

# **2020 IEEE 21st Workshop on Control and Modeling for Power Electronics (COMPEL 2020)**

**Aalborg, Denmark  
9 – 12 November 2020**

**Pages 1-649**



**IEEE Catalog Number: CFP20COM-POD  
ISBN: 978-1-7281-7161-6**

**Copyright © 2020 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP20COM-POD
ISBN (Print-On-Demand):	978-1-7281-7161-6
ISBN (Online):	978-1-7281-7160-9
ISSN:	1093-5142

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

## Table of Contents

---

<b>T1: Stability and Modeling of Grid-Tied Converter</b>	
Modeling and Stability Analysis of Grid-Following Voltage-Source Converters Utilizing Individual Channel Design Method .....	1
<i>Huoming Yang, Hendrik Just, Malte Eggers and Sibylle Dieckerhoff</i>	
A General Integration Method for Stability Analysis of Grid-Forming Converter Connecting to Power System .....	7
<i>Fangzhou Zhao, Xiongfei Wang, Zichao Zhou, Lennart Harnefors, Jan R. Svensson, Lukasz Kocewiak and Mikkel Peter Sidoroff Gryning</i>	
Analytical Small-Signal Modelling of Diode-Rectifier based HVDC Link Based on Physical Switching Actions of Diodes .....	14
<i>Dongsheng Yang and Yin Sun</i>	
<hr/>	
<b>P1: Modeling and Stability of Power Electronics Converter 1</b>	
Stabilizing Effect of Load Converter Operating in DCM on Cascaded System .....	21
<i>Yuan Li, Guohua Zhou, Minrui Leng and Qingxin Tian</i>	
Passivity-Based Stabilization Method for a DC Power Supply System with a Constant Power Load and an LC Filter .....	27
<i>Takashi Funaki, Toshiji Kato and Kaoru Inoue</i>	
Unbalanced Voltage Sag Ride-through Capability for Three-phase Grid-tied Inverter with Low Inductance .....	35
<i>Satoshi Nagai and Jun-Ichi Itoh</i>	
On the Modelling of Fuel Cell-Fed Power System in Electrified Vessels .....	43
<i>Wenjie Chen, Kang Tai, Michael Lau, Ahmed Abdelhakim, Ricky R. Chan, Alf Kåre Ådnanes and Tegoeh Tjahjowidodo</i>	
Small-Signal Modeling of SIMO DC-DC Converters and Comparative Continuous/Discrete-Time Results .....	51
<i>Santanu Kapat, Gopi Reddy Chilukuri and Souvik Jash</i>	
Arm Phase-shift Modulation and Pre-charge Strategy for an Enhanced Alternate Arm Converter .....	56
<i>Shiyuan Fan, Heya Yang, Xin Xiang, Wuhua Li, Huan Yang, Rongxiang Zhao and Xiangning He</i>	
Analysis of a Single-Phase PV Inverter with Generation Control and Power Decoupling Features .....	63
<i>Takaya Sekiguchi and Toshihisa Shimizu</i>	
An Improved Deadbeat Predictive Direct Power Control Using Geometrical Modulation ..	71
<i>Shuo Yan</i>	
Resonant Control with Differentiated Phase Correction for High Power Converters with Negative Sequence Elimination Featuring Double-sided Frequency Asymmetry .....	78
<i>Ye Yan, Yuxiang Wang, Chushan Li, Wuhua Li and Xiangning He</i>	

Phase-Shifted PWM with Dynamic Phase Shift Control and Zero Sequence Injection to Minimize Inductor Current Ripple in Three-Phase Flying Capacitor Multilevel Converters	84
<i>Yong Long Syu, Zitao Liao, Pourya Assem, Derek Chou and Robert Pilawa-Podgurski</i>	
Discrete-Time Voltage Controller for Grid-Forming Inverters based on Complex Vector Theory	91
<i>Ko Oue, Shunya Sano, Toshiji Kato and Kaoru Inoue</i>	
Adaptive MPC-based Cost Function for Capacitorless VAR Compensator in Distribution Networks	96
<i>Wesam Rohouma, Morcos Metry, Robert S. Balog, Aaqib Ahmad Peerzada and Miroslav M. Begovic</i>	
Model Predictive Control based Controller for Grid-Connected Ripple-Port Inverters	102
<i>Morcos Metry, Minjeong Kim, Wesam Rohouma and Robert S. Balog</i>	
Frequency-Freezing FLL for Enhanced Synchronization Stability of Grid-Following Converters during Grid Faults	108
<i>Mads Graungaard Taul, Xiongfei Wang, Pooya Davari and Frede Blaabjerg</i>	
A Fast and Accurate Calculation Method for Predicting the Battery Current Ripple in Battery-fed PWM Inverter Systems	115
<i>Panagiotis Mantzanas, Daniel Kuebrich and Thomas Duerbaum</i>	
Dynamic Modeling and Control of a Resonant Switched Capacitor Converter with Switch Conductance Regulation	121
<i>Peter Renz, Niklas Deneke and Bernhard Wicht</i>	
Automatic Derivation of State-Space Model from Linear Electrical Circuits with Dependent Variables using Modified Nodal Analysis	125
<i>Chuantong Hao and Michael Merlin</i>	
Stability Analysis and Adaptive Resonance Damping of Multi-Converter System Applying Bidirectional Converter	131
<i>Roosa-Maria Sallinen, Tomi Roinila and Hessamaldin Abdollahi</i>	
Analysis and Verification of a Cascaded Advanced AC-Simulator with Non-Linear Loads	138
<i>Peter Jonke, Markus Makoschitz, Sumanta Biswas, Johannes Stöckl and Hans Ertl</i>	
Generalized Nyquist MIMO Stability of Frequency Regulation Services in Power Networks	145
<i>Alberto Bolzoni</i>	
Small-Signal Modeling and Experimental Validation of the Three-phase Quasi-Z-Source Inverter	152
<i>Vincenzo Castiglia, Rosario Miceli, Yongheng Yang and Frede Blaabjerg</i>	
Stability Analysis using Reduced-order Behavioral VSI Input Impedance Converter Model applied to enhance Power-Hardware-In-the-Loop	160
<i>Marina Sanz, Carlos Olalla, Diego Ochoa, Francisco Huerta, Angel Cid and Antonio Lazaro</i>	
An Aggregated Model for Power Electronic System Based on Multi-Port Network Reduction Method	166
<i>Shih-Feng Chou, Xiongfei Wang and Frede Blaabjerg</i>	

Impact of Synchronous Generator Replacement with VSG on Power System Stability . . . . .	172
<i>Meng Chen, Dao Zhou and Frede Blaabjerg</i>	
Modeling the Inherent Damping of High-Power Inverters . . . . .	179
<i>Joseba Erdocia, Andoni Urtasun and Luis Marroyo</i>	
<hr/> <b>P2: Novel Topologies, Advanced Control and Simulation 1</b> <hr/>	
Analysis of Multiple Phase-shift Control for Full-bridge CLLC Resonant Converter Based on Improved Fundamental Harmonic Approximation Method . . . . .	186
<i>Tianhua Zhu, Fang Zhuo, Fangzhou Zhao, Ruijie Song, Feng Wang and Hao Yi</i>	
High Step-Up/Down Switched-Capacitor Based Bidirectional DC-DC Converter . . . . .	192
<i>Zahra Saadatizadeh, Pedram Chavoshipour Heris, Yongheng Yang and Frede Blaabjerg</i>	
Two-Stage Single-Source Full-Bridge Based Three-Phase Inverter for Medium Voltage Applications . . . . .	198
<i>Hossein Khoujahan, Roghayeh Pourebrahimi, Sadjad Tohidi, Saeed Peyghami, Amin M. Shotorbani and Frede Blaabjerg</i>	
Asymmetric Cascaded Multilevel Inverter with Capacitor-based Half-Bridge Cells and Reduced Number of Components . . . . .	204
<i>Reyhaneh Eskandari, Hossein Khoujahan, Amin M. Shotorbani, Mehdi Abapour, Saeed Peyghami and Frede Blaabjerg</i>	
A Novel 7-Leg Topology for 3-Phase 4-Wire Unified Power Quality Conditioner . . . . .	210
<i>Houkai Zhang, Guochun Xiao, Zhaolin Lu, Yuechen Rui, Xianghao Cao and Fangzhou Zhao</i>	
Compensation Range Analysis of 3-Phase 4-Leg Topology DVR Based on Multi-leg Modulation Strategy . . . . .	218
<i>Zhaolin Lu, Guochun Xiao, Houkai Zhang, Yuechen Rui, Xianghao Cao and Fangzhou Zhao</i>	
A Novel Nine and Seventeen Level Multilevel Inverters with Condensed Switch Count . . . . .	226
<i>C Dhanamjayulu, Sanjeevikumar Padmanaban, K Palanisamy, Frede Blaabjerg and Pandav Kiran Maroti</i>	
Capacitor-Based Three-Level Gate Driver for GaN HEMT Only with a Single Voltage Supply . . . . .	232
<i>Junichiro Nagao, Jun Furuta and Kazutoshi Kobayashi</i>	
Downsizing Design of Powdered Iron Core Inductors Based on Variable-Frequency Modulation Targeted at Harmonics Suppression . . . . .	239
<i>Jinshui Zhang, Yan Zhang and Jinjun Liu</i>	
Degradation Assessment of SiC MOSFETs under the Repetitive Short-Circuit Ageing with Different Gate-Source Voltage Bias . . . . .	247
<i>Yuan Li, Yuan Fu Zhao, Alex Q. Huang and Liqi Zhang</i>	
Low-Frequency-Ripple Free Finite Valued Electronic Capacitor . . . . .	253
<i>Pavel Strajnikov, Mor Peretz and Alon Kuperman</i>	
Accelerator for Real-Time Emulation of Modular-Multilevel-Converter Using FPGA . . . . .	257
<i>Mini Namboothiripad, Mandar J Datar, Mukul C Chandorkar and Sachin B Patkar</i>	

Design of Matching Network in High Frequency Converter Considering Flexible Aircore Inductor Effect .....	264
<i>Chang Liu, Yueshi Guan, Yijie Wang, Wei Wang and Dianguo Xu</i>	
A Cascaded Interleaved Bootstrapped Gate Driver Power Supply for Multilevel Photovoltaic Inverters .....	270
<i>Nachiketa Deshmukh and Sandeep Anand</i>	
Commutation Method for a Three-Phase Current Sourced High-Frequency ac-link Inverter	276
<i>Minjeong Kim and Robert Balog</i>	
A Fibonacci Series based Nearest Level Modulation Scheme for MultiLevel Inverters .....	283
<i>Rakesh Kumar, Sanjeevikumar Padmanaban, Partha Sarathi Subudhi, Frede Blaabjerg and Dhanamjayulu C</i>	
Fast temperature sensing for GaN power devices using E-field probes .....	288
<i>Mohammad Hedayati, Harry Dymond, Dawei Liu and Bernard Stark</i>	
Model predictive active thermal control strategy for lifetime extension of a 3L-NPC converter for UPS applications .....	295
<i>Mateja Novak and Frede Blaabjerg</i>	
High Frequency Multicell Cascaded Quasi-Square-Wave Boost Converter .....	302
<i>Jing Yuan, Yanan Chen, Yongheng Yang, Frede Blaabjerg and Minjie Chen</i>	
A Hybrid-bridge based Dual Active Bridge DC/DC Converter with Compact Structure ...	310
<i>Jiahui Wu, Dong Liu, Yanbo Wang and Zhe Chen</i>	
Current-fed Modular Multilevel Converter (CMMC) for Fuel Cell and Photovoltaic Integration .....	316
<i>Ahmed Abdelhakim and Frede Blaabjerg</i>	
Test Setup for Loss Measurements of Inductive Components by using GaN-HEMTs .....	322
<i>Benedikt Kohlhepp, Stefan Peller, Daniel Kübrich and Thomas Dürbaum</i>	
Optimal Synergetic Control of a Three-Phase Two-Stage Ultra-Wide Output Voltage Range EV Battery Charger Employing a Novel Hybrid Quantum Series Resonant DC/DC Converter .....	329
<i>Yunni Li, Jannik Schäfer, Dominik Bortis, Johann Kolar and Gerald Deboy</i>	
A Decentralized Frequency Regulation Scheme in AC Microgrids .....	340
<i>Saeed Peyghami, Seyed Fariborz Zarei, Mohammad Amin Ghasemi, Peter Palensky and Frede Blaabjerg</i>	
<hr/>	
<b>T2: Reliability Assessment in Power Electronics</b>	
Investigation of Active Life Balancing to Recondition Li-ion Battery Packs for 2nd Life ...	345
<i>Marium Rasheed, Mohamed Kamel, Hongjie Wang, Regan Zane and Kandler Smith</i>	
Monte Carlo Based Reliability Estimation Methods in Power Electronics .....	352
<i>Mateja Novak, Ariya Sangwongwanich and Frede Blaabjerg</i>	

Active Power Nodes for Increased Energy Resources Availability in Distribution Networks	359
<i>Alvaro Cardoza and Alexis Kwasinski</i>	

---

### **T3: Wireless Power Transfer**

---

A Burst-Mode Controlled Inductive Wireless Power Transfer System	367
<i>Usama Anwar, Zhaoyi Liu and Dejan Markovic</i>	
Reduced-Fringing-Field Multi-MHz Capacitive Wireless Power Transfer System Utilizing a Metasurface-based Coupler	373
<i>Sounak Maji, Sreyam Sinha, Brandon Regensburger, Francesco Monticone and Khurram Afridi</i>	
Design and Optimization of 6.78 MHz Wireless Power Transfer with Self-Resonant Coils	379
<i>Lei Gu, Grayson Zulauf, Aaron Stein, Phyo Aung Kyaw, Tuofei Chen and Juan M. Rivas-Davila</i>	

---

### **T4: Dynamic Modeling and Control of Power Converter**

---

Inductance Dual Model and Control of Multiphase Coupled Inductor Buck Converter	384
<i>Daniel Zhou, Youssef Elasser, Jaeil Baek, Charles R. Sullivan and Minjie Chen</i>	
Steady-State Convergence of Discrete Time State-Space Modeling with State-Dependent Switching	392
<i>Jared Baxter and Daniel Costinett</i>	
Dynamic Modeling of Hybrid Feedforward Controlled Pulse Width Modulated Switching Converters	400
<i>Usama Anwar and Dejan Markovic</i>	

---

### **T5: Advanced Control of Power Converter**

---

Modulated Model Predictive Control of an LCL-Filtered Neutral-Point Clamped Converter	407
<i>Venkata Yaramasu, Apparao Dekka, Tomislav Dragicevic, Changming Zheng and Jose Rodriguez</i>	
Decentralized Control of Cascaded H-bridge Inverters for Medium Voltage Grid Integration	413
<i>Soham Dutta, Minghui Lu, Rahul Mallik, Branko Majmunovic, Satyaki Mukherjee, Gab-Su Seo, Dragan Maksimovic and Brian Johnson</i>	
Fast Distributed Model Predictive Control for DC Microgrids	419
<i>Lalit Kishore Marepalli, Kaushik Gajula and Luis Herrera</i>	

---

### **T6: Advanced Control of Power Converter**

---

An Online Monitoring Method for Output Capacitors of DC/DC Boost Converters	425
<i>Zhaoyang Zhao, Weiguo Lu, Pooya Davari and Frede Blaabjerg</i>	
Identification of the Terminal-to-Core Couplings in Filter Inductors by Using Double-Pulse-Test Setup	432
<i>Hongbo Zhao, Dipen Narendra Dalal, Jannick Kjær Jørgensen, Asger Bjørn Jørgensen, Xiongfei Wang, Bjørn Rannestad and Stig Munk-Nielsen</i>	

An Online Failure Assessment Approach for SiC-based MOSFET Power Modules Using Iterative Condition Monitoring Technique .....	438
<i>Javad Naghibi, Kamyar Mehran and Martin Foster</i>	

---

### **T7: Novel Topologies of Power Electronics Converter**

---

Analysis of a 48V-12V Hybrid Switched Capacitor Converter with DC Winding Current Autotransformer .....	443
<i>Cheng Li, Diego Serrano and José A. Cobos</i>	
Novel three-phase topology for cascaded multilevel medium-voltage conversion systems in large-scale PV plants .....	450
<i>David Lumbreras, Ernesto Barrios, Julian Balda, Roberto Gonzalez and Pablo Sanchis</i>	
Light-Load Efficiency Improvement for Galvanically Isolated Quasi-Z-Source DC-DC Converter for Photovoltaic Applications .....	458
<i>Hamed Mashinchi Maheri, Andrii Chub and Dmitri Vinnikov</i>	

---

### **T8: Performance Analysis of Power Component**

---

Empirical Core Loss Model for Arbitrary Core Excitations Including DC-bias .....	464
<i>Erika Stenglein and Thomas Dürbaum</i>	
Calibration-Free Calorimeter for Sensitive Loss Measurements: Case of High-Frequency Inductors .....	472
<i>Armin Jafari, Michaël Heijnemans, Reza Soleimanzadeh, Remco Van Erp, Mohammad Samizadeh Nikoo, Enea Figini, Furkan Karakaya, Nirmana Perera and Elison Matioli</i>	
Influence of Driver Integration on GaN Enhancement Mode Transistor Performance .....	480
<i>Martijn Deckers, Simon Ravyts, Mauricio Dalla Vecchia, Urmimala Chatterjee, Xiangdong Li, Stefaan Decoutere and Johan Driesen</i>	

---

### **T9: Model Predictive Control of Inverter**

---

Predictive Torque Control without Weighting Factors for Doubly-Fed Induction Generators in Wind Turbine Applications .....	486
<i>Mohamed Abdelrahem, Christoph Hackl, Jose Rodriguez and Ralph Kennel</i>	
Robustness Analysis of Long-Horizon Direct Model Predictive Control: Permanent Magnet Synchronous Motor Drives .....	492
<i>Ludovico Ortombina, Petros Karamanakos and Mauro Zigliotto</i>	
Alternative Sphere Decoding Algorithm for Long-horizon Model Predictive Control of Multi-level Inverters .....	500
<i>Johan Raath, Toit Mouton and Tobias Geyer</i>	

---

### **T10: High Performance of Power Converter**

---

Power Factor Enhancement of a Soft-Switched Common-Neutral Single-DC-Bus Power Converter .....	508
<i>Danish Shahzad, Nauman Zaffar and Khurram Afridi</i>	



MLB-PoL: A High Performance Hybrid Converter for Direct 48 V to Point-of-Load Applications .....	514
<i>Zichao Ye, Rose Abramson, Yong-Long Syu and Robert Pilawa-Podgurski</i>	
48 V-to-1 V Transformerless Stacked Active Bridge Converters with Merged Regulation Stage .....	522
<i>Jianglin Zhu and Dragan Maksimovic</i>	
<hr/> <b>P3: Modeling and Stability of Power Electronics Converter 2</b> <hr/>	
Performance Limits of Differential Power Processing .....	528
<i>Ping Wang, Robert Pilawa-Podgurski, Philip Krein and Minjie Chen</i>	
Dynamic Model of Active Front-End Converters with 2DOF Type PI Controller for DC Bus Voltage Control .....	536
<i>Anup Thapa and Madhu Sudhan Chinthavali</i>	
Theoretical Limits of Power Transfer in Capacitive Wireless Charging Systems .....	542
<i>Sounak Maji, Sreyam Sinha and Khurram Afridi</i>	
Fault Ride-Through of Flying-Capacitor Multilevel Converters through Rapid Fault Detection and Idle-mode Operation .....	548
<i>Nathan Pallo, Mads Taul, Andrew Stillwell and Robert Pilawa-Podgurski</i>	
Control of a Universal Input Voltage Modular Multilevel DC/DC Converter .....	556
<i>Netan Yakop, Philippe A. Gray and Peter W. Lehn</i>	
Maximising Energy Yield Using Global Maximum Power Point Tracking of Reconfigurable Photovoltaic Panel Array .....	564
<i>Pallavi Bharadwaj and Bradley Lehman</i>	
Analysis of Sliding-Mode-Controlled Boost Converters with Mixed Loads .....	571
<i>Hanqing Lin, Seyyedmilad Ebrahimi, Mohammad Mahdavyfakhr and Juri Jatskevich</i>	
Dual-Loop Frequency Synchronization and Load Regulation using a Discrete Time Model for a 7-Level Switched Capacitor WPT Rectifier .....	579
<i>Spencer Cochran and Daniel Costinett</i>	
10-MW Direct-Drive PMSG-Based Wind Energy Conversion System Model .....	587
<i>Leandro Benhur Klinger Fisch and Marcelo Lobo Heldwein</i>	
Consensus-Based Distributed Control of a Multilevel Battery Energy Storage System .....	595
<i>Sebastián Neira, Pablo Poblete, Javier Pereda and Felipe Nuñez</i>	
Minimum-Deviation Transient Response in Non-Inverting Buck-Boost DC-DC Converters	602
<i>Janko Celikovic, Pier Cavallini, Siamak Abedinpour and Dragan Maksimovic</i>	
Robust Nonsingular Terminal Sliding Mode Control with Constant Frequency for DC/DC Boost Converters .....	610
<i>Jose Robles, Freedy Sotelo and Javier Chavez</i>	
Modulated Model Predictive Torque and Current Control of Squirrel Cage Induction Generator-Based Wind Power Generation System .....	615
<i>Venkata Yaramasu, Apparao Dekka and Jose Rodriguez</i>	

Design of a Grid-Forming, Multi-Loop Control Scheme for Parallel Connected Three-Phase Quasi-Z-Source Inverters .....	622
<i>Adam Emes, Thibaut Harzig and Brandon Grainger</i>	
Distributed Control for a Cost-based Droop-free Microgrid .....	629
<i>Manuel Martinez Gomez, Claudio Burgos Mellado and Roberto Cardenas Dobson</i>	
Capacitor Current Feedback Active Damping with Lagged Compensator for DFIG Wind Turbines with LCL Filter .....	636
<i>Leyre Rosado, Javier Samanes, Eugenio Gubía and Jesús López</i>	
Wirtinger Calculus Based Modeling and Analysis of VSG-Dominated Grids .....	644
<i>Huoming Yang, Hendrik Just, Malte Eggers and Sibylle Dieckerhoff</i>	
SRC as a Reliable Methodology to Evaluate Flux Observer Estimation Accuracy .....	650
<i>Hadi El Khatib, Daniel Gaona, Dieter Gerling and Michael Saur</i>	
Measurement Device for Inverter Output Impedance Considering the Coupling Over Frequency .....	658
<i>Tommi Reinikka, Tomi Roinila and Jian Sun</i>	
Feasible Range of Microgrid Parameters Based on Small-signal Stability Analysis .....	665
<i>Bahram Pournazarian, Meysam Saeedian, Bahman Eskandari, Matti Lehtonen and Edris Pouresmaeil</i>	
Sub-synchronous Resonance Damper Based on the Stator Voltage Feedback for DFIG Wind Turbines .....	671
<i>Javier Samanes, Leyre Rosado, Eugenio Gubia and Jesus Lopez</i>	
Improving Transient Stability of Power Synchronization Control for Weak Grid Applications .....	679
<i>Amir Sepehr, Mobina Pouresmaeil, Mojgan Hojabri, Frede Blaabjerg and Edris Pouresmaeil</i>	
Impedance Network Impact on the Controller Design of the QZSI for PV Applications .....	685
<i>Wenjie Liu, Yongheng Yang, Elizaveta Liivik, Tamas Kerekes and Frede Blaabjerg</i>	
Passivity-Based Virtual Damping Control of Three-Phase Grid-Tied PV Inverters .....	691
<i>Zhiqing Yang, Chirag Shah, Jakob Teichrib, Shenghui Cui and Rik W. De Doncker</i>	

---

#### **P4: Novel Topologies, Advanced Control and Simulation 2**

---

Bi-lateral Energy Resonant Converter (BERC) with Merged Two-Stage Inductor for 48-to-12V Applications .....	699
<i>Wen-Chuen Liu and Robert Pilawa-Podgurski</i>	
Multiple Input Multiple Output (MIMO) Control of a Novel Three Phase Multilevel Inverter .....	705
<i>Tuofei Chen, William Dally and John Fox</i>	
High-Efficiency Operating Modes for Isolated Piezoelectric-Transformer-Based DC-DC Converters .....	713
<i>Jessica Boles, Elaine Ng, Jeffrey Lang and David Perreault</i>	

MMC Applied to Pumped Hydro Storage using a Differentiable Approximation of a Square Wave as Common-Mode Voltage during Low-Frequency Operation .....	721
<i>Matheus Soares and Edson H. Watanabe</i>	
Multi-Inverter Discrete Backoff: A High-Efficiency, Wide-Range RF Power Generation Architecture .....	729
<i>Haoquan Zhang, Anas Al Bastami, Alexander S. Jurkov, Aaron Radomski and David J. Perreault</i>	
Modeling and Design of Planar-Spiral Merged-LC Resonators in a Standard CMOS Process .....	737
<i>Prescott H. McLaughlin, Yue Wu, Charles R. Sullivan and Jason T. Stauth</i>	
Impact of Parasitic Capacitors on Cell Capacitor Voltage Balance in Power Converters Having Integrated Capacitor Blocked Transistor Cells .....	745
<i>Jianghui Yu and Rolando Burgos</i>	
Analysis of Impacts of Compensation Networks on Characteristics of Piezoelectric Transformers .....	751
<i>Le Wang and Rolando Burgos</i>	
Comparison of Radio-Frequency Power Architectures for Plasma Generation .....	758
<i>Anas Al Bastami, Haoquan Zhang, Alexander Jurkov, Aaron Radomski and David Perreault</i>	
Real-Time Hardware-in-the-Loop Simulation and Control of Totem Pole PFC Converter ..	766
<i>Peyman Amiri, Deepak Gautam, Chris Botting, Wilson Eberle and Liwei Wang</i>	
MagNet: A Machine Learning Framework for Magnetic Core Loss Modeling .....	773
<i>Haoran Li, Seungjae Lee, Min Luo, Charles Sullivan, Yuxin Chen and Minjie Chen</i>	
Equivalent Circuit Models for Closed-loop Multiphysics Drive Systems .....	781
<i>Pranav Chandran, Blake Rose and Brian Johnson</i>	
A Quantitative Analysis on the Energy Storage Requirements for Hybrid Cascaded Multilevel .....	788
<i>Levi Bieber, Liwei Wang, Juri Jatskevich and Wei Li</i>	
1 kW, Multi-MHz Wireless Charging for Electric Transportation .....	795
<i>Thaibao Phan, Grayson Zulauf, Jonathan Fan and Juan Rivas-Davila</i>	
Two-Stage 48V-1V Hybrid Switched-Capacitor Point-of-Load Converter with 24V Intermediate Bus .....	802
<i>Yenan Chen, David Giuliano and Minjie Chen</i>	
Leveraging Multi-Phase and Fractional-Turn Integrated Planar Transformers for Miniaturization in Data Center Applications .....	810
<i>Mike Ranjram and David Perreault</i>	
Design of High-frequency Resonant Inverter for Capacitive Wireless Power Transfer .....	818
<i>Minki Kim and Jungwon Choi</i>	
Time-Domain Analysis and ZVS Assistance Design for a DAB LCL-T Resonant Converter in Underwater DC Current Distribution Network .....	825
<i>Tarak Saha, Anindya Chitta Bagchi and Regan Zane</i>	

A Line Commutated - Thyristor Bridge Emulated Rotating Power Electronic Converter for Brushless Exciter Applications .....	832
<i>Manikanta Pallantla, Jeyaram Durga Manian Deivanayagam, Sreekanth T. and Ned Mohan</i>	
Fourier Analysis Method for Wireless Power Transfer Coil Design.....	837
<i>Andrew Foote, Daniel Costinett, Ruediger Kusch, Jason Pries, Mostak Mohammad and Burak Ozpineci</i>	
A New Topology of DC-DC Converter Based On Piezoelectric Resonator .....	845
<i>Mustapha Touhami, Ghislain Despesse and François Costa</i>	
Comparative Study of 48V-based Low-Power Automotive Architectures.....	852
<i>Stefano Cabizza, Luca Corradini, Giorgio Spiazzi and Cristian Garbossa</i>	
A resonant supplied cascaded H-Bridge Cell for a Series Hybrid Cascaded H-Bridge Converter used as a Power Hardware in the Loop Emulator .....	860
<i>Ruediger Schwendemann, Fabian Sommer and Marc Hiller</i>	
Design of Modular Multilevel Converters for the Shipnet in Medium Voltage DC All-Electric Ships .....	868
<i>Vegard Steinsland, Lars Michael Kristensen, Reza Arghandeh and Shujun Zhang</i>	

---

### **T11: Design, Optimization and Simulation Tools**

---

Determination of Power Loop Inductance for High-Current PCB-Based Half-Bridge Circuits .....	876
<i>Christian Winter, Jan Riedel and Stefan Butzmann</i>	
Mixed Simulation-Experimental Optimization of a Modular Multilevel Switched Capacitors Converter Cell .....	883
<i>Georgios Kampitsis, Max Chevron, Remco van Erp, Nirmana Perera, Stavros Papathanassiou and Elison Matioli</i>	
Flexible Test bench arrangement and particular implementation of 3 Level IGBT based VSI for self-sensing Model predictive Control of induction motor.....	889
<i>Ahmed Ibrahim Soliman, Mohammad Vedadi, Billel Kahia, Mohamed Abdelrahem and Ralph Kennel</i>	

---

### **T12: Emerging Applications of Power Electronics**

---

Controlling the Phase Angle in LCC-S IPT for Information Feedback.....	895
<i>Shuxin Chen, Yiming Zhang, Xin Li, Hongchang Li, Yang Chen and Yi Tang</i>	
Hybrid Four-wire Three-Level Inverter Equipped with Model Predictive Control for UPS Applications .....	901
<i>Mahdi Shahparasti, Rasool Heydari, Mehdi Savaghebi, Jose Rodriguez and Frede Blaabjerg</i>	
Design of a high performance VLC-LED driver for Visible Light Communication based on the split of the power .....	907
<i>Daniel G. Aller, Diego G. Lamar, Manuel Arias, Pablo F. Miaja and Javier Sebastián</i>	

---

### **T13: Topics in Grid-Forming Power Converter**

---

Grid-forming Power Converter controller with Artificial Intelligence to Attenuate Inter-Area Modes .....	915
<i>Gregory N. Baltas, Ngoc Bao Lai, Leonardo Marin, Andres Tarasso and Pedro Rodriguez</i>	
Freezing Grid-Forming Converter Virtual Angular Speed to Enhance Transient Stability Under Current Reference Limiting .....	920
<i>Xianxian Zhao and Damian Flynn</i>	
Voltage Sensorless Grid-Forming Power Converters .....	927
<i>Andres Tarrasó, Ngoc Bao Lai, Gregory N. Baltas and Pedro Rodriguez</i>	

---

### **P5: Advanced Control and Modulation**

---

Robust Distributed Optimal Secondary Voltage Control in Islanded Microgrids with Time-Varying Multiple Delays .....	932
<i>Milad Gholami, Alessandro Pisano and Elio Usai</i>	
Distributed Control Strategy Based on a Consensus Algorithm for the Inter-cell and Inter-cluster Voltage Balancing of a Cascaded H-Bridge Based STATCOM .....	940
<i>Claudio Burgos-Mellado, Joseph Gutierrez, Cristian Pineda, Felipe Donoso, Alan Watson, Mark Sumner, Roberto Cardenas and Andres Mora</i>	
Zero-Current Switching (ZCS) for a High Step Ratio Modular Multilevel dc-dc Converter with wide voltage range operation .....	948
<i>Cristian Pineda, Javier Pereda, Claudio Burgos, Alan Watson and Felix Rojas</i>	
Novel Master/Slave Configured Closed Loop Regulated Modular 320kW Isolated Symmetric CLLC Resonant DC/DC Converter .....	956
<i>Nagendra Badiger, Florian Hagel, Patrick Winzer, Alexander Schmitt and Horst Hammerer</i>	
Voltage Sensorless Control for Grid-connected Power Converters based on State Feedback and State Observer .....	964
<i>Ngoc Bao Lai, Gregory N. Baltas, Leonardo Marin, Andres Tarraso and Pedro Rodriguez</i>	
Assessing Power Factor Distortion and Transient Current Response of Grid Converters During Fault Ride-Through with Extended PLL Models .....	969
<i>Hendrik Just, Huoming Yang, Malte Eggers, Marius Kaufmann-Buehler and Sibylle Dieckerhoff</i>	
Noise Attenuation Properties of Multisampled Control in Power Electronics .....	977
<i>Ivan Petric, Paolo Mattavelli and Simone Buso</i>	
Adaptive Model Predictive Control of DFIG-based Wind Farm: A Model-Free Control Approach .....	983
<i>Zahra Rafiee, Mansour Rafiee, Mohammad Reza Aghamohammadi, Rasool Heydari and Jose Rodriguez</i>	
Active Disturbance Rejection Control for DC/DC Converters in MTDC Systems .....	989
<i>Asimonia Korompili and Antonello Monti</i>	
Robustness Analysis of Long-Horizon Direct Model Predictive Control: Induction Motor Drives .....	997
<i>Ludovico Ortombina, Petros Karamanakos and Mauro Zigliotto</i>	

Synthetic inertia control in the generator-side converter control of a grid-connected PMSG wind turbine.....	1005
<i>Stefan Ganzel, Magdalena Gierschner and Uwe Ritschel</i>	
Three-level LLC Resonant Converter with Structure-reconfigurable Control.....	1011
<i>Jiahui Wu, Dong Liu, Yanbo Wang and Zhe Chen</i>	
Small-signal Model and Analysis of a Grid-forming Power Converter based on the Synchronous Power Controller.....	1017
<i>Leonardo Marin, Ngoc Bao Lai, Gregory N. Baltas, Andres Tarraso and Pedro Rodriguez</i>	
An Adaptive Droop Curve for the Superimposed Frequency Method in DC Microgrids....	1023
<i>Mohammad Jafari Matehkolaei, Saeed Peyghami, Hossein Mokhtari and Frede Blaabjerg</i>	
Active control for medium-frequency transformers flux-balancing in a novel three-phase topology for cascaded converters.....	1029
<i>David Lumbreras, Ernesto Barrios, Manuel Navarrete, Julian Balda, Roberto Gonzalez and Pablo Sanchis</i>	
A Novel Symmetrical Boost Modulation Method for qZS-based CHB Inverters.....	1035
<i>Giuseppe Schettino, Rosario Miceli, Fabio Viola, Frede Blaabjerg, Yongheng Yang and Vincenzo Castiglia</i>	
Implementation Oriented Two-Sample Phase Locked Loop for Single-Phase PFCs.....	1042
<i>Paula Lamo, Gustavo A. Ruiz, Francisco J. Azcondo and Alberto Pigazo</i>	
Single-phase synchronisation with Hilbert transformers: a linear and frequency independent orthogonal system generator.....	1047
<i>Sjur Føyen, Chen Zhang, Marta Molinas, Olav B Fosso and Takanori Isobe</i>	
Impact on Efficiency of Inductive Battery Charging System by Sub-Resonant Frequency Control during Large Variations in Coupling Conditions.....	1053
<i>Jiayu Zhou, Giuseppe Guidi and Jon Are Suul</i>	
Optimizing Utilization of an MMSPC with Model Predictive Control.....	1061
<i>Tobias Merz, Christian Korte, Eduard Specht and Marc Hiller</i>	
Effect of the Inner Current Loop on the Voltage Regulation for Three-Phase Photovoltaic Inverters.....	1069
<i>Andoni Urtasun, Pablo Sanchis and Luis Marroyo</i>	
Enhanced Proportional-Resonant (PR) controller with negative decoupling for weak grids.	1076
<i>Andres Tarrasó, Leonardo Marín, Ngoc Bao Lai and Pedro Rodriguez</i>	
Modified Reduced Indirect Finite Control Set Model Predictive Control of Modular Multilevel Converters.....	1080
<i>Saad Hamayoon, Morten Hovd, Jon Are Suul and Mohsen Vatani</i>	
A Unified PWM Switch Model for Current- and Voltage-Mode Control with Automatic Transition between DCM and CCM.....	1086
<i>Burkhard Ulrich</i>	

Impacts of Digital Filters on Admittance Dissipativity of Sequence Current Control for Grid-Connected Converters .....	1094
<i>Hong Gong and Xiongfei Wang</i>	

---

### **P6: Component-level and System-level Simulation**

---

Analytical Modeling of 9-150 kHz EMI in Three-Phase Active Rectifiers .....	1101
<i>Naser Nourani Esfetanaj, Yingzhou Peng, Huai wang, Frede Blaabjerg and Pooya Davari</i>	
Hybrid-bridge Based Dual Active Bridge DC/DC Converter with Wide Voltage Conversion Gain .....	1107
<i>Jiahui Wu, Dong Liu, Yanbo Wang and Zhe Chen</i>	
A Series Chain-Link Modular Multilevel DC-DC Converter For High Voltage and High Power Applications .....	1113
<i>Beeond M. Saleh, Alessandro Costabeber, Alan J. Watson and Jon C. Clare</i>	
Cascaded H-Bridge based Parallel Hybrid Converter – A new Voltage Source for Power-Hardware-in-the-Loop Emulation Systems .....	1119
<i>Lukas Stefanski, Rüdiger Schwendemann, Daniel Bernet, Martin Widenmeyer, Andreas Liske and Marc Hiller</i>	
Design of 4th Order Resonance Filter for 5.4 W 20 MHz Buck Converter with PCB Integrated Inductor .....	1127
<i>Youssef Kandeel and Maeve Duffy</i>	
Multi-Fidelity Model-based PLL Design for Enhanced Dynamics and Transient Stability during Fault Ride-Through .....	1134
<i>Hendrik Just, Huoming Yang, Malte Eggers, Peter Teske and Sibylle Dieckerhoff</i>	
Intrinsic-Capacitance-based Differential Power Processing for Photovoltaic Modules .....	1141
<i>Kamran Ali Khan Niazi, Yongheng Yang and Dezso Sera</i>	
Real-Time Thermal Imaging Using Augmented Reality and Accelerated 3D Models .....	1147
<i>Bawar Jalal, Steve Greedy and Paul Evans</i>	
Power Density and Loss Optimization Design Methodology of a 10 kW 2-Level 3-Phase SiC Inverter .....	1153
<i>Alex Buus Nielsen, Pooya Davari, Frede Blaabjerg and Bo Vork Nielsen</i>	
11kW, 70kHz LLC Converter Design with Adaptive Input Voltage for 98% Efficiency in an MMC .....	1160
<i>Roland Unruh, Frank Schafmeister and Joachim Böcker</i>	
Methodology and Algorithm for Synthesis of Multi-Phase Switched-Capacitor Power Converter Topologies .....	1168
<i>Ravi Karadi</i>	
Real-Time Simulation of Three-Phase Current Source Inverter using Sub-Cycle Averaging Method .....	1176
<i>Sisi Zhao, Niklaus Felderer and Jost Allmeling</i>	
Calculation of Planar Transformer Capacitance Based on the Applied Terminal Voltages ..	1182
<i>Christian Østergaard, Claus Skærsholm Kjeldsen and Morten Nymand</i>	

Pre-Charging of a DC-Link Capacitor from a High Voltage Battery .....	1189
<i>Thomas Langbauer, Alexander Connaughton, Franz Vollmaier and Klaus Krischan</i>	
Calculation of Saturation in Magnetic Cores using the Boundary Element Method .....	1195
<i>Jeremias Kaiser and Thomas Dürbaum</i>	
Model for Conducted Emission of SiC Power Modules for automotive traction Inverter - Comparison to behaviour-based Model .....	1201
<i>Andreas Apelsmeier, Cornelius Rettner and Martin März</i>	
Thermal Modeling of an Electrolytic Capacitor Bank .....	1209
<i>Zhijian Yin, Yongheng Yang and Huai Wang</i>	
Output-Capacitance Hysteresis Losses of Field-Effect Transistors .....	1214
<i>Nirmana Perera, Armin Jafari, Luca Nela, Georgios Kampitsis, Mohammad Samizadeh Nikoo and Elison Matioli</i>	
Methodology for Characterization and Modelling of DC-Biased Surface-Mount Ferrite Power Inductors .....	1222
<i>Josip Bacmaga, Hrvoje Stimac and Adrijan Baric</i>	
Analytical Modeling of High-Frequency Winding Loss in Round-Wire Toroidal Inductors .	1229
<i>David Elizondo, Ernesto L. Barrios, Pablo Sanchis and Alfredo Ursua</i>	
Small-Signal Approach for Precise Evaluation of Gate Losses in Soft-Switched Wide-Band-Gap Transistors .....	1235
<i>Armin Jafari, Mohammad Samizadeh Nikoo, Nirmana Perera, Furkan Karakaya, Reza Soleimanzadeh and Elison Matioli</i>	
Investigation of Output Filter Topologies for a Parallel Hybrid Converter based on Si-IGBTs and Partially-Rated SiC-MOSFETs .....	1240
<i>Marlee Basurto, Paul Judge, Michael Merlin and Stephen Finney</i>	
Si/SiC Hybrid Switch for Improved Switching and Part-Load Performance .....	1247
<i>Ross Mathieson, Paul Judge and Stephen Finney</i>	

---

#### **T14: Control and Real-time Simulation**

---

A Co-Simulation Platform for Modeling and Testing Modular Multilevel Converters and Their Controls in Large Networks .....	1254
<i>Janesh Rupasinghe, Shaahin Filizadeh and Dharshana Muthumuni</i>	
Finite Element Method Analysis of a Three-Media Submarine Cable Ground Return Impedance at Varying Depth .....	1262
<i>Rafael B. P. Chagas, André Furlan and Marcelo L. Heldwein</i>	
Control Strategy and Energy Density Enhancement Methodology for Merged Energy Buffer AC-DC Converters .....	1269
<i>Firehiwot Gurara, Maida Farooq, Mausamjeet Khatua, Danish Shahzad, Saad Pervaiz and Khurram Afridi</i>	

---

#### **T15: Optimized Design of Passive and Active Components**

---



Power Harmonic Elimination Technique for Using Non-linear Ceramic Capacitors under Large Voltage Swings for Single-Phase Active Power Decoupling .....	1275
<i>Zitao Liao and Robert Pilawa-Podgurski</i>	
Evaluating Piezoelectric Materials for Power Conversion .....	1282
<i>Jessica Boles, Pedro Acosta, Yogesh Ramadass, Jeffrey Lang and David Perreault</i>	
Design Considerations of the GaN Power Stage for a GaN/Si Internal Parallel Multilevel Converter based 1500V PV String Inverter .....	1290
<i>Zhongyi Quan, Li Ding, Juncheng Lu and Yunwei Li</i>	