Bao, Géza Joós, Weihua Wang, Wei Li, Luc-Andre Gregoire and Xuebing Zhai  
Global Energy Interconnection Research Institute, China; McGill University, Canada; State Grid Shanghai Municipal Electric Power Co., China; OPAL-RT Technologies Inc., Canada

**Interactions between Bandwidth Limited CPLs and MMC based MVDC Supply ..... 2679**

Uzair Javaid, Alexandre Christe, Francisco D. Freijedo and Drazen Dujic  
EPFL, Switzerland

**Medium-Voltage DC Grid Connection using Modular Multilevel Converter ..... 2686**

Seyyedmahdi Jafarishiadeh, Mehdi Farasat and Arash Khoshkbar Sadigh  
Louisiana State University, United States; Extron Electronics, United States

**A Power Hardware-in-the-Loop-Simulation (P-HILS) System using Two Modular Multilevel DSCC Converters for a Synchronous-Motor Drive ..... 2692**

Kenichiro Saito and Hirofumi Akagi  
Tokyo Institute of Technology, Japan

**Switching Function based Analysis of the Modular Multilevel Converter for Low/Medium Voltage Applications ..... 2700**

Josiah O. Haruna, Olorunfemi Ojo and Rere Fatumbi  
Tennessee Technological University, United States

**Fast Control of a Modular Multilevel Converter STATCOM using Optimized Pulse Patterns ..... 2707**

Vedrana Spudić and Tobias Geyer  
ABB Corporate Research Center, Switzerland

**A Modular Multilevel Converter with Isolated Energy-Balancing Modules for MV Drives Incorporating Symmetrical Six-Phase Machines ..... 2715**

Mohamed S. Diab, B.W. Williams, Derrick Holliday, Ahmed M. Massoud and Shehab Ahmed  
University of Strathclyde, United Kingdom; Qatar University, Qatar; Texas A&M University at Qatar, Qatar

## **Session 73: Batteries and Wireless EV Charging**

**Chair(s): Veda Prakash Galigekere, Jin Ye**

**A Star-Structured Switched-Capacitor Equalizer for Series-Connected Battery Strings ..... 2723**

Yunlong Shang, Bing Xia, Fei Lu, Chenghui Zhang, Naxin Cui, Chunyu Wang and Chris Mi

*Shandong University, China; San Diego State University, United States; University of California-San Diego, United States*

**A Multiplexing LCL Module using Individual Transmitters for Dynamic Wireless Charging of Electric Vehicles ..... 2728**

Shaocong Zhou, Chunbo Zhu, Chunlai Yu and C.C. Chan

*Harbin Institute of Technology, China; Heilongjiang Electric Power Research Institute, China*

**Robust Double D Topology for Roadway IPT Applications ..... 2734**

Matthew G.S. Pearce, Hanyu Gao, Amrit Ramadugu, Grant A. Covic and John T. Boys

*University of Auckland, New Zealand*

**A Sorting Balance Control for Battery Sources in a Single Phase Multilevel Inverter ..... 2742**

Chun-Yu Yang, Yaow-Ming Chen and Kai-Cheung Juang

*National Taiwan University, Taiwan; Industrial Technology Research Institute, Taiwan*

**Active Cell Balancing Algorithm for Serially Connected Li-Ion Batteries based on Power to Energy Ratio ..... 2748**

Geon-Hong Min and Jung-Ik Ha

*Seoul National University, Korea*

**Battery Impedance Measurement using Sinusoidal Ripple Current Emulator ..... 2754**

Md. Kamal Hossain, S.M. Rakul Islam and Sung-Yeul Park

*University of Connecticut, United States*

**A New Magnetic Coupler for EVs Chargers based on Plug-In and IPT Technologies ..... 2760**

Emanuel G. Marques, Sandra V. da Silva and A.M.S. Mendes

*University of Coimbra/Instituto de Telecomunicações, Portugal*

**Sensorless Estimation of Coupling Coefficient based on Current and Voltage Harmonics Analysis for Wireless Charging System ..... 2767**

Mostak Mohammad and Seungdeog Choi

*University of Akron, United States*

**High Power Density Z-Source Resonant Wireless Charger with Line Frequency Sinusoidal Charging ..... 2773**

Hulong Zeng, Xiaorui Wang and Fang Zheng Peng

*Michigan State University, United States*

## **Session 74: AC/DC Converters**

**Chair(s): Wuhua Li, Praveen Jain**

**Investigation of Power Rectifier under Non-Sinusoidal Input based on Hybrid Multilevel Converter ... 2779**

Alan Felinto, Cursino B. Jacobina, Edgard L.L. Fabricio, Victor F.M.B. Melo and João P.R.A. Mello

*Federal University of Campina Grande, Brazil; Federal Institute of Paraíba, Brazil; Federal Institute of Pernambuco, Brazil*

<b>Series Connected Three-Phase AC-DC Power Converters .....</b>	<b>2787</b>
Reuben P.R. Sousa, Cursino B. Jacobina and Luciano M. Barros <i>Universidade Federal de Campina Grande, Brazil; Universidade Federal de Sergipe, Brazil</i>	
<b>A Novel Filter Structure to Suppress Harmonic Currents based on the Sequence of Sideband Harmonics .....</b>	<b>2795</b>
Sungjae Ohn, Hyun-Sam Jung and Seung-Ki Sul <i>Virginia Polytechnic Institute and State University, United States; Seoul National University, Korea</i>	
<b>Asymmetrical Cascaded Three-Phase AC-DC Converters with Injection Transformers .....</b>	<b>2803</b>
Joao Paulo R.A. Mello and Cursino B. Jacobina <i>Federal University of Campina Grande, Brazil</i>	
<b>Voltage Independence Control of Split-DC Bus for a Three-Phase/Level T-Type Converter with Unbalanced Loads .....</b>	<b>2811</b>
Wenlong Ding, Jiajun Liu, Bin Duan, Xiangyang Xing and Chenghui Zhang <i>Shandong University, China</i>	
<b>Single-Stage AC-DC Converters Operating with a Resonant Network and Discrete Switching Frequency .....</b>	<b>2817</b>
Javad Khodabakhsh and Gerry Moschopoulos <i>Western University, Canada</i>	
<b>Capacitor-Isolated Structure with Brightness and Color Controlling for Multicolor LED Strings .....</b>	<b>2823</b>
Ruihong Zhang, Henry Shu-hung Chung, Xuanlyu Wu, Xiaohua Wu, Xiaobin Zhang and Jinrong Wang <i>Northwestern Polytechnical University, China; City University of Hong Kong, Hong Kong</i>	
<b>Session 75: Modeling and Control of Multilevel Converters</b>	
<b>Chair(s): S. Ali Khajehhosseni, Rostan Rodrigues</b>	
<b>An Optimized Neutral-Point Potential Balancing Algorithm for Seven-Level ANPC Inverters .....</b>	<b>2831</b>
Weihui Sheng and Qiongxuan Ge <i>University of Chinese Academy of Sciences, China; Institute of Electrical Engineering, CAS, China</i>	
<b>A Model Predictive Control based Fault-Tolerant Control Strategy for T-Type Three-Level Inverters ...</b>	<b>2839</b>
Jie Chen, Alian Chen, Chenghui Zhang and Ke Li <i>Shandong University, China</i>	
<b>A Repetitive Control Scheme for Circulating Current Suppression in Parallel Three-Level T-Type Inverters under Unbalanced Conditions .....</b>	<b>2846</b>
Changwei Qin, Alian Chen, Xiangyang Xing, Chunshui Du, Guangxian Zhang, Chenghui Zhang and Wenlong Ding <i>Shandong University, China</i>	
<b>Low Frequency Operation and Comparison Study of 4-Level Hybrid Clamped Converter with Modular Multilevel Converter .....</b>	<b>2852</b>
Jianyu Pan, Risha Na and Longya Xu <i>Ohio State University, United States</i>	
<b>Control of the Hybrid Cascaded Converter under Unbalanced Conditions .....</b>	<b>2858</b>
Yu-chen Su, Ping-heng Wu and Po-tai Cheng <i>National Tsing Hua University, Taiwan</i>	

<b>Active Neutral-Point Clamped Five-Level Inverter General Modulation based on Phase-Disposition .....</b>	<b>2866</b>
Fusheng Wang, Zhen Li, Yilin Lyu, Hang Fu, Fei Li and Hieu Thanh Do Hefei University of Technology, China; Hung Yen University of Technology and Education, Viet Nam	
<b>Mixed Single-Phase Three-Level NPC Inverter with Hybrid Modulation Technology .....</b>	<b>2873</b>
Liming Liu ABB Corporate Research Center, United States	
<b>Session 76: Modeling and Control of Grid Connected Converters</b>	
<b>Chair(s): Jiacheng Wang, Kyo-Beum Lee</b>	
<b>Flexible Power Control of Virtual Synchronous Generators under Unbalanced Grid Voltage Conditions .....</b>	<b>2881</b>
Meng Chen, Xiangning Xiao, Chang Yuan and Shun Tao North China Electric Power University, China	
<b>Visualization Analysis of Grid-Connected Inverter System based on Z-Domain D-Partition Method .....</b>	<b>2889</b>
Fei Li, Jizhong Xi, Haoyuan Li, Mingyao Ma, Wenxiang Zhou, Peng Liu and Fan Wu Hefei University of Technology, China	
<b>Systematic Control Design for Half-Bridge Converters with LCL Output Filters through Virtual Circuit Similarity Transformations .....</b>	<b>2895</b>
Korawich Niyomsatian, Piet Vanassche, Ruth V. Sabariego and Johan Gyselinck KU Leuven, Belgium; Université libre de Bruxelles, Belgium; Triphase NV, Belgium	
<b>State Estimation of IEEE 14 Bus with Unified Interphase Power Controller (UIPC) using WLS Method .....</b>	<b>2903</b>
Mohammad Amin Chitsazan, Mohammad Sami Fadali and Andrzej M. Trzynadlowski University of Nevada, United States	
<b>Control of a Three-Phase Inverter under Unbalanced Grid Conditions .....</b>	<b>2909</b>
Vikram Roy Chowdhury, Subhajyoti Mukherjee, Pourya Shamsi and Mehdi Ferdowsi Missouri University of Science and Technology, United States	
<b>Three-Phase Short-Circuit Fault Implementation in Converter based Transmission Line Emulator .....</b>	<b>2914</b>
Shuoting Zhang, Bo Liu, Sheng Zheng, Yiwei Ma, Fred Wang and Leon M. Tolbert University of Tennessee, United States	
<b>Impedance-Phase Reshaping of LCL-filtered Grid-Connected Inverters to improve the Stability in a Weak Grid .....</b>	<b>2921</b>
Yan Du, Linbo Cui, Xiangzhen Yang, Jianhui Su and Fei Wang Hefei University of Technology, China; Shanghai University, China	
<b>A Control Method to Mimic Synchronous Generator Characteristics for Two-Stage Converters .....</b>	<b>2927</b>
Jun Zhu, Feng Gao, Xifeng Liu and Jing Xiao Shandong University, China; Shandong Electric Power Maintenance Company, China	
<b>Study on the Inertia Optimization of Grid-friendly Single-Phase Synchronverter .....</b>	<b>2934</b>
Hong Li, Xiaochao Zhang, Tiancong Shao and Trillion Q. Zheng Beijing Jiaotong University, China	

<b>Predictive Frequency-based Sequence Estimator for Control of Grid-Tied Converters under Highly Distorted Conditions .....</b>	<b>2940</b>
Cristian Blanco, Pablo García, Ángel Navarro-Rodríguez and Mark Sumnery University of Oviedo, Spain; University of Nottingham, United Kingdom	
<b>Single-Loop All-Pass-Filter-based Active Damping for VSCs with LCL Filters Connected to the Grid ...</b>	<b>2948</b>
Javier Roldán-Pérez , Emilio Bueno, R. Peña-Alzola, and Alberto Rodríguez-Cabero IMDEA Energy Institute, Spain; Alcalá de Henares University, Spain; University of Strathclyde, United Kingdom	
<b>Session 77: Power Quality</b>	
<b>Chair(s): Xiaoqiang Guo, Feng Gao</b>	
<b>Single-Phase Universal Active Power Filter based on Four-Leg AC/DC/AC Converters .....</b>	<b>2954</b>
Phelipe L.S. Rodrigues, Cursino B. Jacobina, Mauricio B.R. Correa and Italo Roger F.M.P. da Silva Federal University of Campina Grande, Brazil; Federal Rural University of Pernambuco, Brazil	
<b>A Transformer-Less Unified Power Quality Conditioner having Fast Dynamic Control .....</b>	<b>2962</b>
Sui-pung Cheung, Shun-cheung Yeung, Shu-hung Chung, Wai-lun Lo and Weimin Wu City University of Hong Kong, Hong Kong; Chu Hai College of Higher Education, Hong Kong; Shanghai Maritime University, China	
<b>Application of Singular Value Sensitivity on Harmonic Resonance Analysis for Inverter-based Power Systems .....</b>	<b>2969</b>
Zhikang Shuai, Yang Li, John Shen and Yi Hong Hunan University, China; Illinois Institute of Technology, United States	
<b>Harmonics Compensation with Constant DC-Capacitor Voltage-Control-based Strategy of Smart Charger for Electric Vehicles in Single-Phase Three-Wire Distribution Feeders under Distorted Source Voltages and Load Currents Conditions .....</b>	<b>2975</b>
Fuka Ikeda, Kei Nishikawa, Yuki Okamoto, Hiroaki Yamada, Toshihiko Tanaka and Masayuki Okamoto Yamaguchi University, Japan; Ube College, Japan	
<b>Power Quality Improvement Utilizing Photovoltaic Generation Connected to a Weak Grid .....</b>	<b>2983</b>
Hanny H. Tumbelaka, Eduard Muljadi and Wenzhong Gao Petra Christian University, Indonesia; National Renewable Energy Laboratory (NREL), United States; University of Denver, United States	
<b>A New Control Scheme based on R-APF for Harmonic Power Sharing in Islanded Microgrids .....</b>	<b>2991</b>
Zhirong Zeng, Hao Yi, Fang Zhuo and Zhenxiong Wang Xi'an Jiaotong University, China	
<b>Performance Evaluation of Shunt-Series Switched Multi-Functional Grid-Connected Inverter for Voltage Regulation .....</b>	<b>2996</b>
Wooyoung Choi, Woongkul Lee and Bulent Sarlioglu University of Wisconsin-Madison, United States	
<b>A Grid-Voltage-Sensorless Resistive Active Power Filter with Series LC-Filter .....</b>	<b>3004</b>
Haofeng Bai, Xiongfei Wang and Frede Blaabjerg Aalborg University, Denmark	

## **Session 78: Stability of Converter Systems**

**Chair(s): Jian Sun, Xiongfei Wang**

**A Comprehensive Study on the Gate-Loop Stability of the SiC MOSFET .....** 3012

Xudong Wang, Zhengming Zhao, Yicheng Zhu, Kainan Chen and Liqiang Yuan  
Tsinghua University, China

**Flexible PFC Control Featuring Adaptive Gain, Mode Estimation, and Dual Feedforward Compensation .....** 3019

Joshua Ivaldi and Sung-Yeul Park  
University of Connecticut, United States

**A Stability Analysis Method based on Floquet Theory for Multi-stage DC-DC Converters System .....** 3025

Hong Li, Zhongya Guo, Fang Ren, Xiaochao Zhang and Bo Zhang  
Beijing Jiaotong University, China; South China University of Technology, China

**Stability Enhancement of Single-Loop Inverter-Side Current Feedback Controlled Grid-Connected Inverters with LCL Filters .....** 3030

Teng Liu, Zeng Liu, Jinjun Liu, Yiming Tu and Zipeng Liu  
Xi'an Jiaotong University, China

**Design of Online Supplementary Adaptive Dynamic Programming for Current Control in Power Electronic Systems .....** 3038

Ujjwal Tamrakar, Naresh Malla, Dipesh Shrestha, Zhen Ni and Reinaldo Tonkoski  
South Dakota State University, United States

**A Comparative Benchmark of Digital Delay Compensation Techniques based on a Graphical Approach .....** 3044

Minghui Lu, Xiongfei Wang, Poh Chiang Loh, Tomislav Dragicevic and Frede Blaabjerg  
Aalborg University, Denmark

## **Session 79: Other Topics in Control, Modeling and Optimization of Power Converters**

**Chair(s): Luca Solero, Grant Pitel**

**Control of a Single Phase Inverter with Multiple Modulation Strategies based on Plant Inversion .....** 3049

R. Ramos, D. Serrano, J.A. Oliver and J.A. Cobos  
Universidad Politecnica de Madrid, Spain

**Derivation of Transfer Function of LLC Current Resonant Converter using Numerical Calculation .....** 3056

Masahito Shoyama, Takuma Sagara, Yusuke Yamashita, Jun Imaoka, Yu Yonezawa and Yoshiyasu Nakashima  
Kyushu University, Japan; Fujitsu Laboratories Ltd., Japan

**FPGA-based Direct Repetitive Control for High Performance Ground Power Units .....** 3063

Alessandro Lidozzi, Luca Solero, Fabio Crescimbini, Chao Ji, Stefano Bifaretti and Pericle Zanchetta  
Roma Tre University, Italy; Protean Electric Ltd., United Kingdom; University of Roma Tor Vergata, Italy;  
University of Nottingham, United Kingdom

**Interleaved Hybrid Control Concept for Multiphase DC-DC Converters .....** 3069

Georgios Tsolaridis and Juergen Biela  
ETH Zurich, Switzerland

**Active Damping of Power Converters with Modular Basic Crossover Correction Cells ..... 3077**

V. Spinu, R.B. Dai, M. Lazar, J.L. Duarte  
Eindhoven University of Technology, Netherlands

**Training Neural-Network-based Controller on Distributed Machine Learning Platform for Power Electronics Systems ..... 3083**

Wenguan Wang, Henry Shu-hung Chung, Ralph Cheng, C.S. Leung, Xiaoqing Zhan, Alan Wai-lun Lo, J. Kwok, Chun Jason Xue and Jun Zhang  
City University of Hong Kong, Hong Kong; Chu Hai College of Higher Education, Hong Kong; Hong Kong University of Science and Technology, Hong Kong; South China University of Technology, China

**FPGA Implementation of a Real-Time Model Predictive Controller for Hybrid Power Systems ..... 3090**

Seyed Ata Raziei and Zhenhua Jiang  
University of Dayton, United States

**Equivalent Circuit Model for Modular High Voltage Power Generation Architectures ..... 3098**

Saijun Mao, Jelena Popovic, Jan Abraham Ferreira, Chengmin Li and Wuhua Li  
Delft University of Technology, Netherlands; Zhejiang University, China

**Improved Delayed Signal Cancellation-based SRF-PLL for Unbalanced Grid ..... 3103**

Tuomas Messo, Jussi Sihvo, Dongsheng Yang, Xiongfei Wang and Frede Blaabjerg  
Tampere University of Technology, Finland; Aalborg University, Denmark

**Session 80: Analysis Techniques in Electrical Machines**

Chair(s): Peter Wung, Wei Xu

**Numerical and Experimental Evaluation of Magnetostriction and Magnetic Forces on Transformer Stacks and Joints for the Assessment of Core Vibrations ..... 3111**

Jan Rens, Sigrid Jacobs, Maarten Van Poucke and Emmanuel Attrazic  
ArcelorMittal Global R&D, Belgium; ArcelorMittal Saint Chely d'Apcher, France

**Reliability Analysis of an Adaptive Third-Harmonic Differential Voltage Stator Ground Fault Protection Scheme using a Lab-Scale Generating Station ..... 3119**

Amir Negahdari, Khaled Al Jaafari, Hamid A. Tolaymat, Nader Safari-Shad and Russ Franklin  
Texas A&M University, United States; Petroleum Institute, United Arab Emirates; University of Wisconsin-Platteville, United States; Alliant Energy, United States

**An Improved Core-Loss Calculation Method for Doubly Salient Electromagnetic Motor ..... 3125**

Wanying Jia, Lan Xiao, Hongfei Wu and Deming Zhu  
Nanjing University of Aeronautics and Astronautics, China; Electronic Technology Institute, China

**Damper Current Analysis of Hydro-Generators Considering Interbar Currents ..... 3130**

Yang Zhan, Kangkang Kong, Guorui Xu and Haisen Zhao  
North China Electric Power University, China

**Active Cooling for On-Machine Device ..... 3137**

Xikai Sun, Paul J. Grosskreuz and Mark R. Cooper  
Rockwell Automation, China; Rockwell Automation, United States

**Improved Analytical Modeling of High Frequency Conductive Losses in Isolated Rectangular Conductor ..... 3145**

Xiaohui Wang, Li Wang, Ling Mao and Yaojia Zhang  
Nanjing University of Aeronautics and Astronautics, China

**Nonlinear Analytical Model of an Inductance Considering Saturation and Temperature Variation ..... 3150**

Hilmi Gurleyen, Erkan Mese, Ju Hyung Kim and Bulent Sarlioglu

Yildiz Technical University, Turkey; Ege University, Turkey; University of Wisconsin-Madison, United States

**Session 81: AC Electrical Machines: Performance Estimation**

Chair(s): Avoki Omekanda, Ronghai Qu

**Detection and Estimation of High-Resistance Connection for Inverter-Fed Permanent Magnet****Synchronous Machine Drives ..... 3155**

Jun Hang, Shichuan Ding, Hao Li and Qunjing Wang

Anhui University, China

**A Model-based Signal Processing Method for Fault Diagnosis in PMSM Machine ..... 3160**

Mehrdad Heydarzadeh, Mohsen Zafarani, Enes Ugur, Bilal Akin and Mehrdad Nourani

University of Texas at Dallas, United States

**Separation of Induction Motor Rotor Faults and Low Frequency Load Oscillations through the Radial Leakage Flux ..... 3165**

Taner Goktas, Muslum Arkan, M. Salih Mamis and Bilal Akin

Inonu University, Turkey; University of Texas at Dallas, United States

**Efficiency Estimation of Induction Machines using Nonintrusive No-Load Low Voltage Test ..... 3171**

M. Aminu, P. Barendse and A. Khan

University of Cape Town, South Africa

**Assembly Effects on Stator Cores of Small Synchronous Reluctance Motors ..... 3179**

Zbigniew Gmyrek and Andrea Cavagnino

Lodz University of Technology, Poland; Politecnico di Torino, Italy

**Analysis of Stator/Rotor Pole Combinations in Variable Flux Reluctance Machines using Magnetic Gearing Effect ..... 3187**

L.R. Huang, Z.Q. Zhu, J.H. Feng, S.Y. Guo, J.X. Shi and W.Q. Chu

Sheffield University, United Kingdom; CRRC Zhuzhou Institute Co. Ltd., China

**Methods for d-/q-Axis Saturation Stator-to-Rotor Mutual inductance of Salient-Pole Synchronous Machine ..... 3195**

Hongyu Wang

Ohio State University, United States

**Influence of Magnetoresistance and Temperature on Permanent Magnet Condition Estimation****Methods using High Frequency Signal Injection ..... 3201**

Daniel Fernandez Alonso, David Reigosa, Maria Martinez, Juan Guerrero and Fernando Briz

University of Oviedo, Spain

**Stator Inductance Estimation for Permanent Magnet Motors Using the PWM Excitation ..... 3208**

Ramakrishnan Raja, Tomy Sebastian, Mengqi Wang and Mazharul Chowdhury

Halla Mechatronics, United States; University of Michigan-Dearborn, United States

## **Session 82: Component Technologies**

**Chair(s): Ben Guo, Tsorng-Juu Liang**

**Reduction of the Parasitic Capacitance of a Power Inductor through Conductors Placement .....** 3215

Shushu Zhu, Xibo Yuan and Phil Mellor

Nanjing University of Aeronautics and Astronautics, China; University of Bristol, United Kingdom

**A Half-Turn Winding for Compact, High-Current, High-Turns-Ratio, Low-Leakage-Inductance Transformer .....** 3222

K.V. Iyer, M. Cai, D. Murthy-Bellur, B. Palmer and N. Mohan

Cummins Inc., United States; University of Minnesota, United States; Purdue University, United States

**Power Loss Evaluation for Active and Magnetic Components in a SiC MOSFET-based Power Electronic System .....** 3228

Yi Deng, Zach Pan, Harish Suryanarayana, Arun Kadavelugu, Liming Liu, Christopher Belcastro and Esa-Kai Paatero

ABB Corporate Research Center, United States; ABB Power Solutions, United States; ABB Oy, Finland

**A Method for Hotspot Temperature Estimation of Aluminum Electrolytic Capacitors .....** 3235

Holger Jedtberg, Giampaolo Buticchi, Marco Liserre and Huai Wang

Kiel University, Germany; Aalborg University, Denmark

**Effect of Conductive Magnetic Field Concentrators on the Performance of Anisotropic Magnetoresistors in High Frequency Contactless Current Sensing .....** 3242

Shahriar Jalal Nibir and Babak Parkhideh

University of North Carolina at Charlotte, United States

**Optimized Design for Three Port Transformer Considering Leakage Inductance and Parasitic Capacitance .....** 3247

Ritwik Chattopadhyay, Mark A. Juds, Ghanshyamsinh Gohil, Srinivas Gulur, Paul R. Ohodnicki and Subhashish Bhattacharya

North Carolina State University, United States; Eaton Corporate Research and Technology, United States; National Energy Technology Laboratory, United States

**A Tunable Inductor based on a Magnetic Flux Valve .....** 3255

Junwei Cui, Haosen Wang, Liyan Qu and Wei Qiao

University of Nebraska-Lincoln, United States

## **Session 83: Renewable Energy and Grid Integration**

**Chair(s): Dehong Mark Xu, Yilmaz Sozer**

**An Adaptive DC-Bus Stabilizer for Single-Phase Grid-Connected Renewable Energy Source System .....** 3260

Rong Zeng, Zhiqiang Wang and Madhu Sudhan Chinthavali

Oak Ridge National Laboratory, United States

**Phase Stability Enhancement in big Power Networks using Renewable Generation Units Controlled by SPC .....** 3266

Mostafa Abdollahi, Jose Ignacio Candela, Joan Rocabert, Raul Santiago Munoz Aguilar and Juan Ramon Hermoso

Technical University of Catalonia, Spain

**Single-Phase to Three-Phase Generation System based on Doubly-Fed Induction Generator .....** 3274  
Nady Rocha, Ítalo A. Cavalcanti de Oliveira, Edison Roberto Cabral da Silva and Cursino Brandao Jacobina

*Federal University of Paraíba, Brazil; Federal University of Campina Grande, Brazil*

**Wind Energy Conversion System based on DFIG with Series Grid Side Converter without Transformer .....** 3281  
Ítalo A. Cavalcanti de Oliveira, Nady Rocha, Edison Roberto Cabral da Silva, Luanna M. Silva de Siqueira,

Ely Cavalcanti de Menezes and Cursino Brandao Jacobina

*Federal University of Paraíba, Brazil; Federal University of Campina Grande, Brazil*

**Sensorless HCS MPPT Based Control Strategy for the DPF-WECS .....** 3289

Ying Zhu, Jun Hang, Haixiang Zang and Jingtao Zhao

*Hohai University, China; Anhui University, China; NARI Technology Development Co., Ltd., China*

**Impedance Modeling and Control of STATCOM for Damping Renewable Energy System Resonance .....** 3295

Yang Zhang, Xin Chen and Jian Sun

*Nanjing University of Aeronautics and Astronautics, China; Rensselaer Polytechnic Institute, United States*

**Modeling, Analysis and Parameters Design of Rotor Current Control in DFIG-based Wind Turbines for Dynamic Performance Optimizing .....** 3303

Yuanzhu Chang and Jiabing Hu

*Huazhong University of Science and Technology, China*

**Predictive Voltage Control of Direct Matrix Converter with Reduced Number of Sensors for the Renewable Energy and Microgrid Applications .....** 3309

Jianwei Zhang, Li Li, Zahra Malekjamshidi and David G. Dorrell

*University of Technology Sydney, Australia; University of KwaZulu-Natal, South Africa*

## **Wednesday, October 4**

### **Session 84: Wind Energy Systems**

**Chair(s): Dinesh Kumar, Wei Qiao**

**Field Excitation Scheme using a Machine-Side 4-Leg Converter in MW-Range WRSG Wind Turbine Systems .....** 3316

Yongsug Suh and Thomas A. Lipo

*Chonbuk National University, Korea; University of Wisconsin-Madison, United States*

**Modeling and Control of Interconnected Wind Turbine Drivetrains .....** 3324

Mohsen Farbood, Elaheh Taheran Fard, Mokhtar Sha-Sadeghi, Afshin Izadian and Taher Niknam

*Shiraz University of Technology, Iran; Purdue School of Engineering and Technology, United States*

**Medium Voltage Power Conversion Architecture for High Power PMSG based Wind Energy Conversion System (WECS) .....** 3329

Sayan Acharya, Samir Hazra, Kasunaidu Vechalapu and Subhashish Bhattacharya

*North Carolina State University, United States*

**A Universal Multiple-Vector-based Model Predictive Direct Power Control for Doubly Fed Induction Generators .....** 3337

Yongchang Zhang, Donglin Xu and Dong Jiang

*North China University of Technology, China; Huazhong University of Science and Technology, China*

## **Session 85: Droop Control in Microgrids**

**Chair(s): Sara Ahmed, Amir Yaznadi**

- Breaking the Boundary: A Droop and Master-Slave Hybrid Control Strategy for Parallel Inverters in Islanded Microgrids .....** 3345

Shike Wang, Zeng Liu, Jinjun Liu, Ronghui An and Meng Xin  
Xian Jiaotong University, China

- Hybrid Impedance-based Modelling and Stability Analysis of IMG-PICDPS .....** 3353

Meiqin Mao, Yong Ding, Yatao Shen and Liuchen Chang  
Hefei University of Technology, China

- A Hybrid Adaptive Droop Control Technique with Embedded DC-Bus Voltage Regulation for Single-Phase Microgrids .....** 3359

Sajjad M. Kaviri, Hadis Hajebrahimi, Majid Pahlevani, Praveen Jain and Alireza Bakhshai  
Queen's University, Canada; University of Calgary, Canada

- Enforcing Coherency in Droop-Controlled Inverter Networks through use of Advanced Voltage Regulation and Virtual Impedance .....** 3367

Philip J. Hart, R.H. Lasseter and T.M. Jahns  
University of Wisconsin-Madison, United States

## **Session 86: Grid Connected Converter Stability**

**Chair(s): Johan HR Enslin, Suryanarayana Doolla**

- Stabilization of Grid-Connected Inverter System with Feed-Forward Control .....** 3375

Toshiji Kato, Kaoru Inoue and Yusuke Nakajima  
Doshisha University, Japan

- Impedance-based Stability Criterion for Multiple Offshore Inverters Connected in Parallel with Long Cables .....** 3383

Xin Zhang, Henry Shu-Hung Chung, Ling Ling Cao, Jeff Po Wa Chow and Weimin Wu  
Nanyang Technological University, Singapore; City University of Hong Kong, Hong Kong; Hong Kong Polytechnic University, Hong Kong; Shanghai Maritime University, China

- DAH-FF Approach to Improve the Current Quality and Stability of the LCL Type Grid-Connected Inverter .....** 3390

Xin Zhang, Henry Shu-hung Chung, Yuan-Bin He, Chun-Tak Lai and Weimin Wu  
Nanyang Technological University, Singapore; City University of Hong Kong, Hong Kong; Hangzhou Dianzi University, China; Shanghai Maritime University, China

- Power Factor Correction Capacitors for Multiple Parallel Three-Phase ASD Systems: Analysis and Resonance Damping .....** 3398

Yongheng Yang and Frede Blaabjerg  
Aalborg University, Denmark

## **Session 87: Control and Modulation of Multi-Phase AC/DC Converters**

**Chair(s): Adam Skorek, Dong Cao**

- Direct Power Control of PWM Rectifier with Elimination of DC Voltage Oscillations and Current Harmonics under Unbalanced Network .....** 3405

Yongchang Zhang, Jie Liu, Jihao Gao and Haitao Yang  
North China University of Technology, China; University of Technology Sydney, Australia

**Improved SVPWM Schemes for Vienna Rectifiers without Current Distortion ..... 3410**

Houjian Xu, Wenxi Yao and Shuai Shao  
Zhejiang University, China

**Improved Eight-Segment PWM Scheme with Non-Equally Distributed Zero-Vector Intervals for a Three-Phase Isolated Buck Matrix-Type Rectifier ..... 3415**

Jahangir Afsharian, Dewei Xu, Bin Wu, Bing Gong and Zhihua Yang  
Ryerson University, Canada; Murata Power Solution, Canada

**A Modified SVPWM Strategy Applied to a Three-Phase Three-Port Bidirectional AC-DC Rectifier for Efficiency Enhancement ..... 3420**

Hongfei Wu, Tingting Liu, Tianyu Yang, Jiangfeng Wang, Shun Ding and Yan Xing  
Nanjing University of Aeronautics and Astronautics, China

**Session 88: DC/DC Converter Topologies**

**Chair(s): Regan Zane, Wilson Eberle**

**High Efficiency LC Resonant Boost Topology: Analysis and Design ..... 3427**

Hamed Valipour and Martin Ordóñez  
University of British Columbia, Canada

**A Zero-Voltage Switching, Physically Flexible Multilevel GaN DC-DC Converter ..... 3433**

Derek Chou, Yutian Lei and Robert C.N. Pilawa-Podgurski  
University of Illinois at Urbana-Champaign, United States

**A Switched-Capacitor based High Conversion Ratio Converter for Renewable Energy Applications: Principle and Generation ..... 3440**

Kerui Li, Zhijian Yin, Yongheng Yang Huai Wang and Frede Blaabjerg  
Aalborg University, Denmark

**Design of Very-High-Frequency Synchronous Resonant DC-DC Converter for Variable Load Operation ..... 3447**

Lei Gu, Wei Liang and Juan Rivas Davila  
Stanford University, United States

**Session 89: AC-AC Converters I**

**Chair(s): Junichi Itoh, Lee Empringham**

**A Ride-Through Method using Input-Filter Capacitors for Three-Level Indirect Matrix Converter based Open-End Winding Drive ..... 3455**

Santhosh Krishnamoorthi, Saurabh Tewari, Siddharth Raju, Abhijit Kshirsagar, Daniel Opila and Ned Mohan  
University of Minnesota, United States; MTS Systems Corporation, United States; United States Naval Academy, United States

**A Family of Highly Reliable and Efficient Inductive-Link Universal Power Converters ..... 3462**

Khalegh Mozaffari and Mahshid Amirabadi  
Northeastern University, United States

**Matrix Converter Open Circuit Fault Diagnosis with Asymmetric One Zero SVM ..... 3470**

Jiawei Zhang, Lee Empringham, Liliana De Lillo, Hanbing Dan and Patrick Wheeler  
University of Nottingham, United Kingdom

**A Versatile Inductive-Link Three-Phase Converter Topology ..... 3476**

Khalegh Mozaffari and Mahshid Amirabadi  
Northeastern University, United States

**Session 90: Reliability, Diagnostic, and Faults Analysis in Power Converters I**

Chair(s): Ke Ma, Marco Liserre

**An Active Capacitor with Self-Power and Internal Feedback Control Signals ..... 3484**

Haoran Wang and Huai Wang  
Aalborg University, Denmark

**Impacts of Rotor Current Control Targets on DC-Link Capacitor Lifetime in DFIG-based Wind****Turbine during Grid Voltage Unbalance ..... 3489**

Holger Jettberg, Marius Langwasser, Rongwu Zhu, Giampaolo Buticchi and Marco Liserre  
Christian-Albrechts-Universität zu Kiel, Germany

**Aging Assessment of Discrete SiC MOSFETs under High Temperature Cycling Tests ..... 3496**

Enes Ugur and Bilal Akin  
University of Texas at Dallas, United States

**Live Condition Monitoring of Switching Devices using SSTDR Embedded PWM Sequence: A****Platform for Intelligent Gate-Driver Architecture ..... 3502**

Sourov Roy and Faisal Khan  
University of Missouri-Kansas City, United States

**Session 91: Design Optimization of Power Converters**

Chair(s): Fred Wang, Arijit Banerjee

**Efficiency Optimization of DC-DC Solid State Transformer based on Modular****Multilevel Converters ..... 3508**

Lei Zhang, Zhe Zhao and Jiangchao Qin  
Arizona State University, United States

**Mission-Profile based Multi-Objective Optimization of Power Electronics Converter for****Wind Turbines ..... 3514**

Ghanshyamsinh Gohil, Remus Teodorescu, Tamas Kerekes, Frede Blaabjerg and Subhashish Bhattacharya  
North Carolina State University, United States; Aalborg University, Denmark

**Reducing Reverse Conduction and Switching Losses in GaN HEMT-based High-Speed****Permanent Magnet Brushless DC Motor Drives ..... 3522**

Woongkul Lee, Di Han, Wooyoung Choi and Bulent Sarlioglu  
University of Wisconsin-Madison, United States

**Design by Optimization Methodology: Application to a Wide Input and Output Voltage Ranges****Interleaved Buck Converter ..... 3529**

Mylène Delhommais, Jean-Luc Schanen, Frédéric Wurtz, Cécile Rigaud and Sylvain Chardon  
Université Grenoble Alpes, France; TRONICO-ALCEN, France

## **Session 92: Thermal and Faults of Electric Machines**

**Chair(s): Yilmaz Sozer, Sang Bin Lee**

<b>An Enhanced Active DC-Flux Injection based Approach for Thermal Monitoring of Induction Machines with Direct Torque Control Schemes .....</b>	<b>3537</b>
--	-------------

Sufei Li, Shen Zhang, Chen Jiang, Lijun He and Ronald G. Harley

*Georgia Institute of Technology, United States; General Electric, United States; University of KwaZulu-Natal, South Africa*

<b>Comparison of Thermal Stresses Developed during Transients on a Damaged Rotor Cage .....</b>	<b>3545</b>
---	-------------

Vicente Climente-Alarcon, Antero Arkkio and Jose A. Antonino-Daviu

*Aalto University, Finland; Universitat Politecnica de Valencia, Spain*

<b>A High-Frequency Torque Injection-Based Rotor Thermal Monitoring Scheme for Direct-Torque-Controlled Interior Permanent Magnet Synchronous Machines .....</b>	<b>3552</b>
--	-------------

Shen Zhang, Sufei Li, Lijun He, José A. Restrepo and Thomas G. Habetler

*Georgia Institute of Technology, United States; GE Global Research, United States; Universidad Simón Bolívar, Venezuela*

<b>Evaluation of the Detectability of Rotor Faults and Eccentricities in Induction Motors via Transient Analysis of the Stray Flux .....</b>	<b>3559</b>
--	-------------

Jose Antonino-Daviu, Alfredo Quijano-Lopez, Vicente Climente-Alarcon and Hubert Razik

*Universitat Politecnica de Valencia, Spain; Aalto University, Finland; Université Claude Bernard Lyon 1, France*

## **Session 93: PM Machines and Windings**

**Chair(s): Abraham Gebregergis, Greg Heins**

<b>Preliminary Study on Differences in the Performance Characteristics of Concentrated and Distributed Winding IPM Machines with Different Rotor Topologies .....</b>	<b>3565</b>
---	-------------

Alireza Pouramin, Rukmi Dutta and M.F. Rahman

*University of New South Wales, Australia*

<b>Shaft-to-Frame Voltage Mitigation Method by Changing Winding-to-Rotor Parasitic Capacitance of IPMSM .....</b>	<b>3571</b>
---	-------------

Jun-Kyu Park, Se-Hyun Rhyu and Jin Hur

*Korea Electronics Technology Institute (KETI), Korea; Incheon National University, Korea*

<b>Current Control Strategy for Dynamic Winding Reconfiguration of a Brushless DC Motor .....</b>	<b>3577</b>
---	-------------

Florian Copt, Douglas Martins Araujo, Christian Koechli and Yves Perriard

*EPFL, Switzerland*

<b>Design and Analysis of a Low Cost and High Power Density PM-Assisted Synchronous Reluctance Machine for Automotive Electric Power Management .....</b>	<b>3583</b>
---	-------------

Lei Hao, Murali Pandi, Chandra Mavuru, Chandra Namuduri, Avoki Omekanda and Thomas Nehl

*General Motors R&D Center, United States; General Motors India Technical Center, India*

## **Session 94: Energy Efficient Motor Drives**

**Chair(s): Sayeed Mir, Gui-Jia Su**

<b>Open-Ended Induction Motor Drive with a Floating Capacitor Bridge at Variable DC Link Voltage ....</b>	<b>3591</b>
---	-------------

Albino Amerise, Michele Mengoni, Luca Zarri, Angelo Tani, Sandro Rubino and Radu Bojoi

*University of Bologna, Italy; Politecnico di Torino, Italy*

**Dynamic Loss Minimization Control of Linear Induction Machine ..... 3598**

Dong Hu, Wei Xu, Renjun Dian, Yi Liu and Jianguo Zhu

Huazhong University of Science and Technology, China; University of Technology Sydney, Australia

**Dynamic Loss Minimizing Control of a PM Servomotor Operating Even at the Voltage Limit when using DB-DTFC ..... 3604**

Huthaifa Flieh, Robert D. Lorenz, Eigo Totoki, Shinichi Yamaguchi and Yuichiro Nakamura

University of Wisconsin-Madison, United States; Mitsubishi Electric Corp., Japan

**Comparison of Postfault Control Strategies in Terms of Converter Losses for Dual Three-Phase Machines ..... 3612**

Fernando Baneira, Jesús Doval-Gandoy, Alejandro G. Yepes, Óscar López and Diego Pérez-Estévez

University of Vigo, Spain

**Session 95: Induction Motor Drives****Chair(s): Marcello Pucci, Jingbo Liu****A Three-Dimensional Predictive Current Trajectory Control Method for Open-End Winding Induction Motor ..... 3620**

Bohang Zhu and Kaushik Rajashekara

University of Texas at Dallas, United States; University of Houston, United States

**Comparison of Steady-State Induction Motor-Drive Efficiency Control Schemes ..... 3626**

Andrew Strandt and Lixiang Wei

Rockwell Automation, United States

**Model Predictive Direct Flux Vector Control of Multi Three-Phase Induction Motor Drives ..... 3633**

S. Rubino, R. Bojoi, S.A. Odhano and P. Zanchetta

Politecnico di Torino, Italy; University of Nottingham, United Kingdom

**Open-End Six-Phase Machine Drive System with Six Three-Leg Converters ..... 3641**

Nayara B. de Freitas, Cursino B. Jacobina, Victor F.M.B. Melo, Bruna S. Gehrke and Louelson A.L. de A.C. Costa

Federal University of Campina Grande, Brazil; Federal Institute of Pernambuco, Brazil

**Session 96: Packaging I****Chair(s): Jelena Popovic, Zhuxian Xu****Bonding of Large Substrates by Silver Sintering and Characterization of the Interface Thermal Resistance ..... 3649**

Shan Gao, Zhenwen Yang, Yansong Tan, Xin Li, Xu Chen, Zhan Sun and Guo-Quan Lu

Virginia Polytechnic Institute and State University, United States; Tianjin University, China; Harbin Institute of Technology, China

**A High Power-Density and High Efficiency Insulated Metal Substrate based GaN HEMT Power Module ..... 3654**

Juncheng Lu, Di Chen and Lyubov Yushyna

GaN Systems Inc., Canada

**A High Power Density Multichip Phase-Leg IGBT Module with Void-Free Die Attachment using Nanosilver Paste ..... 3659**

Shancan Fu, Yunhui Mei, Xin Li and Guo-Quan Lu

Tianjin University, China; Virginia Polytechnic Institute and State University, United States

**Paralleling 650 V / 60 A GaN HEMTs for High Power High Efficiency Applications ..... 3663**

Nidhi Haryani, Jun Wang and Rolando Burgos  
Virginia Polytechnic Institute and State University, United States

**Session 97: LED Drivers**

**Chair(s): S. Ali Khajehhoddin, Marcos Alonso**

**Application of Artificial Neural-Network to Control the Light of Multi-Color LED System ..... 3669**

Xiaoqing Zhan, Wenguan Wang and Henry Shu-hung Chung  
City University of Hong Kong, Hong Kong

**GaN-based High-Power-Density Electrolytic-Free Universal Input LED Driver ..... 3676**

Saad Pervaiz, Ashish Kumar and Khurram K. Afriди  
University of Colorado-Boulder, United States

**Forward-Flyback Converter for LED Driving with Reduced Number of Components ..... 3684**

Jong-Woo Kim, Jung-Muk Choe and Jih-Sheng Lai  
Virginia Polytechnic Institute and State University, United States

**High Frequency DC-DC AC-LED Driver based on ZCS-QRCs ..... 3688**

Ignacio Castro, Sergio Lopez, Kevin Martin, Manuel Arias, Diego G. Lamar and Javier Sebastian  
University of Oviedo, Spain

**Session 98: Wind Energy Applications**

**Chair(s): Nathan Weise, Eduard Muljadi**

**Wind Turbine Bearing Fault Diagnosis based on Sparse Representation of Condition Monitoring Signals ..... 3696**

Jun Wang, Wei Qiao and Liyan Qu  
University of Nebraska-Lincoln, United States

**Performance Evaluation of Slip Couplers with Spoke- and Surface-Mounted PM for Wind Energy Applications ..... 3703**

N. Dumakude and M.J. Kamper  
Stellenbosch University, South Africa

**Small Signal Modeling of Wind Farms ..... 3710**

Esmaeil Ebrahimzadeh, Frede Blaabjerg, Xiongfei Wang, Claus Leth Bak, Torsten Lund, Gert K. Andersen, Carlos Gómez Suárez and Jens-Jacob Berg  
Aalborg University, Denmark; Vestas Wind Systems A/S, Denmark

**Battery-Free Power Management Circuit for Impact-Type Micro Wind Piezoelectric Energy Harvester ..... 3717**

Nan Chen and Tingcun Wei  
Northwestern Polytechnical University, China

**Session 99: Power Sharing Techniques in Microgrids**

**Chair(s): Koji Orikawa, Josep M. Guerrero**

**A Proportional Harmonic Power Sharing Scheme for Hierarchical Controlled Microgrids Considering Unequal Feeder Impedances and Nonlinear Loads ..... 3722**

Hong Li, Yang Han, Ping Yang, Jingqi Xiong, Congling Wang and Josep M. Guerrero  
University of Electronic Science and Technology of China, China; Aalborg University, Denmark

<b>Adaptive Synchronous Reference Frame Virtual Impedance Controller for Accurate Power Sharing in Islanded AC-Microgrids: A Faster Alternative to the Conventional Droop Control .....</b>	<b>3728</b>
Carlos Andres Macana and Hemanshu R. Pota University of New South Wales, Australia	
<b>Decentralized Economical-Sharing Scheme for Cascaded AC Microgrids .....</b>	<b>3736</b>
Lang Li, Huawei Ye, Zhangjie Liu, Hua Han, Yao Sun and Mei Su Central South University, China	
<b>Using Consensus Control for Reactive Power Sharing of Distributed Electric Springs .....</b>	<b>3741</b>
Jie Chen, Shuo Yan and S.Y. Ron Hui University of Hong Kong, Hong Kong; Imperial College London, United Kingdom	
<b>Session 100: DC Circuit Breaker Design</b>	
<b>Chair(s): Ty McNutt, Rob Cuzner</b>	
<b>Fault Discrimination using SiC JFET based Self-Powered Solid State Circuit Breakers in a Residential DC Community Microgrid .....</b>	<b>3747</b>
Karthik Palaniappan, Willy Sedano, Nicholas Hoeft, Robert Cuzner and Z. John Shen University of Wisconsin-Milwaukee, United States; Illinois Institute of Technology, United States	
<b>Optimization of Operation Temperature of Gate Commutated Thyristors for Hybrid DC Breaker .....</b>	<b>3754</b>
Gang Lyu, Jiapeng Liu, Wenpeng Zhou, Rong Zeng, Xueqiang Zhang and Patrick Palmer Tsinghua University, China; University of Cambridge, United Kingdom	
<b>A Topology of the Multi-Port DC Circuit Breaker for Multi-Terminal DC System Fault Protection ...</b>	<b>3760</b>
Wenjun Liu, Fei Liu, Xiaoming Zha, Chao Chen and Tianyi Yu Wuhan University, China	
<b>Optimization of a Z-Source, Ultra-Fast Mechanically Switched, High Efficiency DC Circuit Breaker ....</b>	<b>3764</b>
Landon Mackey, Md Rifat Kaisar Rachi, Chang Peng and Iqbal Husain North Carolina State University, United States	
<b>Session 101: LLC Converters</b>	
<b>Chair(s): Regan Zane, Rivas-davila Juan</b>	
<b>Efficiency Improvement of Three-Phase LLC Resonant Converter using Phase Shedding .....</b>	<b>3771</b>
Sayed Abbas Arshadi, Martin Ordóñez, Mehdi Mohammadi and Wilson Eberle University of British Columbia, Canada	
<b>LLC Synchronous Rectification using Homopolarity Cycle Modulation .....</b>	<b>3776</b>
Mehdi Mohammadi and Martin Ordóñez University of British Columbia, Canada	
<b>A Lagrangian Dynamics Model of Integrated Transformer Incorporated in a Multi-phase LLC Resonant Converter .....</b>	<b>3781</b>
Mostafa Noah, Kazuhiro Umetani, Shun Endo, Hiraki Ishibashi, Jun Imaoka and Masayoshi Yamamoto Shimane University, Japan; Okayama University, Japan; Kyushu University, Japan; Nagoya University, Japan	

**DC/DC Fixed Frequency Resonant LLC Full-Bridge Converter with Series-Parallel Transformers for 10kW High Efficiency Aircraft Application ..... 3788**

Y.E. Bouvier, U. Borović, M. Vasić, J.A. Oliver, P. Alou, J.A. Cobos, F. Árevalo, J.C. García-Tembleque and J. Carmena

Universidad Politecnica de Madrid, Spain; Indra Sistemas S.A., Spain

**Session 102: AC-AC Converters II**

**Chair(s): Patrick Wheeler, Luca Zarri**

**Improvement of the Input-Output Quality of Three-Level NPC Inverters with Small DC-Link ..... 3796**

Hyo-Chul In, Seok-Min Kim and Kyo-Beum Lee

Ajou University, Korea

**Transformer-based Single-Phase AC-DC-AC Topology for Grid Issues Mitigation ..... 3802**

Nayara B. de Freitas, Cursino B. Jacobina and Bruna S. Gehrke

Federal University of Campina Grande, Brazil

**Control of Solid-State-Transformer for Minimized Energy Storage Capacitors ..... 3809**

Takanori Isobe, Hiroshi Tadano, Zijin He and Yang Zou

University of Tsukuba, Japan

**Analysis and Design of LC Filters for the 5-Level 3-Phase Back to Back E-Type Converter ..... 3816**

Marco Di Benedetto, Alessandro Lidozzi, Luca Solero, Fabio Crescimbini and Petar J. Grbovic

Roma Tre University, Italy; Huawei Technologies Dusseldorf GmbH, Germany

**Session 103: Reliability, Diagnostic, and Faults Analysis in Power Converters II**

**Chair(s): Yilmaz Sozer, Mario Pacas**

**Thermal Stress Mitigation by Active Thermal Control: Architectures, Models and Specific Hardware ..... 3822**

Alessandro Soldati, Fabrizio Dossena, Giorgio Pietrini, Davide Barater, Carlo Concari and Francesco Iannuzzo

University of Parma, Italy; Aalborg University, Denmark

**Impacts of PV Array Sizing on PV Inverter Lifetime and Reliability ..... 3830**

Ariya Sangwongwanich, Yongheng Yang, Dezso Sera and Frede Blaabjerg

Aalborg University, Denmark

**Reliability Metrics Extraction for Power Electronics Converter Stressed by Thermal Cycles ..... 3838**

Ke Ma, Ui-Min Choi and Frede Blaabjerg

Shanghai Jiao Tong University, China; Aalborg University, Denmark

**Study of PWM Frequency and its Impact to Adjustable Speed Drive Reliability ..... 3844**

Lixiang Wei, Jeffrey McGuire and Jiangang Hu

Rockwell Automation, United States

**Session 104: Modulation Techniques I**

**Chair(s): Babak Parkhideh, Minjie Chen**

**Impact of Carrier Phase Shift PWM on the DC Link Current of Single and Interleaved Three-Phase Voltage Source Converters ..... 3851**

Zhongyi Quan and Yunwei Li

University of Alberta, Canada

<b>A DPWM-Controlled Three-Level T-Type Inverter for Photovoltaic Generation Considering Unbalanced Neutral-Point Voltage .....</b>	<b>3856</b>
Mohammad M. Hashempour, Meng-Ying Yang and Tzung-Lin Lee	
National Sun Yat-sen University, Taiwan	
<b>Over-Modulation Associated to Flash Memory based Multi-Optimal PWM for Three-Phase Inverters .....</b>	<b>3863</b>
Dorin O. Neacșu and Brad Lehman	
Northeastern University, United States; Technical University of Iasi, Romania	
<b>Stability Performance of Multi-connected Inverters with Global Synchronous Pulse Width Modulation .....</b>	<b>3871</b>
Tao Xu and Feng Gao	
Shandong University, China	
<b>Session 105: Modeling and Control of Grid Connected Converters I</b>	
<b>Chair(s): Paolo Mattavelli, Carl Ho</b>	
<b>Improved Resonant Current Controller for Grid-Tied Converters .....</b>	<b>3877</b>
Diego Pérez-Estévez, Jesús Doval-Gandoy, Alejandro G. Yepes, Óscar López and Fernando Baneira	
University of Vigo, Spain	
<b>Filter Capacitor Current Estimation and Grid Current Control in LCL based Grid Connected Inverter .....</b>	<b>3885</b>
Subhajyoti Mukherjee, Vikram Roy Chowdhury, Pourya Shamsi and Mehdi Ferdowsi	
Missouri University of Science and Technology, United States	
<b>A Dual Loop Current Control Structure with Improved Disturbance Rejection for Grid Connected Converters in the Synchronous Rotating Reference Frame .....</b>	<b>3890</b>
Srinivas Gulur, Vishnu Mahadeva Iyer and Subhashish Bhattacharya	
North Carolina State University, United States	
<b>Multi-Frequency Current Controller for Grid-Tied Converters .....</b>	<b>3897</b>
Diego Pérez-Estévez, Jesús Doval-Gandoy, Alejandro G. Yepes, Óscar López and Fernando Baneira	
University of Vigo, Spain	
<b>Session 106: Synchronous Reluctance Machines II</b>	
<b>Chair(s): Ziaur Rahman, David Dorrell</b>	
<b>Synchronous Reluctance Motor with Concentrated Windings for IE4 Efficiency .....</b>	<b>3905</b>
Matteo Gamba, Gianmario Pellegrino, Eric Armando and Simone Ferrari	
Politecnico di Torino, Italy	
<b>Carbon-Fiber Wrapped Synchronous Reluctance Traction Motor .....</b>	<b>3913</b>
Kevin Grace, Steven Galioto, Karthik Bodla and Ayman El-Refaie	
General Electric, United States	
<b>A Novel Fabrication and Assembly Method for Synchronous Reluctance Machines .....</b>	<b>3921</b>
Chirag Desai, Hetal Mehta and Pragasen Pillay	
Concordia University, Canada; Happy Engineering, India	

**High Speed Motors: A Comparison between Synchronous PM and Reluctance Machines ..... 3927**

Cristian Babetto, Giacomo Bacco, Grazia Berardi and Nicola Bianchi  
University of Padova, Italy

**Session 107: Variable Flux PM Machines**

Chair(s): Sang Bin Lee, Zi-Qiang Zhu

**Magnet Design Consideration of a Variable-Flux PM Machine ..... 3935**

Amirmasoud Takbash and Pragases Pillay  
Concordia University, Canada

**Comparative Study of Variable Flux Memory Machines with Parallel and Series Hybrid Magnets ..... 3942**

Hao Hua, Z.Q. Zhu, Adam Pride, Rajesh Deodhar and Toshinori Sasaki  
University of Sheffield, United Kingdom; IMRA Europe SAS, United Kingdom

**Design of Variable Magnetization Pattern Machines for Dynamic Changes in the Back-EMF Waveform ..... 3950**

Ryoko Imamura, Teng Wu and Robert D. Lorenz  
University of Wisconsin-Madison, United States

**Performance Assessment of Ferrite- and Neodymium-Assisted Synchronous Reluctance Machines .... 3958**

Riccardo Leuzzi, Paolo Cagnetta, Francesco Cupertino, Simone Ferrari and Gianmario Pellegrino  
Politecnico di Bari, Italy; Politecnico di Torino, Italy

**Session 108: PM and IPM Motor Drives II**

Chair(s): Ali Bazzi, Prerit Pramod

**Permanent Magnet Synchronous Machine Drive Control using Analog Hall-Effect Sensors ..... 3966**

David Reigosa, Daniel Fernandez, Cristina Gonzalez, Sang Bin Lee and Fernando Briz  
University of Oviedo, Spain

**A New Zero-Sequence Current Suppression Control Strategy for Five-Phase Open-Winding FTFSCW-IPM Motor Driving System ..... 3972**

Ronghua Cui, Ying Fan and Ming Cheng  
Southeast University, China

**An Effective Voltage Control Loop for a Deep Flux-Weakening in IPM Synchronous Motor Drives ..... 3979**

Virginia Manzolini, Davide Da Ru and Silverio Bolognani  
University of Padova, Italy

**Real-Time Disturbance Compensation Algorithm for the Current Control of PMSM Drives ..... 3987**

Milo De Soricellis, Davide Da Rù and Silverio Bolognani  
University of Padova, Italy; Robert Bosch GmbH, Germany

**Session 109: Packaging II**

Chair(s): Zhuxian Xu, Muhammad Nawaz

**A Novel Low Inductive 3D SiC Power Module based on Hybrid Packaging and Integration Method ... 3995**

Zhizhao Huang, Yuxiong Li, Lichuan Chen, Yifan Tan, Cai Chen, Yong Kang and Fang Luo  
Huazhong University of Science and Technology, China; University of Arkansas, United States

**Design of a Novel, High-Density, High-Speed 10 kV SiC MOSFET Module ..... 4003**

Christina DiMarino, Mark Johnson, Bassem Mouawad, Jianfeng Li, Dushan Boroyevich, Rolando Burgos, Guo-Quan Lu and Meiyu Wang  
Virginia Polytechnic Institute and State University, United States; University of Nottingham, United Kingdom

**Flexible Epoxy-Resin Substrate based 1.2 kV SiC Half Bridge Module with Ultra-Low Parasitics and High Functionality ..... 4011**

Xin Zhao, Bo Gao, Yifan Jiang, Lili Zhang, Sizhen Wang, Yang Xu, Kenji Nishiguchi, Yoshi Fukawa and Douglas C. Hopkins  
North Carolina State University, United States; Risho Kogyo Co., Ltd, Japan; TOYOTech LLC, United States

**New Industrial Module Package with Matched CTE Materials ..... 4019**

Mark Steiner, Eric Motto and John Donlon  
Powerex, Inc., United States

**Session 110: Wireless Power Transfer II**

**Chair(s): ChunTaek Rim, Shuo Wang**

**Achieving Low Magnetic Flux Density and Low Electric Field Intensity for an Inductive Wireless Power Transfer System ..... 4022**

Guangqi Zhu and Robert D. Lorenz  
University of Wisconsin-Madison, United States

**FOM-rd Plane: An Effective Design and Analysis Methodology for Resonant Energy Link in Inductive Power Transfer ..... 4030**

Chae-Ho Jeong, Hee-Su Choi and Sung-Jin Choi  
University of Ulsan, Korea

**Output Voltage Control for Series-Series Compensated Wireless Power Transfer System without Direct Feedback from Measurement or Communication ..... 4035**

Euihoon Chung, Gyu Cheol Lim, Jung-Ik Ha and Ki Young Kim  
Seoul National University, Korea; Samsung Electronics Co., Ltd., Korea

**Magnetizable Concrete Composite Materials for Road-Embedded Wireless Power Transfer Pads ..... 4041**

Reza Tavakoli, A. Echols, U. Pratik, Zeljko Pantic, Fray Pozo, Amir Malakooti and Marc Maguire  
Utah State University, United States

**Session 111: PV Plants and PV Farms**

**Chair(s): Rajapandian Ayyanar, Fei Gao**

**AC Impedance Derivation of Utility Scale PV Farm ..... 4049**

Ye Tang, Rolando Burgos, Chi Li and Dushan Boroyevich  
Virginia Polytechnic Institute and State University, United States

**A New Approach for Increasing Energy Harvest in Large Scale PV Plants Employing a Novel Voltage Balancing Topology ..... 4055**

Ahmed Salah Morsy, Sinan A. Sabeeh Al-Obaidi and Prasad Enjeti  
Texas A&M University, United States

**On-Line Health Monitoring of PV Plants ..... 4061**

Matam Manjunath, B. Venugopal Reddy, Y. Zhao and Brad Lehman  
National Institute of Technology Goa, India; Northeastern University, United States

**Hybrid Solar Plant with Synchronous Power Controllers Contribution to Power System Stability ... 4069**

Daniel Remon, Antoni M. Cantarellas, Jorge Martinez-Garcia, Juan M. Escano and Pedro Rodriguez  
Technical University of Catalonia, Spain; Abengoa, Spain; Loyola University Andalusia, Spain

**Session 112: Droop Techniques for Microgrid Operation**

Chair(s): Rolando Burgos, Hui Li

**Comparison between Inverters based on Virtual Synchronous Generator and Droop Control ..... 4077**

Xin Meng, Zeng Liu, Jinjun Liu, Shike Wang, Baojin Liu and Ronghui An  
Xi'an Jiaotong University, China

**Hybrid Isochronous-Droop Control for Power Management in AC Microgrids ..... 4085**

Inam Ullah Nutkani, Lasantha Meegahapola, Donald Grahame Holmes and Chee Shen Lim  
RMIT University, Australia; University of Southampton, Malaysia

**Improved Droop Control Strategy based on Improved PSO Algorithm ..... 4092**

Zishun Peng, Jun Wang, Daqiang Bi, Z. John Shen, Yuxing Dai and Yeting Wen  
Hunan University, China; Tsinghua University, China

**A Modified Q-V Droop Control for Accurate Reactive Power Sharing in Distributed Generation Microgrid ..... 4099**

Jiuyang Zhou and Po-Tai Cheng  
National Tsing Hua University, Taiwan

**Session 113: Control in DC Microgrids**

Chair(s): Tomislav Dragicevic, Xiaonan Lu

**Admittance-type RC-mode Droop Control to introduce Virtual Inertia in DC Microgrids ..... 4107**

Zheming Jin, Lexuan Meng, Renke Han, Josep M. Guerrero and Juan C. Vasquez  
Aalborg University, Denmark

**Power-based Droop Control Suppressing the Effect of Bus Voltage Harmonics for DC Microgrids ..... 4113**

Guangyuan Liu, Tommaso Caldognetto, Paolo Mattavelli and Paolo Magnone  
University of Padova, Italy

**Containment-based Distributed Coordination Control to Achieve Both Bounded Voltage and Precise Current Sharing in Reverse-Droop-based DC Microgrid ..... 4121**

Renke Han, Haojie Wang, Zheming Jin, Lexuan Meng and Josep M. Guerrero  
Aalborg University, Denmark; North China Electric Power University, China

**A High-Efficiency Interleaved Single-Phase AC-DC Converter with Common-Mode Voltage Regulation for 380 V DC Microgrids ..... 4128**

Fang Chen, Rolando Burgos and Dushan Boroyevich  
Virginia Polytechnic Institute and State University, United States

**Session 114: Resonant DC/DC Converters**

Chair(s): Hongliang Wang, Aleksandar Prodic

**An Improved Voltage Balancing Technique for a Soft-Switched High-Gain Converter with Low Voltage Stress using Duty Ratio Control for Wind Energy Application ..... 4136**

Mehdi Abbasi and John Lam  
York University, Canada

**A Power Converter for an Electrostatic Precipitator using SiC MOSFETs ..... 4144**

Pedro J. Villegas, Juan A. Martin Ramos, Juan Diaz Gonzalez and Juan A. Martinez Esteban  
University of Oviedo, Spain

**A Hybrid Resonant Three-Level Converter for Renewable Energy in MVDC Collection Systems .... 4152**

Guangfu Ning, Xiaopeng Cao, Liangcai Shu, Wu Chen and Baojian Ji  
Southeast University, China; Nanjing University of Technology, China

**Time Domain Analysis of LLC Resonant Converters in the Boost Mode for Battery Charger Applications ..... 4157**

Navid Shafiei, Mohammad Ali Saket and Martin Ordóñez  
University of British Columbia, Canada

**Session 115: Modular Multilevel Converters (MMC)**

Chair(s): Luca Solero, Rostan Rodrigues

**A Fault-Tolerant Operation Scheme for a Modular Multilevel Converter with a Distributed Control Architecture ..... 4163**

Shunfeng Yang, Yi Tang, Pengfei Tu and Peng Wang  
Nanyang Technological University, Singapore

**Redistributed Pulse Width Modulation of MMC Battery Energy Storage System under Submodule Fault Condition ..... 4171**

Xin Gu, Feng Gao, Farooq Aamir, Xifeng Liu and Jing Xiao  
Shandong University, China; Shandong Electric Power Maintenance Company, China

**Compensation Method of Arm Current Sensor Scaling Error in MMC System ..... 4177**

Belete Belayneh Negesse, Chang-Hwan Park and Jang-Mok Kim  
Pusan National University, Korea

**A Novel Sub-module Topology for MMC against DC Side Short-Circuit Faults ..... 4185**

Yao Xue, Xiaofeng Yang, Trillion Q. Zheng, Bowei Chen and Yan Li  
Beijing Jiaotong University, China; Electric Power Research Institute, China

**Session 116: Reliability, Diagnostic, and Faults Analysis for Power Devices**

Chair(s): Behrooz Mirafzal, Jun Wang

**Fault Detection Method for IGBT Open-Circuit Faults in the Modular Multilevel Converter based on Predictive Model ..... 4190**

Kunshan Xu, Shaojun Xie, Ye Yan, Zhao Zhang, Binfeng Zhang and Qiang Qian  
Nanjing University of Aeronautics and Astronautics, China

**Asymmetric Power Device Rating Selection for Even Temperature Distribution in NPC Inverter .... 4196**

Ui-Min Choi and Frede Blaabjerg  
Aalborg University, Denmark

**Impact of Lifetime Model Selections on the Reliability Prediction of IGBT Modules in Modular Multilevel Converters ..... 4202**

Yi Zhang, Huai Wang, Zhongxu Wang, Yongheng Yang and Frede Blaabjerg  
Aalborg University, Denmark

**Open-circuit Fault Diagnosis of Switching Devices in a Modular Multilevel Converter with Distributed Control .....** 4208

Shunfeng Yang, Yi Tang and Peng Wang  
Nanyang Technological University, Singapore

**Session 117: Modulation Techniques II**

**Chair(s): Jason Lai, Martin Ordóñez**

**New Constraint in SHE-PWM for Single Phase Inverter Applications .....** 4215

Mohammad Sharifzadeh, Hani Vahedi and Kamal Al-Haddad  
University du Québec, Canada; Ossiaco Inc., Canada

**Novel Modulation Schemes and Switching Pattern for Z-Source Ultra-Sparse Matrix Converter ....** 4223

Amir Masoud Bozorgi, Mehdi Farasat and Ekrem Karaman  
Louisiana State University, United States; Warner Power LLC, United States

**A New Adaptive Switching Frequency Modulation for Optimizing Low Power Cascaded Buck-Boost Converter .....** 4230

Xi Chen, Anirudh Pise, Issa Batarseh and John Elmes  
University of Central Florida, United States; Advanced Power Electronics Corporation, United States

**An Improved Modulation Strategy for the Three-Phase Z-Source Inverters (ZSIs) .....** 4237

Ahmed Abdelhakim, Pooya Davari, Frede Blaabjerg and Paolo Mattavelli  
University of Padova, Italy; Aalborg University, Denmark

**Session 118: Modeling and Control of Grid Connected Converters II**

**Chair(s): Jian Sun, Mahshid Amirabadi**

**Improved Control Strategy of Grid Connected Inverter without Phase Locked Loop on PCC Voltage Disturbance .....** 4244

Liang Chen, Heng Nian, Boliang Lou and HongYang Huang  
Zhejiang University, China; State Grid Zhejiang Electric Power Company, China

**Automated and Scalable Optimal Control of Three-Phase Embedded Power Grids including PLL .....** 4252

David Dewar, Andrea Formentini and Pericle Zanchetta  
University of Nottingham, United Kingdom

**Optimal Variable Switching Frequency Scheme for Grid Connected Full Bridge Inverters with Bipolar Modulation Scheme .....** 4260

Yinglai Xia, Jinia Roy and Raja Ayyanar  
Texas Instruments, United States; Arizona State University, United States

**Grid-Connected Power Converters with Distributed Virtual Power System Inertia .....** 4267

Jingyang Fang, Xiaoqiang Li and Yi Tang  
Nanyang Technological University, Singapore

**Session 119: Linear Machines**

**Chair(s): Siavash Pakdelen, David Diaz Reigosa**

**Comparative Study of Coreless-Type PM Linear Synchronous Machines with Non-Overlapping Windings .....** 4274

Seun Guy Min and Bulent Sarlioglu  
University of Wisconsin-Madison, United States

<b>Comparative Study of Novel Tubular Flux-Reversal Transverse Flux Permanent Magnet Linear Machine .....</b>	<b>4282</b>
Shaohong Zhu, Tom Cox and Chris Gerada University of Nottingham, United Kingdom	
<b>Electrical Losses Minimization of Linear Induction Motors Considering the Dynamic End-Effects ...</b>	<b>4288</b>
A. Accetta, M.C. Di Piazza, M. Luna and M. Pucci ISSIA-CNR, Italy	
<b>Design and Performance Investigation of Doubly Salient Slot Permanent Magnet Linear Machines ....</b>	<b>4295</b>
Yiming Shen, Qinfen Lu and Lijian Wu Zhejiang University, China	
<b>Session 120: PM Motor Design, Control and Testing</b>	
Chair(s): Junichi Asama, Andrea Cavagnino	
<b>Inductance Testing According to the New IEEE Std 1812 – Application and Possible Extensions for IPM Machines .....</b>	<b>4302</b>
Vandana Rallabandi, Narges Taran, Dan M. Ionel and Ping Zhou University of Kentucky, United States; ANSYS, Inc., United States	
<b>Parametric Design Method for SPM Machines Including Rounded PM Shape .....</b>	<b>4309</b>
Chao Lu, Simone Ferrari, Gianmario Pellegrino, Claudio Bianchini and Matteo Davoli Politecnico di Torino, Italy; University of Modena and Reggio Emilia, Italy	
<b>Investigation of Different Servo Motor Designs for Servo Cycle Operations and Loss Minimizing Control Performance .....</b>	<b>4316</b>
Huthaifa Flieh, Robert D. Lorenz, Eigo Totoki, Shinichi Yamaguchi and Yuichiro Nakamura University of Wisconsin-Madison, United States; Mitsubishi Electric Corp., Japan	
<b>Synchronous SVPWM for Field-Oriented Control of PMSM using Phase-Lock Loop .....</b>	<b>4324</b>
Lifan Xiao, Jian Li, Junhua Chen, Ronghai Qu and Yongqian Xiong Huazhong University of Science and Technology, China	
<b>Session 121: Drive Applications</b>	
Chair(s): Mazharul Chowdhury, Annette Muetze	
<b>Over-Voltage Mitigation on SiC based Motor Drives through an Open End Winding Configuration ...</b>	<b>4332</b>
S. De Caro, S. Foti, T. Scimone, A. Testa, G. Scelba, M. Pulvirenti and S. Russo University of Messina, Italy; University of Catania, Italy; STMicroelectronics, Italy	
<b>A Fault Monitoring System for a Reciprocating Pump Driven by a Linear Motor for Oil Pumping Systems .....</b>	<b>4338</b>
Hussain A. Hussain and Hamid A. Toliat Texas A&M University, United States	
<b>The Impact of Grid Unbalances on the Reliability of DC-Link Capacitors in a Motor Drive .....</b>	<b>4345</b>
Huai Wang, Pooya Davari, Dinesh Kumar, Firuz Zare and Frede Blaabjerg Aalborg University, Denmark; Danfoss Drives A/S, Denmark; University of Queensland, Australia	

<b>Achieving Zero Common Mode Voltage Generation in a Balanced Inverter with Neutral-Point Diode-Clamping .....</b>	<b>4351</b>
Di Han, Silong Li, Woongkul Lee and Bulent Sarlioglu University of Wisconsin-Madison, United States	

## **Session 122: High Voltage Devices**

**Chair(s): Daniel Costinett, Ruxi Wang**

<b>Development of PSpice Modeling Platform for 10kV/100 A SiC MOSFET Power Module .....</b>	<b>4358</b>
João Martins, Muhammad Nawaz, Kalle Ilves and Francesco Iannuzzo ABB Corporate Research, Sweden; Aalborg University, Denmark	

<b>Continuous Switching Operation of 15 kV FREEDM Super-Cascode .....</b>	<b>4366</b>
---	-------------

Soumik Sen, Xiaoqing Song, Lili Zhang and Alex Q. Huang  
North Carolina State University, United States; ABB Corporate Research Center, United States

<b>Experimental Optical Transistor for All-Optical SiC ETO Thyristor .....</b>	<b>4373</b>
--	-------------

Alireza Mojab and Sudip K. Mazumder  
University of Illinois at Chicago, United States

<b>Modeling and Power Loss Evaluation of Ultra Wide Band Gap Ga2O3 Device for High Power Applications .....</b>	<b>4377</b>
---	-------------

Inhwan Lee, Avinash Kumar, Ke Zeng, Uttam Singisetti and Xiu Yao  
State University of New York at Buffalo, United States

## **Session 123: Wireless Power Transfer III**

**Chair(s): Xu She, Alireza Safaei**

<b>The Effect of Matrix Power Repeaters on Magnetic Field Distribution of IPT Systems .....</b>	<b>4383</b>
---	-------------

Rong Hua, Aiguo Patrick Hu and Ho Fai Leung  
University of Auckland, New Zealand

<b>Soft-Switching Self-Tuning H-Bridge Converter for Inductive Power Transfer Systems .....</b>	<b>4388</b>
---	-------------

Masood Moghaddami, Andres Cavada and Arif I. Sarwat  
Florida International University, United States

<b>Load-Independent Transconductance and ZPA Input for Symmetrical Resonant Converter in IPT System .....</b>	<b>4393</b>
---	-------------

Jiang-Hua Lu, Guo-Rong Zhu, Jin Jiang, Wen-Jing Li and Bo Li  
Wuhan University of Technology, China; University of Western Ontario, Canada

<b>Design of Wireless Power Transfer System for Devices Carried by a Freely Moving Animal in Cage ...</b>	<b>4398</b>
---	-------------

Jeff Po Wa Chow, Henry Shu Hung Chung, Leanne Lai Hang Chan, Nathan Judson McDannold and Sai Chun Tang  
City University of Hong Kong, Hong Kong; Brigham and Women's Hospital, United States

## **Session 124: Solar Photovoltaic Technologies**

**Chair(s): Afshin Izadian, Yongheng Yang**

<b>Subcell Modelling of Partially Shaded Solar Photovoltaic Panels .....</b>	<b>4406</b>
--	-------------

Pallavi Bharadwaj and Vinod John  
Indian Institute of Science, India

**Effect of Water on Parasitic Capacitance of Photovoltaic Panel ..... 4414**

Shaolin Yu, Jianing Wang and Xing Zhang  
Hefei University of Technology, China

**An Application of Support Vector Machine to PV Power Forecasting under Different Weather Conditions ..... 4420**

Utpal Kumar Das, Kok Soon Tey, Mohd Yamani Idna Idris, Saad Mekhilef and Mutsuo Nakaoka  
University of Malaya, Malaysia

**High Performance Buck-Boost Converter based PV Characterisation Set-Up ..... 4425**

Pallavi Bharadwaj and Vinod John  
Indian Institute of Science, India

**Session 125: Control and Design Techniques for Microgrids I**

**Chair(s): Josep M. Guerrero, Mohammad B.Shadmand**

**A Stabilization Method of LC Input Filter in DC Microgrids Feeding Constant Power Loads ..... 4433**

Hao Wang, Hua Han, Zhangjie Liu, Yao Sun, Mei Su, Xiaochao Hou and Peng Yang  
Central South University, China

**Model-Predictive-Control-based Distributed Control Scheme for Bus Voltage Unbalance and Harmonics Compensation in Microgrids ..... 4439**

Jia Liu, Yushi Miura and Toshifumi Ise  
Osaka University, Japan

**Smart Inverter Volt-Watt Control Design in High PV Penetrated Distribution Systems ..... 4447**

Mahsa Ghapandar Kashani, Maziar Mobarrez and Subhashish Bhattacharya  
North Carolina State University, United States

**Virtual Resistance Technique for Power Limit Management of Microgrid DG Inverters ..... 4453**

Siddhesh Shinde, S. Milad Tayebi, Hu Haibing, Nasser Kutkut and Issa Batarseh  
University of Central Florida, United States; Nanjing University of Aeronautics & Astronautics, China

**Session 126: Datacenters and Telecommunication Applications**

**Chair(s): Al-Thaddeus Avestruz, Ashish Kumar**

**A High Efficiency Resonant Switched-Capacitor Converter for Data Center ..... 4460**

Yanchao Li, Xiaofeng Lyu, Dong Cao, Shuai Jiang and Chenhao Nan  
North Dakota State University, United States; Google Inc., United States

**A Series-Stacked Architecture with 4-to-1 GaN-based Isolated Converters for High-Efficiency Data Center Power Delivery ..... 4467**

Yizhe Zhang, Enver Candan and Robert C.N. Pilawa-Podgurski  
University of Illinois at Urbana-Champaign, United States

**Improved Model Predictive Control for High Voltage Quality in Microgrid Applications ..... 4475**

T. Dragicevic, M. Alhasheem, M. Lu, and F. Blaabjerg  
Aalborg University, Denmark; Arab Academy for Science, Technology and Maritime Transport, Egypt

**Virtual Resistance-based Control Strategy for DC link Regeneration Protection and Current Sharing in Uninterruptible Power Supply ..... 4481**

Jinghang Lu, Yajuan Guan, Mehdi Savaghebi and Josep Guerrero  
Aalborg University, Denmark

## **Session 127: Power Electronics in Electrified Vehicles**

**Chair(s): Matthias Preindl, Gui-Jia Su**

### **Range Extension of Electric Vehicles by Two Battery HEECS Chopper based Power Train ..... 4488**

Ayataro Tamura, Koji Kobayashi, Yukinori Tsuruta, Kazuaki Kojima, Hidemine Obara and Atsuo Kawamura  
Yokohama National University, Japan

### **A Delta-Structured Switched-Capacitor Equalizer for Series-Connected Battery Strings ..... 4493**

Yunlong Shang, Bing Xia, Jufeng Yang, Chenghui Zhang, Naxin Cui and Chris Mi  
Shandong University, China; San Diego State University, United States; University of California-San Diego,  
United States; Nanjing University of Aeronautics and Astronautics, China

### **An Automatic EMI Filter Design Methodology for Electric Vehicle Application ..... 4497**

Dong Zhang, Tao Fan, Puqi Ning and Xuhui Wen  
China Academy of Sciences, China

### **1.8MHz Isolated DC-DC Converter with Multi-Transformer Structure for Automotive Applications ..... 4504**

Goh Teck Chiang, Shuji Tomura and Takahide Sugiyama  
Toyota Central R&D Labs., Inc., Japan

## **Session 128: DAB DC/DC Converters**

**Chair(s): Alessandro Costabeber, Madhav Manjrekar**

### **Wide Range ZVS Operation of Three-Phase Dual Active Bridge Converters using Reduced Coupling Factor Transformers ..... 4512**

Carlos Teixeira, Jan Riedel, Brendan McGrath and Donald Grahame Holmes  
RMIT University, Australia

### **Modelling and Analysis of the Transformer Current Resonance in Dual Active Bridge Converters ..... 4520**

Zian Qin, Zhan Shen and Frede Blaabjerg  
Aalborg University, Denmark

### **A Novel ISOP Current-Fed Modular Dual-Active-Bridge (CF-MDAB) DC-DC Converter with DC Fault Ride-Through Capability for MVDC Application ..... 4525**

Yuxiang Shi, Ran Mo, Hui Li and Zhiguo Pan  
ABB Inc., United States; Florida State University, United States

### **Design Considerations for a High-Power Dual Active Bridge DC-DC Converter with Galvanically Isolated Transformer ..... 4531**

Youngsil Lee, Alan J. Watson, Gaurang Vakil and Patrick W. Wheeler  
University of Nottingham, United Kingdom

## **Session 129: MMC Modulation and Control**

**Chair(s): Pericle Zanchetta, Jean-Luc Schanen**

### **Lagrange-based Optimization of Cell Voltage and Arm Current with Zero-Sequence Current Injection in Modular Multilevel Converter ..... 4538**

Tsai-Fu Wu, Chun-Wei Huang and Tzu-Chieh Chou  
National Tsing Hua University, Taiwan

**Discontinuous PWM Scheme for a Modular Multilevel Converter with Advanced Switching Losses Reduction Ability ..... 4546**

Min-Gyo Jeong, Seok-Min Kim and Kyo-Beum Lee  
Ajou University, Korea

**Dynamic Matrix Predictive Control on DC-AC Modular Multilevel Converter: Design, Control and Real-Time Simulation ..... 4552**

Isaac Gonzalez-Torres, Homero Miranda, Cesar Mendez-Barrios, Victor Cardenas, Jose Espinoza, Marcos I. Gonzalez and Marcelo Perez  
Universidad Autónoma de San Luis Potosí, Mexico; Concepcion University, Chile; Universidad Tecnica Federico Santa Maria, Chile

**Capacitor Voltage Ripples Characterization and Reduction of Hybrid Modular Multilevel Converter with Circulating Current Injection ..... 4560**

Cong Zhao, Yaohua Li, Fei Xu, Zixin Li, Ping Wang and Ming Lei  
Chinese Academy of Sciences, China; University of Chinese Academy of Sciences, China

**Session 130: Control of Grid Connected Converter**

**Chair(s): Joseph Olorunfemi Ojo, Xiongfei Wang**

**An Envelope-based Detection Method for Resonance Damping in Grid-Connected Converters .... 4568**

Chia-Tse Lee, Akira Kikuchi and Tomomichi Ito  
Hitachi, Ltd., Japan

**Manitoba Inverter – Single Phase Single-Stage Buck-Boost VSI Topology ..... 4576**

Carl Ngai Man Ho and Ken King Man Siu  
University of Manitoba, Canada

**Direct Decoupled Active and Reactive Predictive Power Control of Grid-Tied Quasi-Z-Source Inverter for Photovoltaic Applications ..... 4582**

Sarthak Jain, Sivasai Praneeth Nanduri, Mohammad B. Shadmand, Robert S. Balog and Haitham Abu-Rub  
Texas A&M University, United States; Kansas State University; United States; Texas A&M University at Qatar, Qatar

**Optimal Phase Shifted Method to Reduce Current Ripples for a Parallel Grid-Connected Voltage Source Inverter under Unequal DC-Link Voltage ..... 4589**

June-Hee Lee and Kyo-Beum Lee  
Ajou University, Korea

**Session 131: Modeling and Control of AC-DC Converters**

**Chair(s): Frede Blaabjerg, Marco Dalla Costa**

**A Robust Deadbeat Predictive Power Control with Sliding Mode Disturbance Observer for PWM Rectifiers ..... 4595**

Haitao Yang, Yongchang Zhang, Jiejunyi Liang, Nong Zhang and Paul Walker  
University of Technology, Sydney, Australia; North China University of Technology, China

**A Control Strategy to Compensate for Current and Voltage Measurement Errors in Three-Phase PWM Rectifiers ..... 4601**

Trinh Quoc Nam, Choo Fook Hoong, Tang Yi and Wang Peng  
Nanyang Technological University, Singapore

<b>Carrier based PWM for Reduced Capacitor Voltage Ripple in Three-Phase Three-Switch Buck-Type Rectifier System .....</b>	<b>4609</b>
Beomseok Chae, Yongsug Suh and Tahnun Kang Chonbuk National University, Korea; Milimsyscon Co., Korea	
<b>Direct Power Control of PWM Rectifier under Unbalanced Network using Extended Power Theory ....</b>	<b>4617</b>
Yongchang Zhang, Jie Liu and Jihao Gao North China University of Technology, China	
<b>Session 132: Model Predictive Control of Power Converters I</b>	
<b>Chair(s): Ralph Kennel, Tobias Geyer</b>	
<b>Modulated Model Predictive Control for Active Split DC-bus 4-leg Power Supply .....</b>	<b>4622</b>
S. Bifaretti, S. Pipolo, A. Lidozzi, L. Solero, L. Tarisciotti and P. Zanchetta University of Rome Tor Vergata, Italy; Roma Tre University, Italy; University of Nottingham, United Kingdom	
<b>On the Inherent Relationship between Finite Control Set Model Predictive Control and SVM-based Deadbeat Control for Power Converters .....</b>	<b>4628</b>
Yongchang Zhang, Jie Liu and Shengwen Fan North China University of Technology, China	
<b>Predictive Current Control for Stabilizing Power Electronics based AC Power Systems .....</b>	<b>4634</b>
M.A. Awal, Iqbal Husain and Wensong Yu North Carolina State University, United States	
<b>Computationally Efficient Long-Horizon Direct Model Predictive Control for Transient Operation .....</b>	<b>4642</b>
Petros Karamanakos, Tobias Geyer and Ricardo P. Aguilera Tampere University of Technology, Finland; ABB Corporate Research, Switzerland; University of Technology Sydney, Australia	
<b>Session 133: Thermal Model of Electric Machines</b>	
<b>Chair(s): Davide Barater, Rashmi Prasad</b>	
<b>Improved Thermal Model for Predicting End-Windings Heat Transfer .....</b>	<b>4650</b>
Gabriele Luca Basso, Yew Chuan Chong, James Goss and Dave Staton Royal Institute of Technology, Sweden; Motor Design Ltd, United Kingdom	
<b>Reducing the Complexity of Thermal Models for Electric Machines via Sensitivity Analyses .....</b>	<b>4658</b>
B. Assaad, K. El kadri Benkara, G. Friedrich, S. Vivier and A. Michon Renault SAS, France; Université de technologie de Compiègne, France; CETIM, France	
<b>Importance of Thermal Modeling for Design Optimization Scenarios of Induction Motors .....</b>	<b>4666</b>
Gerd Bramerdorfer, Andrea Cavagnino and Silvio Vaschetto Johannes Kepler University Linz, Austria; Politecnico di Torino, Italy	
<b>Reduced Lumped Parameter Thermal Model for External Rotor Permanent Magnet Motor Design .....</b>	<b>4673</b>
Aitor Tovar-Barranco, Fernando Briz, Amaia López-de-Heredia and Irma Villar IK4-Ikerlan, Spain; Universidad de Oviedo, Spain	

## **Session 134: PM Machines, Demagnetization, Eccentricity and Losses**

**Chair(s): Gianmario Pellegrino, Bulent Sarliglu**

### **On-Line Detection of Rotor Eccentricity for PMSMs based on Hall-Effect Field**

**Sensor Measurements .....** 4678

Yonghyun Park, Daniel Fernandez, Sang Bin Lee, Doosoo Hyun, Myung Jeong, Suneel Kumar Kommuri, Changhee Cho, David Reigosa and Fernando Briz  
Korea University, Korea; University of Oviedo, Spain; Gyeonggi College of Science & Technology, Korea

### **Detection of Demagnetization in Permanent Magnet Synchronous Machines using Hall-Effect Sensors .....** 4686

David Reigosa, Daniel Fernandez, Yonghyun Park, Alberto B. Diez, Sang Bin Lee and Fernando Briz  
University of Oviedo, Spain

### **Demagnetization Study of an Interior Permanent Magnet Synchronous Machine Considering Transient Peak 3 Phase Short-Circuit Current .....** 4694

Seong Taek Lee  
BorgWarner, United States

### **Reduction of Inverter Carrier Harmonic Losses in Interior Permanent Magnet Synchronous Motors by Optimizing Rotor and Stator Shapes .....** 4699

Katsumi Yamazaki, Yusuke Togashi, Takeshi Ikemi, Shunji Ohki and Ryoichi Mizokami  
Chiba Institute of Technology, Japan; Nissan Motor Co., Ltd., Japan

## **Session 135: Control of Electric Drives II**

**Chair(s): Michael Harke, Alireza Fatemi**

### **Robust Control for High Performance Induction Motor Drives based on Partial State-Feedback Linearization .....** 4707

A. Accetta, F. Alonge, M. Cirrincione, F. D'Ippolito, M. Pucci, R. Rabbeni and A. Sferlazza  
University of Palermo, Italy; University of the South Pacific, Fiji; ISSIA CNR, Italy; CNRS, LAAS, France

### **The Vector Space Decomposition based Control for Multiple-Channel Indirect Matrix Converter Fed Dual Three-Phase PMSM Drives .....** 4714

Yang Xiao and Zheng Wang  
Southeast University, China

### **Predictive Current Control for Induction Motor using Online Optimization Algorithm with Constraints .....** 4720

Zhiguo Wang, Zedong Zheng, Yongdong Li, Boran Fan and Guibin Li  
Tsinghua University Beijing, China; Xinjiang University, China

### **Implementing Observer-based Design Methodology for Deadbeat-Direct Torque and Flux Control with Back-EMF Self-Sensing using Rapid Control Prototyping .....** 4726

Shang-Chuan Lee and Robert D. Lorenz  
University of Wisconsin-Madison, United States

## **Session 136: Emerging Applications**

**Chair(s): Jin Wang, Mark J Scott**

### **Design of a Linear Permanent Magnet Synchronous Motor for Needle-Free Jet Injection .....** 4734

Nick N.L. Do, Andrew J. Taberner and Bryan P. Ruddy  
University of Auckland, New Zealand

**An Energy Harvesting Scheme for Dielectric Elastomer Generators ..... 4741**

Ramanuja Panigrahi, Santanu Mishra, Arpit Kumar Srivastava and Sumit Basu  
Indian Institute of Technology Kanpur, India

**A Bipolar Self-Start up Boost Converter for Thermoelectric Energy Harvesting ..... 4747**

Keita Taeda and Hirotaka Koizumi  
Tokyo University of Science, Japan

**Comparative Analysis and Evaluation of High Voltage Power Generation Architectures ..... 4753**

Saijun Mao, Jelena Popovic, Jan Abraham Ferreira, Chengmin Li and Wuhua Li  
Delft University of Technology, Netherlands; Zhejiang University, China

**Thursday, October 5****Session 137: Other Topics in Renewable Energy Applications**

Chair(s): Fei Gao, John Lam

**Performance of Anti-Islanding of an Improved Reactive Power Variation Method based on Positive Feedback ..... 4761**

Jongmin Jo and Hanju Cha  
Chungnam National University, Korea

**Shaping of PWM Converter Admittance with Outer Power Control Loop ..... 4766**

Byeong-Heon Kim and Seung-Ki Sul  
North Carolina State University, United States; Seoul National University, Korea

**Hydrokinetic Powered Irrigation Network Automation: A Scalable Architecture for the Enablement of Real-Time Automated Decentralized Control of the Irrigation Water Delivery System in Developing Countries ..... 4773**

Mohammad A. Bharmal, Syeda Q. Akbar, Sana Noor, Rabiya Farooq and Nauman A. Zaffar  
Lahore University of Management Sciences, Pakistan

**Wind Farm Grounding System Analysis ..... 4780**

Massood Keshavarz Siahpouosh, Li Li and David G. Dorrell  
University of Technology Sydney, Australia; University of KwaZulu-Natal, South Africa

**Session 138: Power Quality of Grid Connected Converters I**

Chair(s): Brandon Grainger, Stefano Bifaretti

**Diversifying the Role of Distributed Generation Grid Side Converters for Improving the Power Quality of Distribution Networks using Advanced Control Techniques ..... 4786**

Zunaib Ali, Nicholas Christofides, Lenos Hadjidemetriou and Elias Kyriakides  
Frederick University, Cyprus; University of Cyprus, Cyprus

**Circulating Resonant Current Suppression for Current-Controlled Inverters based on Output Impedance Shaping ..... 4794**

Qiang Qian, Binfeng Zhang, Zhaojun Ni, Shaojun Xie, Jinming Xu and Kunshan Xu  
Nanjing University of Aeronautics and Astronautics, China

**Sensorless Unbalance Correction as an Ancillary Service for LV 4-Wire/3-Phase Power Converters ... 4799**

Andres Suárez-González, Pablo García, Ángel Navarro-Rodríguez, Geber Villa and Jose M. Cano  
University of Oviedo, Spain

<b>Convertible Static Transmission Controller Model and Supervisory Vector Control for Operation under Unbalanced Grid Conditions .....</b>	<b>4806</b>
---	-------------

Faris E. Alfaris and Subhashish Bhattacharya  
North Carolina State University, United States

## **Session 139: Control and Design Techniques for Microgrids II**

**Chair(s): Ron Hui, Tsai-Fu Wu**

<b>Operation Optimization for Multi-microgrids Based on Centralized-Decentralized Hybrid Hierarchical Energy Management .....</b>	<b>4813</b>
---	-------------

Meiqin Mao, Yangyang Wang, Liuchen Chang and Yan Du  
Hefei University of Technology, China

<b>Coordinated Failure Response and Recovery in a Decentralized Microgrid Architecture .....</b>	<b>4821</b>
--	-------------

Abedalsalam Bani-Ahmed, Mohammad Rashidi and Adel Nasiri  
University of Wisconsin-Milwaukee, United States

<b>Analysis and Improvement of Synchronous Stability of Micro-Grids with Parallel Connected Inverters .....</b>	<b>4826</b>
---	-------------

Vikram Roy Chowdhury, Subhajyoti Mukherjee, Pourya Shamsi and Mehdi Ferdowsi  
Missouri University of Science and Technology, United States

<b>Smart Resistor: Trajectory Control of Constant Power Loads in DC Microgrids .....</b>	<b>4832</b>
--	-------------

Eric Bauer, Karun Arjun Potty, He Li and Jin Wang  
Ohio State University, United States

## **Session 140: Wireless Charging for EV**

**Chair(s): ChunTaek Rim, Dong Dong**

<b>Load Power Agnostic 6.6 kW Wireless EV Charger with LCL Tuned Primary and Secondary Side Regulation .....</b>	<b>4839</b>
--	-------------

Veda P. Galigekere, Omer C. Onar, Madhu Chinthalapudi, and Zhiqiang Wang  
Oak Ridge National Laboratory, United States

<b>High Power Factor Z-Source Resonant Wireless Charger with Soft Switching .....</b>	<b>4845</b>
---	-------------

Hulong Zeng and Fang Zheng Peng  
Michigan State University, United States

<b>Bifurcation Phenomenon Limits for Three Phase IPT Systems with Constant Coupling Coefficient .....</b>	<b>4851</b>
---	-------------

Ugaitz Iruretagoyena, Asier Garcia-Bediaga, Luis Mir, Haritza Camblong and Irma Villar  
IK4-Ikerlan Technology Research Centre, Spain; University of the Basque Country, Spain; École Supérieure des Technologies Industrielles Avances, France

<b>A Practical Static Simulator for Dynamic Wireless Charging of Electric Vehicle using Receiver Open Circuit Voltage Equivalent .....</b>	<b>4859</b>
--	-------------

Shuangcheng Song, Qianfan Zhang, Chunbo Zhu and Diri Wang  
Harbin Institute of Technology, China

## **Session 141: Multilevel Converters Applications**

**Chair(s): Sheldon Williamson, Liliana De Lillo**

- Low-Voltage-Ride-Through Control of a Modular Multilevel SDBC Inverter for Utility-Scale Photovoltaic Systems .....** 4865

Paul Sochor, Hiroyuki Akagi and Nadia M.L. Tan  
Tokyo Institute of Technology, Japan; Universiti Tenaga Nasional, Malaysia

- Common-Mode Voltage Analysis and Suppression in Five-Level Modular Composited Converter .....** 4873

Jiawei Hu, Junsong Tang, Ye Mei, Senjun Hu, Wuhua Li and Xiangning He  
Zhejiang University, China

- Low Voltage Ride through Performance of a STATCOM based on Modular Multilevel Cascade Converters for Offshore Wind Application .....** 4879

Takaaki Tanaka, Huai Wang, Ke Ma and Frede Blaabjerg  
Aalborg University, Denmark; Fuji Electric Co., Ltd., Japan; Shanghai Jiao Tong University, China

- Asymmetrical Hybrid Unidirectional T-Type Rectifier for High-Speed Gen-Set Applications .....** 4887

S. Foti, A. Testa, G. Scelba, V. Sabatini, A. Lidozzi and L. Solero  
University of Messina, Italy; University of Catania, Italy; Roma Tre University, Italy

## **Session 142: MMC New Topologies**

**Chair(s): Andrea Formentini, Marcello Pucci**

- ESBC: An Enhanced Modular Multilevel Converter with H-Bridge Front End .....** 4894

Emmanuel Amankwah, Alessandro Costabeber, Omar Jasim, David Trainer and Jon Clare  
The University of Nottingham, United Kingdom; GE Energy Connections, United Kingdom

- Investigation of a New Modular Multilevel Converter with DC Fault Blocking Capability .....** 4902

Xing Hu, Jianzhong Zhang, Shuai Xu and Yongjiang Jiang  
Southeast University, China

- A New Hybrid MMC with Integrated Battery Energy Storage .....** 4908

Ping Wang, Tao Zhang and Rui Li  
Shanghai Jiao Tong University, China

- Enhanced Modular Multilevel Converter based Battery Energy Storage System .....** 4914

Xiaofeng Yang, Yao Xue, Bowei Chen, Fan Yang, Trillion Q. Zheng and Youyun Wang  
Beijing Jiaotong University, China; Tianshui Electric Drive Research Institute Co. Ltd., China

## **Session 143: Modeling and Control of DC-DC Converters I**

**Chair(s): Praveen Jain, Petros Karamanakos**

- Seamless Transition of the Operating Zones for the Extended-Duty-Ratio Boost Converter .....** 4920

Jinia Roy and Raja Ayyanar  
Arizona State University, United States

- A Digital Closed-Loop Control Strategy for Maintaining the 180° Phase Shift of an Interleaved BCM Boost Converter for PFC Applications .....** 4927

Robert T. Ryan, John G. Hayes, Richard Morrison and Diarmuid Hogan  
University College Cork, Ireland; Excelsys Technologies, Ireland

<b>Digital Type II Compensation with Forced-Output Control of an Interleaved Two-Phase Coupled-Inductor Boost Converter .....</b>	<b>4935</b>
Brendan C. Barry, John G. Hayes, Robert T. Ryan, Marek S. Rylko, Robert Stala, Adam Penczek and Andrzej Mondzik	
University College Cork, Ireland; SMA Magnetics Sp. z.o.o. R&D, Poland	
<b>Dual-Frequency On-Off Control for a 20 MHz Class E DC-DC Converter .....</b>	<b>4942</b>
Ying Li, Xinbo Ruan, Jiandong Dai and Zhihong Ye	
Nanjing University of Aeronautics and Astronautics, China; Lite-On Technology, China	
<b>Session 144: Model Predictive Control of Power Converters II</b>	
<b>Chair(s): Jian Guo Zhu, Jose Rodriguez</b>	
<b>Long Horizon Linear MPC of Grid-Connected VSIs: Regulation Problems and a Plug-In Solution .....</b>	<b>4950</b>
Chee Shen Lim, Sze Sing Lee, Xin Kong and Inam Ullah Nutkani	
University of Southampton Malaysia Campus, Malaysia; Agency for Science Technology and Research, Singapore; Royal Melbourne Institute of Technology, Australia	
<b>Voltage Sensorless Improved Model Predictive Direct Power Control for Three-Phase Grid-Connected Converters .....</b>	<b>4957</b>
Amir Masoud Bozorgi, Hosein Gholami-Khesht, Mehdi Farasat, Shahab Mehraeen and Mohammad Monfared	
Louisiana State University, United States; Ferdowsi University of Mashhad, Iran	
<b>Finite Control Set Model Predictive Control Assisted by a Linear Controller for True Parameter Uncertainty Compensation .....</b>	<b>4964</b>
Rodrigo Mendez, Daniel Sbarbaro, Jose Espinoza and Christian Rojas	
Concepcion University, Chile	
<b>Model Predictive Control of Dual-Mode Operations Z-Source Inverter: Islanded and Grid-Connected .....</b>	<b>4971</b>
Sally Sajadian and Reza Ahmadi	
University of Kansas, United States	
<b>Session 145: Stability in Power Converters</b>	
<b>Chair(s): Yam Siwakoti, Jiangchao Qin</b>	
<b>LCL Filter Design based on Non-Minimum-Phase Stability Region for Grid-Connected Inverters in Weak Grid .....</b>	<b>4978</b>
Fang Liu, Jie Zhang, Haizhen Xu, Xing Zhang, Wenguang Zhao and Meng Wang	
Hefei University of Technology, China	
<b>A Way of Increasing Stability Margin of Current Control in VSCs Connected to the Grid through LCL Filters .....</b>	<b>4983</b>
Leonardo Marin, Pedro Rodriguez, Ignacio Candela and Joan Rocabert	
Polytechnic University of Catalonia, Spain	
<b>Small-Signal Modeling of Single-Phase PLLs using Harmonic Signal-Flow Graphs .....</b>	<b>4989</b>
Shahil Shah and Leila Parsa	
Rensselaer Polytechnic Institute, United States; University of California-Santa Cruz, United States	

**Current-Mode Controlled Single-Inductor Dual-Output Buck Converter with Ramp Compensation .... 4996**

Yao Wang, Jianping Xu, Shuhan Zhou, Tianyang Zhao and Kai Liao

Southwest Jiaotong University, China; Southwest Minzu University, China; Nanyang Technological University, Singapore

**Session 146: High Torque Machines****Chair(s): Hamid A. Toliyat, Wei Xu****A New Perspective on the PM Vernier Machine Mechanism ..... 5001**

Kangfu Xie, Dawei Li, Ronghai Qu, Xiang Ren and Yuan Pan

Huazhong University of Science and Technology, China

**Internal Rotor Airgap-Less Electric Motors ..... 5009**

Omar Nezamuddin, Maryam Alibeik, Rishikesh Bagwe, Matthew Rubin and Euzeli dos Santos Jr.

Purdue University-Indianapolis, United States; Indiana University, United States

**Design, Construction, and Analysis of a Large Scale Inner Stator Radial Flux Magnetically Geared Generator for Wave Energy Conversion ..... 5017**Matthew Johnson, Matthew C. Gardner, Hamid A. Toliyat, Steven Englebretson, Wen Ouyang and Colin Tschida  
Texas A&M University, United States; ABB Inc., United States**Magnetic Gearing Effect in Vernier Permanent Magnet Synchronous Machines ..... 5025**

Yue Liu and Z.Q. Zhu

University of Sheffield, United Kingdom

**Session 147: Small PM Motors****Chair(s): Akira Chiba, Rajib Mikail****Design Optimization of a Small Single-Phase Motor with Auxiliary Permanent Magnet ..... 5033**

Mauro Andriollo, Andrea Tortella and Stefano Trubian

University of Padova, Italy

**Slotless Lightweight Motor for Drone Applications ..... 5041**

Md Sariful Islam, Iqbal Husain and Rajib Mikail

North Carolina State University, United States; ABB Inc., United States

**Novel 4/4 Stator/Rotor Single-Phase Asymmetric-Stator-Pole Doubly Salient Permanent Magnet Machine ..... 5049**

Mingjie He, Wei Xu and Caiyong Ye

Huazhong University of Science and Technology, China

**Design Optimization of a Line-start PMSM Considering Transient and Steady-state Performance Objectives ..... 5057**

Alber J. Sorgdrager, Rong-Jie Wang and Andre J. Grobler

Stellenbosch University, South Africa; North-West University, South Africa

**Session 148: Electric Drives for Wind and Other Renewable Integration****Chair(s): Jiangbiao He, Yue Zhao****Power Conversion and Control of a Magnetic Gear Integrated Permanent Magnet Generator for Wave Energy Generation ..... 5065**

Samir Hazra, Prathamesh Kamat, Subhashish Bhattacharya, Wen Ouyang and Steven Englebretson

North Carolina State University, United States; ABB Corporate Research Center, United States

**A Novel Active Damping Scheme for use with Regenerative Converters ..... 5073**

Mahesh Swamy  
Yaskawa America, Inc., United States

**Model Predictive Power Control of a Brushless Doubly Fed Twin Stator Induction Generator ..... 5080**

Xinchi Wei, Ming Cheng, Wei Hua, Jianguo Zhu and Haitao Yang  
Southeast University, China; University of Technology Sydney, Australia

**A New Rotor Speed Observer for Stand-Alone Brushless Doubly-Fed Induction Generators ..... 5086**

Yi Liu, Wei Xu, Teng Long and Frede Blaabjerg  
Huanggang Normal University, China; Huazhong University of Science and Technology, China; University of Cambridge, United Kingdom; Aalborg University, Denmark

**Session 149: SiC Switching I**

**Chair(s): Francesco Iannuzzo, Shashank Krishnamurthy**

**Low Inductance Switching for SiC MOSFET based Power Circuit ..... 5093**

Edward Shelton, Xueqiang Zhang, Tianqi Zhang, Nikita Hari and Patrick Palmer  
University of Cambridge, United Kingdom

**Self-Supplied Isolated Gate Driver for SiC Power MOSFETs based on Bi-Level Modulation Scheme .... 5101**

Jorge Garcia, Emre Gurpinar, Alberto Castellazzi and Pablo Garcia  
University of Oviedo, Spain; University of Nottingham, United Kingdom

**Multi-Level Active Gate Driver for SiC MOSFETs ..... 5107**

Harry C.P. Dymond, Dawei Liu, Jianjing Wang, Jeremy J.O. Dalton and Bernard H. Stark  
University of Bristol, United Kingdom

**Analytical Investigation on Design Instruction to Avoid Oscillatory False Triggering of Fast  
Switching SiC-MOSFETs ..... 5113**

Yusuke Sugihara, Kimihiro Nanamori, Seiya Ishiwaki, Yuma Hayashi, Kyota Aikawa, Kazuhiro Umetani,  
Eiji Hiraki and Masayoshi Yamamoto  
Shimane University, Japan; Okayama University, Japan; Nagoya University, Japan

**Session 150: New Device, Circuit and Control Strategies**

**Chair(s): Xiu Yao, Lihua Chen**

**Comparison of 1.7kV, 450A SiC-MOSFET and Si-IGBT based Modular Three Phase Power Block ..... 5119**

Sayan Acharya, Xu She, Rajib Datta, Maja Harfman Todorovic and Gary Mandrusiak  
North Carolina State University, United States; GE Global Research, United States

**A Fast Dynamic Photovoltaic Simulator with Instantaneous Output Impedance  
Matching Controller ..... 5126**

Isuru D.G. Jayawardana, Carl Ngai Man Ho, Mandip Pokharel and Gerardo Escobar  
University of Manitoba, Canada; Universidad Autonoma del Carmen, Mexico

**High-Frequency Induction Heating for Small-Foreign-Metal Particle Detection using 400 kHz  
SiC-MOSFETs Inverter ..... 5133**

Takuya Shijo, Shinya Kurachi, Yuki Uchino, Yujiro Noda, Hiroaki Yamada and Toshihiko Tanaka  
Yamaguchi University, Japan

**Compact Integrated Gate Drives and Current Sensing Solution for SiC Power Modules ..... 5139**

Dazhong Gu and Parag Kshirsagar

United Technologies Research Center, United States

**Session 151: Energy Storage Systems****Chair(s): Jae-Do Park, Bilal Akin****Fractional Converter for High Efficiency High Power Battery Energy Storage System ..... 5144**

Fei Xue, Ruiyang Yu and Alex Huang

North Carolina State University, United States

**Investigation of Hybrid Electrode Optimization for Energy Storage Applications with Varying Energy and Power Requirements using HPPC Cycling ..... 5151**

Kevin J. Frankforter, M. Isabel Tejedor-Tejedor, Marc A. Anderson and Thomas M. Jahns

University of Wisconsin-Madison, United States; IMDEA Energy Institute, Spain

**Modeling and State-Space Feedback Design of the Battery Current Controller for the Energy Stored Quasi-Z-Source Inverter ..... 5159**

Dongqi Fan, Yujie Wang, Sideng Hu, Min Chen and Xiangning He

Zhejiang University, China

**A Novel Battery Management System using a Duality of the Adaptive Droop Control Theory ..... 5164**

Sifat M. Chowdhury, Mohamed Badawy, Yilmaz Sozer and J. Alexis De Abreu-Garcia

University of Akron, United States; San Jose State University, United States

**Session 152: Power Conversion Systems for AC and DC Grids****Chair(s): Yazan Alsmadi, Srdjan Lukic****A Modular SCR-based DC-DC Converter for Medium-Voltage Direct-Current (MVDC) Grid Applications ..... 5170**

Abdulgafor Alfares, Ehsan Afshari, Mahshid Amirabadi and Brad Lehman

Northeastern University, United States

**N-Series Modules based on SST for Mobile Power Substations ..... 5178**

Cheng Deng, Tao Yang and Juan Carlos Balda

University of Arkansas, United States; Xiangtan University, China

**Re-Synchronization Strategy for the Synchronous Power Controller in HVDC Systems ..... 5186**

Cristian Verdugo, Jose Ignacio Candela and Pedro Rodriguez

Polytechnic University of Catalonia, Spain; Loyola Andalucía University, Spain

**A Design Method of MMC-HVDC Physical Simulation System ..... 5192**

Liu Dong, He Zhiyuan, Gao Lu and Kou Longze

Global Energy Interconnection Research Institute, China

**Session 153: Power Quality of Grid Connected Converters II****Chair(s): Liuchen Chang, Jonathan Kimball****Four-Wired Dynamic Voltage Restorers based on Cascade Open-End Winding Transformers ..... 5198**

Gregory A.A. Carlos, Cursino B. Jacobina, Joao P.R.A. Mello and Alexandre C. Oliveira

Federal Institute of Alagoas, Brazil; Federal University of Campina Grande, Brazil

<b>Investigation of CCL Filter for Multilevel Selective Harmonic Compensation (SHC) with Staircase Waveform .....</b>	<b>5206</b>
Hui Zhao, Shuo Wang, Amirhossein Moeini and Le Yang University of Florida, United States	
<b>Power Electronics Intelligence at the Network Edge (PINE) .....</b>	<b>5214</b>
Hung-Ming Chou, Le Xie, Prasad Enjeti and P.R. Kumar Dominion Energy, United States; Texas A&M University, United States	
<b>Performance Investigation of Hybrid Active Filter During Low Load Condition .....</b>	<b>5222</b>
Richard Beddingfield, David Storelli, Hesam Mirzaee and Subhashish Bhattacharya North Carolina State University, United States; Quanta Technology, United States	
<b>Session 154: Modeling and Monitoring of Batteries I</b>	
<b>Chair(s): Veda Prakash Galigekere, Fei Gao</b>	
<b>On-Board State-of-Health Estimation based on Charging Current Analysis for LiFePO4 Batteries .....</b>	<b>5229</b>
Jufeng Yang, Bing Xia, Wenxin Huang and Chris Mi Nanjing University of Aeronautics and Astronautics, China; San Diego State University, United States; University of California-San Diego, United States	
<b>A Compact Unified Methodology via a Recurrent Neural Network for Accurate Modeling of Lithium-Ion Battery Voltage and State-of-Charge .....</b>	<b>5234</b>
Ruxiu Zhao, Phillip J. Kollmeyer, Robert D. Lorenz and Thomas M. Jahns University of Wisconsin-Madison, United States	
<b>A Novel Li-Ion Battery Pack Modeling Considering Single Cell Information and Capacity Variation ...</b>	<b>5242</b>
Jaehyung Lee, Jung-Hoon Ahn and Byoung Kuk Lee Sungkyunkwan University, Korea	
<b>A Real-Time Condition Monitoring for Lithium-Ion Batteries using a Low-Priced Microcontroller .....</b>	<b>5248</b>
Taesic Kim, Amit Adhikaree, Daewook Kang, Myoungho Kim, Chang-Yeol Oh and Juwon Baek Texas A&M University-Kingsville, United States; Korea Electrotechnology Research Institute, Korea	
<b>Session 155: Multilevel Converters I</b>	
<b>Chair(s): Pericle Zanchetta, Luca Solero</b>	
<b>Interleaved Operation of Paralleled Neutral-Point Clamped Inverters with Reduced Circulating Current .....</b>	<b>5254</b>
Zhi-Xiang Zou, Frederik Hahn, Sebastian Brueske, Sandro Guenter, Giampaolo Buticchi, Marco Liserre and Friedrich W. Fuchs Christian-Albrechts-Universität zu Kiel, Germany	
<b>A New Modulation Method for a Five-Level Hybrid-Clamped Inverter with Reduced Flying Capacitor Size .....</b>	<b>5262</b>
Boran Fan, Kui Wang, Zedong Zheng, Lie Xu and Yongdong Li Tsinghua University, China	
<b>A Novel Multilevel Converter with Reduced Switch Count for Low and Medium Voltage Applications .....</b>	<b>5267</b>
Margarita Norambuena, Jose Rodriguez, Samir Kouro and Akshay Rathore Universidad Tecnica Federico Santa Maria, Chile; Universidad Andres Bello, Chile; Concordia University, Canada	

**Five-Level Reduced Hybrid Inverter with Coupled Inductors ..... 5273**

Diego A. Acevedo-Bueno, Juliano C. Leal da Silva, Edison Roberto C. da Silva and Montie A. Vitorino  
UFCG, Brazil; UFPB, Brazil

**Session 156: PFC Converters**

**Chair(s): Gerry Moschopoulos, Giacomo Scelba**

**Dynamic Response Optimization for Interleaved Boost PFC Converter with Improved Dual Feedforward Control ..... 5280**

Lei Bai, Xiaoyong Ren, Qi Hui, Yu Wu, Kunqi Li, Zhehui Guo and Yue Zhang  
Nanjing University of Aeronautics and Astronautics, China; State Grid Nanjing Power Supply Company, China

**Manitoba Rectifier – Bridgeless Buck-Boost PFC ..... 5287**

Ken King Man Siu and Carl Ngai Man Ho  
University of Manitoba, Canada

**Low THD Multipliers for BCM Buck and Cascaded Buck-Boost PFC Converters ..... 5293**

Ramanujam Ramabhadran, Yehuda Levy, Bruce Roberts and Pradeep V.  
GE Global Research, United States

**Multi-Objective Optimisation of a Bidirectional Single-Phase Grid Connected AC/DC Converter (PFC) with Two Different Modulation Principles ..... 5298**

Johan Le Leslé, Rémy Caillaud, Florent Morel, Nicolas Degrenne, Cyril Buttay, Roberto Mrad, Christian Vollaire and Stefan Mollov  
Mitsubishi Electric R&D Centre Europe, France; Université de Lyon, France

**Session 157: Modeling and Control of DC-DC Converters II**

**Chair(s): Xinbo Ruan, Khurram Afzidi**

**Approximate-Model-based Predictive Current Control for Buck Converter in CCM ..... 5306**

Benfei Wang, Liang Xian, Abhisek Ukil and Hoay Beng Gooi  
Nanyang Technological University, Singapore

**Stable Output Current Estimation for Switching Power Converter ..... 5312**

Hiidenori Maruta, Shingo Watanabe, Nobumasa Matsui, Fujio Kurokawa and İlhami Colak  
Nagasaki University, Japan; Nagasaki Institute of Applied Science, Japan; Nisantasi University, Japan

**Design and Optimization of the High Frequency Transformer for a 800V/1.2MHz SiC LLC Resonant Converter ..... 5317**

Suxuan Guo, Pengkun Liu, Lili Zhang and Alex Q. Huang  
North Carolina State University, United States; Texas Instruments Inc., United States

**Extension of Zero-Voltage-Switching Range in Dual Active Bridge Converter by Switched Auxiliary Inductance ..... 5324**

Hayato Higa and Jun-ichi Itoh  
Nagaoka University of Technology, Japan

## **Session 158: Modeling and Control of DC-AC Converters I**

**Chair(s): Luca Zarri, Yi Tang**

**IGBT-SiC Dual Fed Ground Power Unit .....** 5332

Luca Rovere, Andrea Formentini, Giovanni Lo Calzo, Pericle Zanchetta, Andrea Cassia and Mario

Marchesoni

University of Nottingham, United Kingdom; University of Genova, Italy

**Multi-Rate Modeling for Low Switching Frequency VSCs Applying Multi-Sampling Control .....** 5339

Hao Tian, Yun Wei Li and Qing Zhao

University of Alberta, Canada

**H-Infinity Current Control of the LC Coupled Voltage Source Inverter .....** 5347

Lucas Koleff, Lourenco Matakas Jr., Diego Colon and Eduardo Pellini

University of Sao Paulo, Brazil

**Analytical Averaged Loss Model of Three-Phase T-type STATCOM with Virtual Zero Level Modulation .....** 5355

Jun Wang, Xibo Yuan, Yonglei Zhang, Kfir J. Dagan, Xu Liu, David Drury, Phil Mellor and Andrew Bloor

University of Bristol, United Kingdom; Safran Electrical and Power UK, United Kingdom

## **Session 159: EMI in Power Converters**

**Chair(s): Jason Lai, Lixiang Wei**

**A Symmetrical Resonant Converter and PCB Transformer Structure for Common Mode Noise Reduction .....** 5362

Bin Li, Qiang Li, Fred C. Lee and Yuchen Yang

Virginia Polytechnic Institute and State University, United States

**Aperiodic Pulse-Modulation Technique to Reduce Peak EMI in Impedance-Source DC-DC Converters .....** 5369

Saad Ul Hasan, Yuba Raj Kafle and Graham E. Town

Macquarie University, Australia

**Integrated Common Mode and Differential Mode Inductors with Low Near Magnetic Field Emission .....** 5375

Huan Zhang, Boyi Zhang and Shuo Wang

University of Florida, United States

**Design, Implementation, and Evaluation of a GaN-based Four-Leg Inverter with Minimal Common Mode Voltage Generation .....** 5383

Di Han, Silong Li, Wooyoung Choi and Bulent Sarlioglu

University of Wisconsin-Madison, United States

## **Session 160: High Speed Machines**

**Chair(s): Jonathan Bird, Ronghai Qu**

**Design and Rotor Shape Modification of a Multiphase High Speed Permanent Magnet Assisted Synchronous Reluctance Motor for Stress Reduction .....** 5389

Md Tawhid Bin Tarek and Seungdeog Choi

University of Akron, United States

**Rotor Losses Reduction in High Speed PM Generators for Organic Rankine Cycle Systems ..... 5396**

Grazia Berardi and Nicola Bianchi

University of Padova, Italy

**Ripple Compensation of Suspension Force and Torque in a Bearingless SPM Motor with Integrated Winding ..... 5403**

Junichi Asama, Kenta Sasaki, Takaaki Oiwa and Akira Chiba

Shizuoka University, Japan; Tokyo Institute of Technology, Japan

**Electromagnetic and Thermodynamic Design of a Novel Integrated Flux-Switching Motor-Compressor with Airfoil-Shaped Rotor ..... 5409**

Hao Ding, Yingjie Li, Seun Guy Min and Bulent Sarlioglu

University of Wisconsin-Madison, United States

**Session 161: Noise, Vibration, Short Circuit of Electric Machines****Chair(s): Konstantinos Gyftakis, Rashmi Prasad****Inter-Turn Short Circuit Ratio Estimation in IPMSMs based on a Fault Index Current Observer ..... 5417**

Pablo Castro Palavicino, Dheeraj Bobba and Bulent Sarlioglu

University of Wisconsin-Madison, United States

**A Review of Condition Monitoring of Induction Motors based on Stray Flux ..... 5424**

Chen Jiang, Sufei Li and Thomas G. Habetler

Georgia Institute of Technology, United States

**Investigation of Design based Solutions to Reduce Vibration in Permanent Magnet Synchronous Machines with Low Order Radial Forces ..... 5431**

Iftekhar Hasan, Yilmaz Sozer, Alejandro Piña Ortega, Subhra Paul and Rakib Islam

University of Akron, United States; Nexteer Automotive, United States

**Analysis of Vibration of Permanent Magnet Synchronous Motor with Distributed Winding for the PWM Method of Voltage Source Inverters ..... 5438**Takafumi Hara, Toshiyuki Ajima, Yousuke Tanabe, Masanori Watanabe, Katsuhiro Hoshino and Kazuto Oyama  
Hitachi, Ltd., Japan; Hitachi Automotive Systems Ltd., Japan**Session 162: Electric Drives for Aerospace and Traction Applications****Chair(s): John Neely, Long Wu****A Current-Fed Quasi Z-Source Inverter with SiC Power Modules for EV/HEV Applications ..... 5445**

Faris E. Alfaris and Subhashish Bhattacharya

North Carolina State University, United States

**High Performance 12 kW Motor and Drive for Modern Aircrafts ..... 5453**

Sayeed Mir, John Neely and Stan Seely

Eaton Aerospace, United States

**Temperature Effects Compensation Control Algorithm of IPM Machines Utilizing Current Pulse Injection and Online Multi-Parameter Estimation for Traction Applications ..... 5461**

Silong Li, Di Han and Bulent Sarlioglu

University of Wisconsin-Madison, United States

**A Versatile Power-Hardware-in-the-Loop based Emulator for Rapid Testing of Electric Drives ..... 5468**

Amitkumar K.S., R. Sudharshan Kaarthik and Pragasen Pillay

Concordia University, Canada; Indian Institute of Space Science and Technology, India

**Session 163: SiC Switching II**

Chair(s): Keiji Wada, Ben Guo

**Extraction of Parasitic Inductances of SiC MOSFET Power Modules based on Two-Port S-****Parameters Measurement ..... 5475**Tianjiao Liu, Yanjun Feng, Runtao Ning, Wendi Wang, Thomas T.Y. Wong and Z. John Shen  
Illinois Institute of Technology, United States**High Speed dV/dt Control Technology for SiC Power Module for EV/HEV Inverters ..... 5483**Taku Shimomura, Takayuki Ikari, Akinori Okubo, Ryusei Yamada and Tetsuya Hayashi  
Nissan Motor Co., Ltd., Japan**Switching Performance of a SiC MOSFET Body Diode and SiC Schottky Diodes at****Different Temperatures ..... 5487**M.R. Ahmed, R. Todd and A.J. Forsyth  
University of Manchester, United Kingdom**Digital Control based Voltage Balancing for Series Connected SiC MOSFETs under****Switching Operations ..... 5495**Katsuya Shingu and Keiji Wada  
Tokyo Metropolitan University, Japan**Session 164: Wireless Power Transfer IV**

Chair(s): Huang-jen Chiu, Luis Herrera

**Optimization of Coils and Control Strategy for a Three-Phase Magnetically Coupled Resonant****Wireless Power Transfer System Oriented by the Optimal Output Power Characteristics ..... 5501**Xiewei Fu, Fuxin Liu and Xuling Chen  
Nanjing University of Aeronautics and Astronautics, China**Radiation Noise Reduction using Spread Spectrum for Inductive Power Transfer Systems****considering Misalignment of Coils ..... 5507**Keisuke Kusaka, Kent Inoue and Jun-ichi Itoh  
Nagaoka University of Technology, Japan**Maximum Power Point Tracker for Electromagnetic Energy Harvesting System**..... 5515  
Kimberley Hiu Kwan Tse and Henry Shu Hung Chung  
City University of Hong Kong, Hong Kong**Exciting Voltage Control for Transfer Efficiency Maximization for Multiple Wireless Power****Transfer Systems ..... 5523**Masato Sasaki and Masayoshi Yamamoto  
Sharp Corporation, Japan; Shimane University, Japan

## **Session 165: Hybrid Energy Systems**

**Chair(s): Jiacheng Wang, Jorge Garciav Garcia**

**Direct Storage Hybrid (DSH) Inverter: A New Concept of Intelligent Hybrid Inverter ..... 5529**

Ha Pham

University of Technology Sydney, Australia

**New Soft-Switched High Frequency Multi-Input Step-up/down Converters for High Voltage DC-**

**Distributed Hybrid Renewable Systems ..... 5537**

Sanjida Moury and John Lam

York University, Canada

**Optimal Sizing of Photovoltaic-Wind Hybrid System for Community Living Environment and**

**Smart Grid Interaction ..... 5545**

Mohammad B. Shadmand, Mehran Mirjafari and Robert S. Balog

Kansas State University, United States; Dell Inc., United States; Texas A&M University, United States

**Modeling and Control of Brushless DC Motor for Compressor Driving ..... 5553**

Zhiguang Hua, Dongdong Zhao, Manfeng Dou, Liming Yan and Haitao Zhang

Northwestern Polytechnical University, China

## **Session 166: Wave Energy System**

**Chair(s): Martin Ordóñez, Mazharul Chowdhury**

**Electromechanical Design and Experimental Evaluation of a Double-Sided, Dual Airgap Linear**

**Vernier Generator for Wave Energy Conversion ..... 5557**

Jennifer Vining, Tim Mundon and Balky Nair

Oscilla Power, United States

**Grid-Connected Operation of Direct-Drive Wave Energy Converter by using HVDC Line and**

**Undersea Storage System ..... 5565**

Seyyedmahdi Jafarishiadeh, Mehdi Farasat and Shahab Mehraeen

Louisiana State University, United States

**Power Conversion and Control of a Pole-Modulated Permanent Magnet Synchronous Generator**

**for Wave Energy Generation ..... 5572**

Samir Hazra, Prathamesh Kamat, Subhashish Bhattacharya, Wen Ouyang and Steven Englebretson

North Carolina State University, United States; ABB Corporate Research Center, United States

**Competitive Control of Wave Power Plants through Price-Signal Optimum Allocation of**

**Available Resources ..... 5579**

Antoni M. Cantarellas, Daniel Remón, Jorge M. García and Pedro Rodríguez

Abengoa, Spain; Technical University of Catalonia, Spain; Loyola Andalucía University, Spain

## **Session 167: Grid Connected Inverters and LCL Filter Design**

**Chair(s): Edison da Silva, Mahshid Amirabadi**

**Analysis and Design of LCL Filter based Synchronverter ..... 5587**

Roberto Rosso, Jair Cassoli, Soenke Engelken, Giampaolo Buticchi and Marco Liserre

WRD GmbH, Germany; Christian-Albrechts-University of Kiel, Germany

**A Common Magnetic Integration Method for Single-Phase LCL Filters and LLCL Filters ..... 5595**

Xiaoqiang Li, Jingyang Fang, Pengfeng Lin and Yi Tang  
Nanyang Technological University, Singapore

**Investigation of the Sideband Effect for the LCL-type Grid-connected Inverter with High LCL Resonance Frequency ..... 5601**

Dongsheng Yang, Xiongfei Wang and Frede Blaabjerg  
Aalborg University, Denmark

**An Improved Active Damping Method with Grid-Side Current Feedback to Maximize Damping Ratio for LCL-Type Grid-Connected Inverter ..... 5607**

Weibiao Wu, Li Peng, Yu Qi, Qian Liu, Zeyi Huang, Fangming Dong, Manlin Chen and Bowen Wang  
Huazhong University of Science and Technology, China; CRRC Zhuzhou institute Co., Ltd., China; Commercial Aircraft Corporation of China, Ltd., China; Shenzhen Hopewind Electric Co., Ltd., China

**Session 168: Modeling and Monitoring of Batteries II**

**Chair(s): Phillip Kollmeyer, Mohammad Anwar**

**An Advanced SOF Estimation Algorithm for LiFePO4 SLI Battery of Vehicle with Online Update of Cranking Resistance ..... 5612**

Tae-Won Noh, Jung-Hoon Ahn and Byoung Kuk Lee  
Sungkyunkwan University, Korea

**Online Condition Monitoring of Lithium-Ion Batteries using Impedance Spectroscopy ..... 5617**

Sean Moore and Paul Barendse  
University of Cape Town, South Africa

**A New State of Charge Estimation Method for Lithium-Ion Battery based on Sliding Mode Observer ..... 5625**

Chunyu Wang, Naxin Cui, Miao Liu and Chenghui Zhang  
Shandong University, China

**Accelerated Ageing of Lithium-Ion Batteries based on Electric Vehicle Mission Profile ..... 5631**

Daniel-Ioan Stroe, Maciej Swierczynski, Søren Knudsen Kær, Egoitz Martinez Laserna  
and Elixabet Sarasketa Zabala  
Aalborg University, Denmark; IK4-Ikerlan, Spain

**Session 169: Single-Phase AC/DC Converters**

**Chair(s): Hongliang Wang, Petar Grbovic**

**Half-Wave Class DE Low dv/dt Rectifier using Thinned-Out Method with Delta-Sigma Modulation .... 5638**

Akinobu Shigeno and Hirotaka Koizumi  
Tokyo University of Science, Japan

**A Single-Stage Asymmetrical Half-Bridge AC/DC Converter with Coupled Inductors ..... 5645**

Chia-Hao Li, Ying-Ting Huang, Yaow-Ming Chen and Yung-Ping Tong  
National Taiwan University, Taiwan; Lite-On Technology Corporation, Taiwan

**A 220-V AC, LUT-Controlled 6-Segmented LED Driver with Background Calibration ..... 5651**

Hyunseung Lee, Eunseo Kim and Jaeha Kim  
Seoul National University, Korea

<b>A Moving Pole-Placement Compensation Design Method to Increase the Bandwidth of RC-Damper-based Dual "Buck-Boost" AC/DC Converter .....</b>	<b>5657</b>
--	-------------

Weimin Wu, Weibo Qin, Houqing Wang, Min Huang, Frede Blaabjerg and Marco Liserre  
Shanghai Maritime University, China; Aalborg University, Denmark; Kiel University, Germany

## **Session 170: Multilevel Converters II**

**Chair(s): Alessandro Costabeber, Yi Tang**

<b>On-Line Switching Loss Reduction Scheme by General Space Vector PWM for Multilevel NPC Inverter .....</b>	<b>5665</b>
--	-------------

Toshiji Kato, Kaoru Inoue and Takumi Sono  
Doshisha University, Japan

<b>Three-Level Two-Stage Decoupled Active NPC Converter with Si IGBT and SiC MOSFET .....</b>	<b>5671</b>
---	-------------

Di Zhang, Jiangbiao He and Sachin Madhusoodhanan  
GE Global Research Center, United States

<b>A Ladder Transistor-Clamped Multilevel Inverter with High-Voltage Variation .....</b>	<b>5679</b>
--	-------------

Eshet T. Wodajo, Malik Elbuluk, Seungdeog Choi and Haitham Abu Rub  
University of Akron, United States; Texas A&M University at Qatar, Qatar

<b>Predictive Control of Modular Multilevel Series/Parallel Converter for Battery Systems .....</b>	<b>5685</b>
---	-------------

Zhongxi Li, Ricardo Lizana, Angel V. Peterchev and Stefan M. Goetz  
Duke University, United States; Universidad Católica de la Santísima Concepción, Chile

## **Session 171: Isolated DC/DC Converters**

**Chair(s): Luca Tarisciotti, Alireza Safaei**

<b>High-gain Soft-switching DC-DC Converter with Voltage-doubler Rectifier Modules .....</b>	<b>5692</b>
--	-------------

Rohit Suryadevara, Tao Li, Kumar Modepalli and Leila Parsa  
Rensselaer Polytechnic Institute, United States; Dialog Semiconductor, United States; FINsix Corporation, United States; University of California Santa Cruz, United States

<b>Driving Piezoelectric-Transformer-based DC/DC Converters using Pulse Density Modulation .....</b>	<b>5698</b>
--	-------------

Juan Diaz, Miguel J. Prieto, Fernando Nuno, Juan A. Martin-Ramos and Juan A. Martinez  
University of Oviedo, Spain

<b>Bidirectional DC-DC Converter Utilizing Magnetic and Capacitive Power Transfer – 97.1% Efficiency at 1.2-MHz Switching .....</b>	<b>5704</b>
---	-------------

Jong-Won Shin, Masanori Ishigaki, Ercan M. Dede and Jae Seung Lee  
Toyota Research Institute of North America, United States; Toyota Central RD Labs., Inc., Japan

<b>LLC Resonant Converter with Shared Power Switches and Dual Coupled Resonant Tanks to Achieve Automatic Current Sharing .....</b>	<b>5712</b>
---	-------------

Hongliang Wang, Yang Chen, Yan-Fei Liu, Zhihua Yang, Jahangir Afsharian and Bing Gong  
Queen's University, Canada; Murata Power Solutions, Canada

## **Session 172: Grid Synchronization Techniques**

**Chair(s): Zheng Wang, Alireza Bakhshai**

<b>A Voltage Sensorless Phase Locked Loop Structure for Single Phase Grid Connected Converter System .....</b>	<b>5720</b>
--	-------------

Subhajyoti Mukherjee, Vikram Roy Chowdhury, Pourya Shamsi and Mehdi Ferdowsi  
Missouri University of Science and Technology, United States

<b>Comparative Analysis about Dynamic Performances of Grid Synchronization Schemes .....</b>	<b>5726</b>
--	-------------

Hao Yi, Xiongfei Wang, Frede Blaabjerg and Fang Zhuo  
Xi'an Jiaotong University, China; Aalborg University, Denmark

<b>A Phase-Locked Loop based on Cascaded Least-Error Squares Filter .....</b>	<b>5731</b>
---	-------------

Bowen Wang, Li Peng, Manlin Chen, Weibiao Wu and Yuntao Xiao  
Huazhong University of Science and Technology, China

<b>New Frequency and Amplitude Estimation Techniques for Grid-Connected DC/AC Inverters .....</b>	<b>5738</b>
---	-------------

Iman Askarian, Suzan Eren, Majid Pahlevani and Andy Knight  
University of Calgary, Canada; Queen's University, Canada

## **Session 173: Modeling and Control of DC-AC Converters II**

**Chair(s): Leon M Tolbert, Dong Dong**

<b>Anti-Windup Control for Stationary Frame Current Regulators using Digital Conditioning Architectures .....</b>	<b>5744</b>
---	-------------

B.P. McGrath and D.G. Holmes  
RMIT University, Australia

<b>A Current Sharing Technique for Parallel-Operated Unipolar-PWM Inverters .....</b>	<b>5752</b>
---	-------------

Dong Li, Carl Ngai Man Ho and Ken King Man Siu  
University of Manitoba, Canada

<b>Low Frequency Current Ripple Reduction of a Current-Fed Switched Inverter .....</b>	<b>5760</b>
--	-------------

Anil Gambhir and Santanu Mishra  
Indian Institute of Technology Kanpur, India

<b>Accuracy Analysis of the Zero-Order Hold Model for Digital Pulsewidth Modulation .....</b>	<b>5767</b>
---	-------------

Junpeng Ma, Xiongfei Wang, Frede Blaabjerg, Lennart Harnefors and Wensheng Song  
Southwest Jiaotong University, China; Aalborg University, Denmark; ABB Corporate Research Center, Sweden

## **Session 174: Testing, Measurement, and Validation of Power Converters**

**Chair(s): Vladimir Blasko, Qin Lei**

<b>DC Current Determination in Grid-Connected Transformerless Inverter Systems using a DC Link Sensing Technique .....</b>	<b>5775</b>
--	-------------

Weichi Zhang, Matthew Armstrong and Mohammed Elgendy  
Newcastle University, United Kingdom

<b>Online Measurement of Bus Impedance of Interconnected Power Electronics Systems: Applying Orthogonal Sequences .....</b>	<b>5783</b>
---	-------------

Tomi Roinila, Hessamaldin Abdollahim, Silvia Arrua and Enrico Santi  
University of South Carolina, United States

**Switching Frequency Characterization of Hysteresis Control in a Pump Back Test Configuration ..... 5789**

Xu She, Tony Frangieh and Rajib Datta  
GE Global Research, United States

**Capacitance Estimation Algorithm based on DC-Link Voltage Harmonics Using Artificial Neural Network in Three-Phase Motor Drive Systems ..... 5795**

Hammam Soliman, Pooya Davari, Huai Wang and Frede Blaabjerg  
Aalborg University, Denmark; Arab Academy for Science and Technology, Egypt

**Session 175: Motors for Transportation**

**Chair(s): Ronghai Qu, Khwaja Rahman**

**Principle of Variable Leakage Flux IPMSM using Arc-Shaped Magnet Considering Variable Motor Parameter Characteristics Depending on Load Current ..... 5803**

Takashi Kato, Toru Matsuura, Kensuke Sasaki and Tsutomu Tanimoto  
Nissan Motor Co., Ltd., Japan

**Performance Analysis of Surface Permanent Magnet Synchronous Machine Topologies with Dual-Wound Stators ..... 5811**

Subhra Paul, Alejandro Piña Ortega, Cong Ma, Rakesh Mitra, Prerit Pramod and Rakib Islam  
Nexteer Automotive Corp., United States

**Breakdown Resistance Analysis of Traction Motor Winding Insulation under Thermal Ageing ..... 5819**

K.N. Gyftakis, P.A. Panagiotou, N. Lophitis, D.A. Howey and M.D. McCulloch  
Coventry University, United Kingdom; University of Oxford, United Kingdom

**High Torque Density PM Motor for Racing Applications ..... 5826**

Marco Munaro, Nicola Bianchi and Giovanni Meneghetti  
University of Padova, Italy

**Session 176: General Topics in Electrical Machines**

**Chair(s): Jose Antonino-Daviu, Dong Jiang**

**Design and Experimental Evaluation of a Multilayer AC Winding Configuration for Sinusoidal MMF with Shorter End-turn Length ..... 5834**

Md Ashfanoor Kabir, Mohamed Zubair M. Jaffar, Zhao Wan and Iqbal Husain  
North Carolina State University, United States

**Impact of Machine Magnetization State on Permanent Magnet Losses in Permanent Magnet Synchronous Machines ..... 5840**

Daniel Fernández Alonso, David Reigosa, Juan Guerrero, Carlos Suarez and Fernando Briz  
University of Oviedo, Spain

**Operating Limits and Practical Operation of a Brushless Doubly-Fed Reluctance Machine ..... 5846**

William K. Song, David G. Dorrell, Andrew M. Knight, Robert E. Betz and David Gay  
University of Technology Sydney, Australia; University of KwaZulu-Natal, South Africa; University of Calgary, Canada; University of Newcastle, Australia

**A Novel Flux-Reversal Hybrid Magnet Memory Machine ..... 5853**

Hui Yang, Heyun Lin, Z.Q. Zhu, Haitao Wang, Shuhua Fang and Yunkai Huang  
Southeast University, China; University of Sheffield, United Kingdom

## **Session 177: PM and IPM Motor Drives III**

**Chair(s): Bilal Akin, Annette Muetze**

<b>Online Stator Resistance Tracking for Reluctance and Interior Permanent Magnet Synchronous Motors .....</b>	<b>5861</b>
--	-------------

R. Antonello, L. Ortombina, F. Tinazzi and M. Zigliotto  
University of Padova, Italy

<b>On-Line Stator Resistance and Permanent Magnet Flux Linkage Identification on Open-end Winding PMSM Drives .....</b>	<b>5869</b>
---	-------------

M. Pulvirenti, G. Scarella, G. Scelba, A. Testa and M.M. Harbaugh  
University of Catania, Italy; University of Messina, Italy; Rockwell Automation, United States

<b>Quick Compensation Method of Motor Phase Current Sensor Offsets without Motor Parameters for PMSM Drive .....</b>	<b>5877</b>
--	-------------

Koroku Nishizawa, Jun-ichi Itoh and Yoshinobu Nishizawa  
Nagaoka University of Technology, Japan

<b>Analytical Design and Auto-Tuning of Adaptive Flux-Weakening Voltage Regulation Loop in IPMSM Drives with Accurate Torque Regulation .....</b>	<b>5884</b>
---	-------------

Nicola Bedetti, Sandro Calligaro and Roberto Petrella  
Gefran S.p.A., Italy; Free University of Bozen, Italy; University of Udine, Italy

## **Session 178: Device Self Sensing Techniques**

**Chair(s): Adam Skorek, Jing Xu**

<b>Elimination of Bus Voltage Impact on Temperature Sensitive Electrical Parameter During Turn-on Transition for Junction Temperature Estimation of High-power IGBT Modules .....</b>	<b>5892</b>
---	-------------

Haoze Luo, Francesco Iannuzzo, Frede Blaabjerg, Xiang Wang, Wuhua Li and Xiangning He  
Aalborg University, Denmark; University of Cassino and Southern Lazio, Italy; Zhejiang University, China

<b>IGBT Junction Temperature Estimation via Gate Voltage Plateau Sensing .....</b>	<b>5899</b>
--	-------------

Christoph H. van der Broeck, Alexander Gospodinov and Rik W. De Doncker  
RWTH Aachen University, Germany

<b>On-Line Temperature Estimation of SiC Power MOSFET Modules through On-State Resistance Mapping .....</b>	<b>5907</b>
---	-------------

Fausto Stella, Gianmario Pellegrino, Eric Armando and Davide Dapprà  
Politecnico di Torino, Italy; Vishay Semiconductor Italiana S.p.A., Italy

<b>Characterization of SenseGaN Current-Mirroring for PowerGaN with the Virtual Grounding in a Boost Converter .....</b>	<b>5915</b>
--	-------------

Mehrdad Biglarbegian and Babak Parkhideh  
University of North Carolina at Charlotte, United States