

IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS

A PUBLICATION OF
THE IEEE POWER ELECTRONICS SOCIETY
THE IEEE INDUSTRY APPLICATIONS SOCIETY



AUGUST 2021

VOLUME 9

NUMBER 4

IJESN2

(ISSN 2168-6777)

SPECIAL ISSUE ON DESIGN AND TESTING METHODS OF POWER ELECTRONIC COMPONENTS AND CIRCUITS

EDITORIAL

In Praise Of JESTPE Associate Editors—Part III *O. Ojo* 3840

GUEST EDITORIAL

Special Issue on Design and Testing Methods of Power Electronics Components and Circuits *J. Liu and K. Ma* 3845

SPECIAL ISSUE PAPERS

Packaging of Components

Investigation of Low-Profile, High-Performance 62-mm SiC Power Module Package
..... *J. Ke, S. Huang, Z. Yuan, Z. Zhao, X. Cui, S. S. Ang, and Z. Chen* 3850

Heterogeneous Integration of Magnetic Component Windings on Ceramic Substrates
..... *A. Stratta, B. Mouawad, M. Antonini, L. de Lillo, L. Empringham, and M. C. Johnson* 3867

High-Temperature Analysis of GaN-Based MQW Photodetector for Optical Galvanic Isolations in High-Density Integrated Power
Modules *S. Madhusoodhanan, A. Sabbar, H. Tran, B. Dong, J. Wang, A. Mantooth, S.-Q. Yu, and Z. Chen* 3877

Finite Element and Experimental Analysis of Spacer Designs for Reducing the Thermomechanical Stress in Double-Sided Cooling
Power Modules *J. Jeon, J. Seong, J. Lim, M. K. Kim, T. Kim, and S. W. Yoon* 3883

Elastic Half-Space Theory-Based Distributed-Press-Pack Packaging Technology for Power Module With Balanced Thermal
Stress *Y. Chang, C. Li, H. Luo, W. Li, F. Iannuzzo, and X. He* 3892

Vertically Stacked, Flip-Chip Wide Bandgap MOSFET Co-Optimized for Reliability and Switching Performance
..... *M. Montazeri, D. R. Huitink, A. Wallace, H. Peng, S. Seal, F. Luo, and H. A. Mantooth* 3904

Power Cell Design and Assessment Methodology Based on a High-Current 10-kV SiC MOSFET Half-Bridge Module
..... *S. Mocevic, J. Yu, Y. Xu, J. Stewart, J. Wang, I. Cvetkovic, D. Dong, R. Burgos, and D. Boroyevich* 3916

Thermal Modeling and Management

A Real-Time Adaptive IGBT Thermal Model Based on an Effective Heat Propagation Path Concept
..... *Z. Wang, W. Qiao, and L. Qu* 3936

Thermal Characterization of Silicon Carbide MOSFET Module Suitable for High-Temperature Computationally Efficient
Thermal-Profile Prediction *M. Chen, H. Wang, D. Pan, X. Wang, and F. Blaabjerg* 3947

(Contents Continued on Back Cover)



A Transient 3-D Thermal Modeling Method for IGBT Modules Considering Uneven Power Losses and Cooling Conditions	3959
..... J. Wang, W. Chen, L. Wang, B. Wang, C. Zhao, D. Ma, F. Yang, and Y. Li	
Modeling and Correlation of Two Thermal Paths in Frequency-Domain Thermal Impedance Model of Power Module	3971
..... M. Xu, K. Ma, B. Liu, and X. Cai	
Selective Soft-Switching for Thermal Balancing in IGBT-Based Multichip Systems	3982
..... V. Ferreira, M. Andresen, B. Cardoso, and M. Liserre	
Air-Cooling System Optimization for IGBT Modules in MMC Using Embedded O-Shaped Heat Pipes	3992
..... B. Wang, L. Wang, F. Yang, W. Mu, M. Qin, F. Zhang, D. Ma, J. Wang, and J. Liu	
<i>Characterization and Monitoring of Components</i>	
An Online Parameters Monitoring Method for Output Capacitor of Buck Converter Based on Large-Signal Load Transient Trajectory Analysis	4004
..... Z. Zhao, W. Lu, P. Davari, X. Du, H. H.-C. Iu, and F. Blaabjerg	
Channel Turn-Off Energy Model for Zero-Voltage-Switching Wide Bandgap Devices ...	4016
..... H. Wen, D. Jiao, C.-S. Yeh, and J.-S. Lai	
Characterization of Threshold Voltage Instability Under OFF-State Drain Stress and Its Impact on p-GaN HEMT Performance	4026
..... F. Yang, C. Xu, and B. Akin	
Quantifying Dynamic On-State Resistance of GaN HEMTs for Power Converter Design via a Survey of Low and High Voltage Devices	4036
..... T. Foulkes, T. Modeer, and R. C. N. Pilawa-Podgurski	
SOC and SOH Identification Method of Li-Ion Battery Based on SWPSO-DRNN	4050
..... Y. Che, Y. Liu, Z. Cheng, and J. Zhang	
Detection and Identification of Power Switch Failures Using Discrete Fourier Transform for DC-DC Flying Capacitor Buck Converters	4062
..... S. Tang, J. Wang, R. Zheng, D. Wang, X. Yin, Z. Shuai, and Z. J. Shen	
Influence of Gate Loop Inductance on TSEP-Based Junction Temperature Monitoring for IGBT	4072
..... Z. Zeng, Z. Li, J. Wang, X. Jiang, F. Li, H. Yu, J. Chen, and Z. J. Shen	
Origins of Soft-Switching C_{oss} Losses in SiC Power MOSFETs and Diodes for Resonant Converter Applications	4082
..... Z. Tong, J. Roig-Guitart, T. Neyer, J. D. Plummer, and J. M. Rivas-Davila	
A Review of Switching Slew Rate Control for Silicon Carbide Devices Using Active Gate Drivers	4096
..... S. Zhao, X. Zhao, Y. Wei, Y. Zhao, and H. A. Mantooth	
A High-Resolution <i>In Situ</i> Condition Monitoring Circuit for SiC Gate Turn-Off Thyristor in Grid Applications	4115
..... Y. Liu, L. Liu, S. Yin, Y. Gu, S. Deng, Z. Xing, Q. Zhou, Z. Li, and K. Zhou	
<i>Design, Simulation and Emulation of Systems</i>	
Snubber and Metal Oxide Varistor Optimization Design of Modular IGCT Switch for Overvoltage Suppression in Hybrid DC Circuit Breaker	4126
..... Q. Yi, F. Yang, Y. Wu, Y. Wu, C. Gao, W. Zhuang, and M. Rong	
DC-Link Busbar Network Design and Evaluation Method for the Large-Capacity Power Electronic Converter	4137
..... Z. Liang, S. Hu, M. Wang, and X. He	
EMI Attenuation in a DC-DC Buck Converter Using GaN HEMT	4146
..... P. B. Derkacz, P. Musznicki, and P. J. Chrzan	
Emulation of Multi-Inverter Integrated Weak Grid via Interaction-Preserved Aggregation	4153
..... S. Liao, M. Huang, X. Zha, and J. M. Guerrero	
Applying Wavelet Decomposition and Reconstruction to Solve Conflict Between Macroscale and Microscale Simulation Step of Buck Converter	4165
..... S. Guo, B. Zhang, F. Xie, D. Qiu, and Y. Chen	
A General Frequency-Domain Model of Trailing-Edge and Leading-Edge Carrier PWM dc-dc Converter Based on Hybrid Continuous and Discrete-Time Descriptions	4175
..... Y. Chen, B. Zhang, Y. Jiang, F. Xie, D. Qiu, and Y. Chen	
Transient Analysis of ZCS PWM Converter Based on Equivalent Small Parameter Method	4188
..... D. Wen, Y. Chen, B. Zhang, D. Qiu, and F. Xie	
Insulation Design of Wireless Auxiliary Power Supply for Medium Voltage Converters	4200
..... K. Sun, Y. Xu, J. Wang, R. Burgos, and D. Boroyevich	
FPGA-Based Submicrosecond-Level Real-Time Simulation of Solid-State Transformer With a Switching Frequency of 50 kHz	4212
..... J. Xu, K. Wang, P. Wu, Z. Li, Y. Liu, G. Li, and W. Zheng	
Multiscale Modeling and Analysis of Boost Converter Based on Device Mechanism Model and Continuous Switching Function	4225
..... Z. Jiang, Y. Chen, B. Zhang, D. Qiu, and F. Xie	
An Improved Impedance Measurement Method for Grid-Connected Inverter Systems Considering the Background Harmonics and Frequency Deviation	4236
..... P. Zhong, J. Sun, Z. Tian, M. Huang, P. Yu, and X. Zha	
<i>Life Time Evaluation and Reliability Testing</i>	
Lifetime Analysis of Metallized Polypropylene Capacitors in Modular Multilevel Converter Based on Finite Element Method	4248
..... R. Yao, H. Li, W. Lai, A. S. Bahman, and F. Iannuzzo	
Study of IGBTs Reliability Under Coupled Electrical-Thermal Environment	4260
..... H. Meng, Y. Wang, X. Zheng, J. Chen, Y. Wu, A. Li, and Y. Huang	
Electrothermal Stress Analysis and Lifetime Evaluation of DC-Link Capacitor Banks in the Railway Traction Drive System	4269
..... B. Yao, X. Ge, D. Xie, S. Li, Y. Zhang, H. Wang, and H. Wang	
Lifetime Evaluation of Three-Level Inverters for 1500-V Photovoltaic Systems	4285
..... J. He, A. Sangwongwanich, Y. Yang, and F. Iannuzzo	

Investigation on Degradation of SiC MOSFET Under Accelerated Stress in a PFC Converter	X. Jiang, J. Wang, J. Chen, H. Yu, Z. Li, and Z. J. Shen	4299
Reliability Modeling for Metallized Film Capacitors Based on Time-Varying Stress Mission Profile and Aging of ESR	C. Lv, J. Liu, Y. Zhang, W. Lei, R. Cao, and G. Lv	4311
Reliability and Robustness Tests for Next-Generation High-Voltage SiC MOSFETs	V. Soler, M. Cabello, V. Banu, X. Jordà, J. Montserrat, J. Rebollo, M. R. Rogina, A. Mihaila, and P. Godignon	4320
<hr/>		
REGULAR PAPERS		
<i>Motor Drives and Generators</i>		
Sensorless Synchronous Reluctance Motor Drives: Auxiliary Flux-Based Position Observer	A. Varatharajan, G. Pellegrino, and E. Armando	4330
FPGA-Based High-Bandwidth Motor Emulator for Interior Permanent Magnet Machine Utilizing SiC Power Converter	Y. Luo, M. A. Awal, W. Yu, and I. Husain	4340
Current Control for DFIG Systems Under Distorted Voltage Using Predictive–Repetitive Control	E. R. Conde D., A. Lunardi, and A. J. S. Filho	4354
Flux-Trajectory-Optimization-Based Predictive Flux Control of Permanent Magnet Synchronous Machines	Z. Song, Y. Cui, Y. Wang, and T. Liu	4364
Analysis and Design of Dual-Rotor Synchronous Reluctance Machine	M. Alani, M. Degano, N. Bianchi, H. Mahmoud, and C. Gerada	4376
Rapid Torque Rising of PMSM by Directly Chasing Rotating Flux Linkage Vector	W. Wang, M. Du, and K. Wei	4384
A Novel Torque Boundary-Based Model Predictive Torque Control for PMSM Without Weighting Factor	C. Ma, X. Yao, H. Li, H. Vansompel, C. Garcia, J. Rodriguez, and F. De Belie	4395
An Enhanced SMO-Based Permanent-Magnet Synchronous Machine Sensorless Drive Scheme With Current Measurement Error Compensation	S. Ye and X. Yao	4407
A Newly Designed VSC-Based Current Regulator for Sensorless Control of PMSM Considering VSI Nonlinearity	Z.-H. Liu, J. Nie, H.-L. Wei, L. Chen, X.-H. Li, and H.-Q. Zhang	4420
<i>Micro Grids and HVDC</i>		
New Stationary Frame Transformation for Control of a Three-Phase Power Converter Under Unbalanced Grid Voltage Sags	G. Iwanski, P. Maciejewski, and T. Luszczuk	4432
Operation and Control of an HVDC Circuit Breaker With Current Flow Control Capability	W. Liu, C. Li, C. E. Ugalde-Loo, S. Wang, G. Li, and J. Liang	4447
Operation Limits of the Hybrid DC/DC Modular Multilevel Converter for HVdc Grids Connections	R. Razani and Y. A.-R. I. Mohamed	4459
Control Algorithms to Establish Hybrid AC/DC Distribution Systems Using Conventional Six-Switch Inverters	A. Elrayyah	4470
Comparative Study of Small-Signal Stability Under Weak AC System Integration for Different VSCs	X. Lu, W. Xiang, W. Lin, and J. Wen	4482
Rapid Power Compensation-Based Frequency Response Strategy for Low-Inertia Power Systems	L. Xiong, X. Liu, D. Zhang, and Y. Liu	4500
Detailed Dynamic DC Models of VSC Considering Controls for DC-Fault Simulations in Modernized Microgrid Protection	M. Davari, A. Aghazadeh, W. Gao, and F. Blaabjerg	4514
Review of Dual-Buck-Type Single-Phase Grid-Connected Inverters	Z. Yao	4533
Wideband Harmonic Voltage Feedforward Control Strategy of STATCOM for Mitigating Subsynchronous Resonance in Wind Farm Connected to Weak Grid and LCC HVDC	G. Li, Y. Chen, A. Luo, and X. Liu	4546
An Estimation-Based Solution to Weak-Grid-Induced Small-Signal Stability Problems of Power Converters	J. Fang, J. Yu, Y. Zhang, and S. M. Goetz	4558
Unified Virtual Oscillator Control for Grid-Forming and Grid-Following Converters	M. A. Awal and I. Husain	4573
Load Balancing of a Modular Multilevel Grid-Interface Converter for Transformer-Less Large-Scale Wireless Electric Vehicle Charging Infrastructure	G. Guidi, S. D’Arco, K. Nishikawa, and J. A. Suul	4587
Fault Reconstruction of Islanded Nonlinear DC Microgrids: An LPV-Based Sliding Mode Observer Approach	S. Asadi, N. Vafamand, M. Moallem, and T. Dragičević	4606
A Full State-Variable Direct Predictive Control for Islanded Microgrids With Parallel Converters	Y. Li, Z. Zhang, C. Hu, M. Abdelrahem, R. Kennel, and J. Rodriguez	4615
Decentralized Coordinated Cyberattack Detection and Mitigation Strategy in DC Microgrids Based on Artificial Neural Networks	M. R. Habibi, S. Sahoo, S. Rivera, T. Dragičević, and F. Blaabjerg	4629
Cyber–Physical Security of Powertrain Systems in Modern Electric Vehicles: Vulnerabilities, Challenges, and Future Visions	J. Ye, L. Guo, B. Yang, F. Li, L. Du, L. Guan, and W. Song	4639
<i>Converters and Systems</i>		
Stability Effect of Control Weight on Multiloop COT-Controlled Buck Converter With PI Compensator and Small Output Capacitor ESR	X. Zhang, Z. Zhang, H. Bao, B. Bao, and X. Qu	4658

Bidirectional Soft-Switching Converter With Reduced Current Ripple at Low-Voltage Side	<i>M. Packnezhad and H. Farzanehfard</i>	4668
Open-Switch and Open-Clamping Diode Fault Diagnosis for Single-Phase Five-Level Neutral-Point-Clamped Inverters	<i>S. Ahmadi, P. Poure, S. Saadate, and D. Arab Khaburi</i>	4676
A Simple Zero-Sequence Voltage Injection Method for Carrier-Based Pulsewidth Modulation of the Three-Level NPC Inverter	<i>F. Chen, W. Qiao, H. Wang, and L. Qu</i>	4687
A Capacitor-Voltage-Balancing Method Based on Optimal Zero-Sequence Voltage Injection in Stacked Multicell Converter	<i>Q. Cheng, C. Wang, Z. Chen, and Z. Li</i>	4700
Modified SVPWM Scheme for Fault-Tolerant Control of AC–DC PWM Converter	<i>W. Qin, Y. Qiu, C. Sun, and Y. Feng</i>	4715
A Transformer-Less High-Gain Inverter With Step-Up/Down and Single Energy-Processing Features	<i>C.-H. Chang and K.-H. Ho</i>	4726
Quantitative Analysis of Harmonic Transfer for Modular Multilevel Converter	<i>N. Jiao, S. Wang, J. Ma, and T. Liu</i>	4739
Hybrid SVPWM Modulation Strategy for Auxiliary Resonant Commutated Pole Inverter	<i>D. Ma, P. Wang, R. Wang, S. Li, and Q. Sun</i>	4750
Topology and Voltage-Balance Control of a Single-Phase Active Neutral Point Clamped Seven-Level Inverter	<i>J. Chen and Y. Fu</i>	4762
Partially Signed Binary Voltage Control of Hybrid Modular Multilevel Converter	<i>H.w. Lee, S. H. Lee, and J.-W. Park</i>	4774
Four-Level Hybrid Neutral Point Clamped Converters	<i>J. Chen, Y. Zhong, C. Wang, and Y. Fu</i>	4786
Coupled Current Tracking Capability and Stability Analyses of 3 Φ 3W LCL Converter With Decoupled Control and Variable Filter Inductances	<i>T.-F. Wu, Y.-T. Liu, H.-Y. Wu, and K.-C. Lin</i>	4802
Research on Capacitor-Switching Semi-Full-Bridge Submodule of Modular Multilevel Converter Using Si-IGBT and SiC-MOSFET	<i>C. Xu, J. He, and L. Lin</i>	4814
Hybrid SHM-PWM for Common-Mode Voltage Reduction in Three-Phase Three-Level NPC Inverter	<i>M. Sharifzadeh, M. Babaie, G. Chouinard, K. Al-Haddad, R. Portillo, L. Garcia Franquelo, and K. Gopakumar</i>	4826
<i>Semiconductor Devices</i>		
Investigation of Switching Oscillations for Silicon Carbide MOSFETs in Three-Level Active Neutral-Point-Clamped Inverters ...	<i>M. Chen, D. Pan, H. Wang, X. Wang, and F. Blaabjerg</i>	4839
Research on the Multiphysics Field-Circuit Coupling Model of Press Pack IGBT Considering the Application of Hybrid HVDC Breakers	<i>E. Deng, O. Wenzel, Z. Zhao, Y. Zhang, X. Ying, J. Li, and Y. Huang</i>	4854
Exploiting Distinct Thermal Response Properties for Power Semiconductor Module Health Monitoring	<i>T. A. Polom, C. H. van der Broeck, R. W. De Doncker, and R. D. Lorenz</i>	4865
Effects of High-Field Velocity Saturation on the Performance of V-Doped 6H Silicon-Carbide Photoconductive Switches	<i>L. Wang, X. Chu, Q. Wu, T. Xun, H. Yang, J. He, and J. Zhang</i>	4879
A Way to Reduce Leakage Current and Improve Reliability of Wire-Bonds for 300-A Multichip SiC Hybrid Modules	<i>W. Deng, Y. Mei, M. Wang, X. Li, C. Ma, and G.-Q. Lu</i>	4887
<i>Electric Charging Systems</i>		
Robust Control of Wireless Power Transfer Despite Load and Data Communications Uncertainties	<i>R. Naghash, S. M. M. Alavi, and S. E. Afjei</i>	4897
Modified Inductive Multicoil Wireless Power Transfer Approach Based on Z-Source Network	<i>B. Pakhaliuk, O. Husev, V. Shevchenko, J. Zakis, K. Maksym, and R. Strzelecki</i>	4906
A PS/S Current-Fed IPT System With Variable Capacitors for Achieving ZPA Operation	<i>X. Pan, C. Zhang, H. Niu, Y. Zuo, and F. Zhao</i>	4918
Long-Range Wireless Microwave Power Transmission: A Review of Recent Progress	<i>X. Zhu, K. Jin, Q. Hui, W. Gong, and D. Mao</i>	4932
Review and Comparative Analysis of Topologies and Control Methods in Dynamic Wireless Charging of Electric Vehicles	<i>A. C. Bagchi, A. Kamineni, R. A. Zane, and R. Carlson</i>	4947
<i>PhotoVoltaic Systems</i>		
A Flying Squirrel Search Optimization for MPPT Under Partial Shaded Photovoltaic System	<i>N. Singh, K. K. Gupta, S. K. Jain, N. K. Dewangan, and P. Bhatnagar</i>	4963
JAYA Algorithm Based on Lévy Flight for Global MPPT Under Partial Shading in Photovoltaic System	<i>R. Motamarri and N. Bhookya</i>	4979
Decentralized PV–BES Coordination Control With Improved Dynamic Performance for Islanded Plug-n-Play DC Microgrid	<i>D. Li and C. N. M. Ho</i>	4992
Modeling and Bifurcation Analysis for Photovoltaic Single-Sourced Trinary Inverter With Auxiliary Floating Capacitors Controlled by Finite-Control-Set Model Predictive Control	<i>M. S. Manoharan, A. Ahmed, and J.-H. Park</i>	5002
A Five-Level Boosting Inverter for PV Application	<i>M. J. Sathik, N. Sandeep, D. J. Almakhles, and U. R. Yaragatti</i>	5016
<i>Modeling and Control of Systems</i>		
Current Control of LCL-Type Shunt APFs: Damping Characteristics, Stability Analysis, and Robust Design Against Grid Impedance Variation	<i>L. Yang, J. Yang, M. Gao, A. Watson, and P. Wheeler</i>	5026

Design Optimization of Medium-Frequency Transformer for DAB Converters With DC Bias Capacity	<i>P. Yao, X. Jiang, P. Xue, S. Li, S. Lu, and F. Wang</i>	5043
Realizable Reference Antiwindup Implementation for Parallel Controller Structures	<i>C. González Moral, J. M. Guerrero, D. Fernández, D. Reigosa, C. R. Pereda, and F. Briz</i>	5055
Generalized IDA-PBC Control Using Enhanced Decoupled Power Sharing for Parallel Distributed Generators in Standalone Microgrids	<i>N. Khefifi, A. Houari, M. Machmoum, A. Saim, and M. Ghanes</i>	5069
Optimal Design of a Multiwinding High-Frequency Transformer Using Reluctance Network Modeling and Particle Swarm Optimization Techniques for the Application of PV-Linked Grid-Connected Modular Multilevel Inverters	<i>M. Jafari, Z. Malekjamshidi, and M. R. Islam</i>	5083
Parallel Frameworks for Robust Optimization of Medium-Frequency Transformers	<i>K. Booth, H. Subramanyan, J. Liu, and S. M. Lukic</i>	5097
Resonant-Linear Hybrid Structure for Power Amplifier at Radio Frequency Band	<i>X. Zhu, K. Jin, and R. Tan</i>	5113
Fuzzy Entropy-Based State of Health Estimation for Li-Ion Batteries	<i>X. Sui, S. He, J. Meng, R. Teodorescu, and D.-I. Stroe</i>	5125
