

International Exhibition & Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management (PCIM Europe 2017)

Power for Efficiency

Nuremberg, Germany
16 - 18 May 2017

Volume 1 of 3

ISBN: 978-1-5108-4397-4

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2017) by VDE VERLAG GMBH
All rights reserved.

Printed by Curran Associates, Inc. (2017)

For permission requests, please contact Mesago PCIM GmbH
at the address below.

Mesago PCIM GmbH
Rotebuehlstrasse 83-85
70178 Stuttgart Germany

Phone: 49 711 619 460
Fax: 49 711 619 4690

info@mesago.com

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
Email: curran@proceedings.com
Web: www.proceedings.com

Table of Content PCIM Europe 2017

HV-SiC-MOSFET

3.3 kV/450 A Full-SiC nHPD² (next High Power Density Dual) with Smooth Switching	33
Takashi Ishigaki, Seiichi Hayakawa, Tatsunori Murata, Toshio Nozoe, Hidekatsu Onose, Hiroshi Miki, Masakazu Sagawa, Tetsuo Oda, Kan Yasui, Daisuke Kawase, Yuji Takayanagi, Renichi Yamada, Hitachi Power Semiconductor Device, J; Toru Masuda, Naoki Tega, Kumiko Konishi, Ryusei Fujita, Hiroyuki Matsushima, Akio Shima, Hitachi, J; Katsuaki Saito, Hitachi Europe, GB	
Characterization of 3.3 kV and 6.5 kV SiC MOSFETs	39
Takui Sakaguchi, Masatoshi Aketa, Takashi Nakamura, ROHM, J; Masaharu Nakanishi, ROHM Semiconductor, D; Munaf Rahimo, ABB Switzerland, CH	
Dynamic Characterization of Next Generation Medium Voltage (3.3 kV, 10 kV) Silicon Carbide Power Modules	44
Jonathan Hayes, William Austin Curbow, Brett Sparkman, Daniel Martin, Kraig Olejniczak, Ajith Wijenayake, Ty McNutt, Wolfspeed, USA	
3.3 kV All-SiC Power Module for Traction System Use	51
Tetsu Negishi, Ryo Tsuda, Kenji Ota, Shinichi Iura, Hiroshi Yamaguchi, Mitsubishi Electric Corporation, J	

Power Converters with Wide Bandgap Devices I

Two-Switch Quasi-Resonant Flyback Converter with SiC Switches	57
Stefan Schmitt, Watts & Bytes, F; Jens Marten, BLOCK Transformatoren, D	
Characterization of 1.7 kV SiC MOSFET Modules for Medium/High Power Current Source Inverter in Photovoltaic Applications	60
Luis Gabriel Alves Rodrigues, Jérémy Martin, Stéphane Catellani, Commissariat à l'Énergie Atomique et aux Énergies Alternatives, F; Jean-Paul Ferrieux, Université Grenoble Alpes, G2Elab, F	
 Power Loss Evaluation of 2.5 MHz High Frequency Inverter Based on Frequency Multiplying Method	68
Koji Orikawa, Satoshi Ogasawara, Hokkaido University, J; Jun-ichi Itoh, Nagaoka University of Technology, J	
Gate Driver Architectures for High Speed Power Devices in Series Connection	75
Van-Sang Nguyen, Pierre LeFranc, Jean-Christophe Crebier, Université Grenoble Alpes, G2ELab, F	

Materials

Reliable Interconnection Technologies for High-Temperature Operation of SiC MOSFETs	83
Fabian Mohn, Chunlei Liu, Jürgen Schuderer, ABB Switzerland, CH	

Sintering Copper Die-Bonding Paste Curable Under Pressureless Conditions91
Hideo Nakako, Dai Ishikawa, Chie Sugama, Yuki Kawana, Motohiro Negishi, Yoshinori Ejiri, Hitachi Chemical, J

Taking Power Semiconductors to the Next Level: Novel Plug & Play High Thermal Performance Insulated Molded Power Package96
Christian Kasztelan, Thomas Basler, Manfred Mengel, Edward Fürgut, Infineon Technologies, D

Development of Thermal Fatigue-Tolerant Active Metal Brazing Substrates Using Highly-Thermal Conductive Silicon Nitrides with High Toughness101
Hiroyuki Miyazaki, You Zhou, Kiyoshi Hirao, Shinji Fukuda, Noriya Izu, Hideki Hyuga, National Institute of Advanced Industrial Science and Technology (AIST), J; Shoji Iwakiri, Hideki Hirotsuru, Denka Company Limited, J

Sensorless Drives

Initial Rotor Position Determination of a Soft Starter Driven Synchronous Motor107
Hauke Nannen, Heiko Zatocil, Siemens, D

A Robust Encoderless Predictive Current Control Using Novel MRAS Observer for Surface-Mounted Permanent-Magnet Synchronous Generators113
Mohamed Abdelrahem, Christoph Hackl, Ralph Kennel, Technical University of Munich, D



FPGA-based Sensorless Control of a PMSM at Low-Speed Range121
Fernando David Ramirez Figueroa, Mario Pacas, University of Siegen, D; Cesar Gonzalez, Tecnologico de Monterrey, MX

Application of a Position Sensorless Control to a Reluctance Synchronous Drive Including Flux Weakening129
Matthias Hofer, Mario Nikowitz, Manfred Schrödl, Vienna University of Technology, AT

Modular Multilevel Converter for High Voltage Applications

Four-Level MMC Cell Type with DC Fault Blocking Capability for HVDC136
Viktor Hofmann, Mark M. Bakran, University of Bayreuth, D

Virtual Submodule Applied to the Modular Multilevel Converter145
Alexandre Christe, Drazen Dujic, Ecole Polytechnique Fédérale de Lausanne (EPFL), CH

  **IGCT based Modular Multilevel Converter for an AC-AC Rail Power Supply153**
David Weiss, Michail Vasiladiotis, Cosmin Bănceanu, Noemi Drack, Bjørn Ødegård, ABB Switzerland, CH; Andrea Grondona, ABB Sweden, SE

Development of a Full-Bridge Sub-Module for HVDC and STATCOM Markets161
Javier Chivite-Zabalza, Jerome Perrier, Mike Boden, Tianning Xu, John Outram, GE's Grid Solutions, GB

SiC MOSFET

The New CoolSiC™ Trench MOSFET Technology for Low Gate Oxide Stress and High Performance	168
Dethard Peters, Thomas Basler, Bernd Zippelius, Infineon Technologies, D; Thomas Aichinger, Wolfgang Bergner, Romain Esteve, Daniel Kueck, Ralf Siemieniec, Infineon Technologies, AT	
Short-Circuit Robustness of Discrete SiC MOSFETs in Half-Bridge Configuration	175
Nicolas Degrenne, Anthony Roy, Johan Le Lesle, Erwan David, Stefan Mollov, Mitsubishi Electric, F	
Design Rules to Adapt the Desaturation Detection for SiC MOSFET Modules	182
Teresa Bertelshofer, Andreas März, Mark-M. Bakran, University of Bayreuth, D	
Device Simulation Modeling of 1200 V SiC MOSFETs	190
Kwangwon Lee, Martin Domeij, Benedetto Buono, Krister Gumaelius, Jimmy Franchi, Fredrik Allerstam, ON Semiconductor, SE; James Victory, Mehrdad Baghaie Yazdi, Thomas Neyer, ON Semiconductor, D	

Power Converter Design

Enhancing Power Density and Efficiency of Variable Speed Drives with 1200 V SiC T-MOSFETs	196
Benjamin Sahan, Anastasia Brodt, Daniel Heer, Ulrich Schwarzer, Maximilian Slawinski, Tim Villbusch, Klaus Vogel, Infineon Technologies, D	



Air Cooled SiC Three Level Inverter with High Power Density for Industrial Applications	204
Alexander Hensler, Thomas Bigl, Stephan Neugebauer, Stefan Pfefferlein, Siemens, D	

Generic Approach for Design, Configuration and Control of Modular Converters	212
Lyubomir Kerachev, Yves Lembeye, André Andreta, Jean-Christophe Crebier, Université Grenoble Alpes, F	

Current Sensors



IGBT Gate Driver with Accurate Measurement of Junction Temperature and Inverter Output Current	220
Marco Denk, Mark-M. Bakran, University of Bayreuth, D	

An Inverted Rogowski Coil: A High Speed, Wide-Band, Compact Current Transducer with High Immunity to Voltage Transients	228
Chris Hewson, Joanne Aberdeen, Power Electronic Measurements, GB	

Design of a 300 Amps Pulsed Current Source with Slopes up to 27 Amps per Nanosecond for Current Probe Analysis	235
Nathan Tröster, Dennis Bura, Julian Wölfle, Martin Stempfle, Jörg Roth-Stielow, University of Stuttgart, D	

New and Renewable Energy Systems

A 70 kW Next Generation Three-phase Solar Inverter with Multiple MPPTs using Advanced Cooling Concept and Stacked-PCB Architecture	241
Rémi Freiche, Sebastian Franz, Marc Fink, Stephan Liese, Fraunhofer Institute ISE, D	
Enhanced Current Control Scheme for Large-Scale Solar Inverters	247
Tomomichi Ito, Akira Kikuchi, Haruo Nemoto, Masaya Ichinose, Masahiro Taniguchi, Hitachi, J	
Improved Bias Supply Scheme for a Maximum Power Point Tracking Universal Topology for Low-Voltage Electromagnetic Harvesters in Battery Powered Applications	253
Mahmoud Shousha, Dragan Dinulovic, Martin Haug, Würth Elektronik eiSos, D	

Special Session: Smart Grid & Communication

A New Configuration for a Grid Forming Converter in AC Islanded Microgrid	257
Hélio Antunes, Sidelmo Silva, Braz Filho, Reginaldo Ferreira, Danilo Iglesias Brandão, Federal University of Minas Gerais, BR	
Design and Control of a DC Grid for Railway Stations	265
Sabah Siad, Gilney Damm, Paris Saclay University, F; Lilia Galai Dol, Alexandre de Bernardinis, Efficacity, F	
Distributed Nonlinear Control for a MicroGrid Embedding Renewables, Train's Energy Recovery System and Storages	273
Alessio Iovine, Lilia Galai Dol, EFFICACITY, F; Elena De Santis, Maria Di Benedetto, L'Aquila University, I; Gilney Damm, Paris Saclay University, F	
Reliability Enhancement of Modular Smart Transformers by Uneven Loading of Cells	281
Vivek Raveendran, Markus Andresen, Giampaolo Buticchi, Marco Liserre, Christian-Albrechts University, D	

Power Converters with Wide Bandgap Devices II

800 V Three-Phase LLC Series Resonant DC/DC Converter Using SiC MOSFETs	289
Yusuke Nakakohara, Hirotaka Otake, Ken Nakahara, ROHM, J; Tomohiko Yoshida, Mamoru Tsuruya, Power Assist Technology, J	
Destructive Energy Hidden on DC/DC Converter Power Module Supply Lines	294
Roland Kratz, Würth Elektronik, D	
Optimization of a DCDC Dual Active Bridge Converter for Aircraft Application	302
Maximin Blanc, Yves Lembeye, Jean-Paul Ferrieux, Université Grenoble Alpes, G2Elab, F; Corentin Rizet, Sirepe, F; Arnaud Mahe, Taoufik Bensalah, Thales AES, F	
Highly Integrated Silicon Carbide 80 kW Resonant Inverter for High Voltage Generation Switching at 500 kHz	309
Ulf Müter, Klaus F. Hoffmann, Helmut Schmidt University – University of the Federal Armed Forces Hamburg, D; Arne Lunding, Bernhard Wagner, Philips Medical Systems, D	

IGBT



Dual Side-Gate HiGT Breaking Through the Limitation of IGBT Loss Reduction	315
Tomoyuki Miyoshi, Yujiro Takeuchi, Tomoyasu Furukawa, Masaki Shiraishi, Mutsuhiro Mori, Hitachi, J	
An Optimized Plug-In BIGT with No Requirements for Gate Control Adaptations	323
Munaf Rahimo, Charalampos Papadopoulos, Chiara Corvasce, Arnost Kopta, ABB Switzerland, CH	
Power Rating Extension with 7th Generation IGBT and Thermal Management by Newly Developed Package Technologies	329
Kenichi Yoshida, Shinichi Yoshiwatari, Mutsumi Sawada, Yuichi Onozawa, Souichi Okita, Osamu Ikawa, Fuji Electric, J	
The Next Generation High Power Modules with Enhanced Trench BIGT Technology	335
Charalampos Papadopoulos, Munaf Rahimo, Chiara Corvasce, Arnost Kopta, Maxi Andenna, ABB Switzerland, CH	
High Efficient and Soft IGBT Technology	340
Suguru Hondo, Yu Enomoto, Yuta Kawamoto, Akihiro Hikasa, Kazuhide Ino, ROHM, J	

Module Design

A New Intelligent IGBT Module for Quasi-Resonant Inverter Applications	344
Wonjin Cho, Bum-Seok Suh, Alpha and Omega Semiconductor, USA	
Relaxing Thermal Stress by SLC Technology and New PC-TIM	350
Koichi Masuda, Yoshitaka Otsubo, Tomohiro Hieda, Mitsubishi Electric Corporation, J	
Lifetime Estimation Model of HVIGBT Considering Humidity	353
Yumie Kitajima, Kenji Hatori, Shinichi Iura, Keiichi Nakamura, Yasutaka Kusakabe, Kazuhiro Kurachi, Mitsubishi Electric Corporation, J; Eugen Wiesner, Eckhard Thal, Mitsubishi Electric, D	
Effects of Influencing the Individual Leg Inductance in Case of Paralleling Modules on Basis of XHP 3 and EconoDUAL	359
Matthias Wissen, Daniel Domes, Waleri Brekel, Thomas Holtij, Andreas Groove, Infineon Technologies, D	
Breakdown of Gate Oxide of SiC-MOSFETs and Si-IGBTs under High Temperature and High Gate Voltage	365
Menia Beier-Möbius, Josef Lutz, Technical University of Chemnitz, D	

Control Techniques in Intelligent Motion Systems

Harmonic Speed Control for Repetitive Mechanical Systems	373
Van Trang Phung, Mario Pacas, University of Siegen, D	
Hybrid Current and Acceleration Control of Servo Drives	381
Josef Wittmann, Rainer Hagl, University of Applied Sciences Rosenheim, D; Ralph Kennel, Technical University Munich, D	

Analysis of Instantaneous Switching Frequency of a Hysteresis Based PWM for Control of Power Electronics390
Malte Thielmann, Axel Klein, Michael Homann, Walter Schumacher, Technical University of Braunschweig, D

Natural-Sampled, Quasi-Continuous and Synchronous Pulse Width Modulator Enables Field Oriented Control for High Speed Drives398
Jens Onno Krahn, Markus Hölting, TH Köln – University of Applied Sciences, D; Jochen Pieper, Christoph Klarenbach, Beckhoff Automation, D

Special Session: Passive Components

Estimating the Pulse Performance of Wirewound Power Resistors404
Bertram Schott, Vishay Electronic, D

Inductance versus DC Current Measurements on the Anhysteresis of Magnetic Material411
Jörn Schlieve, Stefan Scheffler, Matthias Köppen, Achim Siersch, Stefan Weber, EPCOS, D

Experimental Evaluation of Capacitors for High Power Resonant Converters417
Miroslav Vasić, Jesús A. Oliver, Pedro Alou, Jose A. Cobos, University of Madrid, ES; Petar J. Grbović, Huawei Technologies, D

  **Medium Frequency Transformer Design and Optimization423**
Marko Mogorovic, Drazen Dujic, École Polytechnique Fédérale de Lausanne (EPFL), CH


SiC-Systems


A Novel Gate Drive Concept to Eliminate Parasitic Turn-on of SiC MOSFET in Low Inductance Power Modules431
Andreas März, Teresa Bertelshofer, Mark-M. Bakran, University of Bayreuth, D; Martin Helsper, Siemens, D



Evaluation of Current Measurement Accuracy for a Power Module with Integrated Shunt Resistors438
Matthias Spang, Niklas Hofstoetter, SEMIKRON Elektronik, D

Optical Power Isolation Enables Novel IGBT and Sensor Applications446
Jan-Gustav Werthen, Mort Cohen, L2W Energy, USA

Power Electronics Optimization

 **Development of a High Efficient MPPT for Space Applications Using GaN Power Transistors451**
Cornelius Armbruster, Christian Schöner, Fraunhofer Institute ISE, D; Torben Schönbett, Alfons Klönne, Rainer Merz, University of Applied Sciences Karlsruhe, D

	Parasitic Inductance Analysis of a Fast Switching 100 kW Full SiC Inverter457
	Matthias Kegeleers, Julian Körner, Stefan Matlok, Maximilian Hofmann, Martin März, Fraunhofer Institute IISB, D

		Design Method for the Minimization of CM Inductor Volume with Consideration of Core Saturation in EMI Filters464
		Bilel Zaidi, Arnaud Videt, Nadir Idir, University of Lille (L2EP), F

Cooling Thermal Management

Temperature Swing Issue, How a Passive Two-Phase Cooling Loop Can Improve the Power Electronic Lifetime472
Vincent Dupont, Thomas Nicolle, Cyrille Billet, CALYOS, BE

New Electro-Thermal Model for a Multichip Power Module Used in a Motor Drive479
Merouane Ouhab, Radoslava Mitova, Miao-Xin Wang, Schneider Electric, F; Zoubir Khatir, Ali Ibrahim, Jean-Pierre Ousten, IFSTTAR, F

A Double Side Cooled Electronic Power Module487
Jacques Favre, APSI3D, F; Jean-Michel Reynes, IRT Saint Exupery, F; Jean-Pierre Fradin, Claudia Cadile, Sébastien Sanchez, Dominique Elzo, ICAM, F; Emmanuel Marcault, CEA Tech, F

Metering and Diagnostics and Standards

Monitoring of Current Balance in Parallel-connected Power Converters495
Lorenzo Giuntini, GE Consumer & Industrial, CH

Online IGBT Temperature Measurement Method Using a Greybox Model501
Georg Pangalos, Malte Päsler, Holger Kapels, Fraunhofer Institute ISIT, D

Impact of Temperature Imbalance on Junction Temperature Identification for Multiple Chip Modules Using TSEPs507
Jose Ortiz Gonzalez, Olayiwola Alatise, Li Ran, Philip Mawby, University of Warwick, GB

Passive Components and New Materials

Evolution of Magnetics in Power Electronics Applications and Facing the Challenges of Future Electronics Industry515
Kapila Warnakulasuriya, Andrea Polti, Murata Power Solutions, GB; Farhad Nabhani, Teesside University, GB

High Performance Common-Differential Mode Chokes for High Efficient EMI Filters520
Thiemo Kleeb, Juliane Hinze, Peter Zacharias, University of Kassel, D

Dimensioning and Testing Planar Inductors for High Frequency Operation528
Gérard Delette, Gaëlla Frajer, Cyril Rado, Pierre Perichon, Florence Servant, CEA-LITEN, F; Hervé Chazal, G2Elab, F; Olivier Isnard, CNRS, F


Advanced Wide Bandgap – GaN

Investigation of GaN-HEMTs in Reverse Conduction	533
Richard Reiner, Patrick Waltereit, Beatrix Weiss, Rüdiger Quay, Oliver Ambacher, Fraunhofer Institute IAF, D	
Dispersion of Electrical Characteristics and Short-Circuit Robustness of 600 V Emode GaN Transistors	541
Matthieu Landel, Cyrille Gautier, Denis Labrousse, Stéphane Levebvre, Fadi Zaki, Zoubir Khatir, ENS Cachan – SATIE, F	
Mechatronic Design of 2 kW SiC DC/AC Converter with 200 W/inch	550
Thomas Menrath, Stefan Endres, Stefan Zeltner, Stefan Matlok, Bernd Eckardt, Fraunhofer Institute IISB, D	
A Full SiC Module Operational at 200 °C Junction Realized by a New Fatigue-Free Structure	556
Hiroshi Notsu, Hisato Michikoshi, Kenji Fukuda, National Institute of Advanced Industrial Science and Technology (AIST), J; Dai Ishikawa, Yoshinori Ejiri, Hitachi Chemical, J; Satoshi Hatsukawa, Sumitomo Electric Industries, J	
A Novel SiC Power Module with 3D Integration	561
Jinchang Zhou, ON Semiconductor, USA	

Power Electronics in Automotive

Influences of WPT-Coil Losses and Coupling Coefficient on the Resonance Circuits of Wireless Power Transfer Systems	566
Christof Ziegler, Stefan Weber, EPCOS, D; Georg Heiland, Finepower D; Denis Kraus, Technical University of Munich, D	
6 kW Bidirectional, Insulated On-board Charger With Normally-Off GaN Gate Injection Transistors	573
Stefan Endres, Christoph Seßler, Stefan Zeltner, Bernd Eckardt, Fraunhofer Institute IISB, D; Tatsuo Morita, Panasonic Corporation, J	
650 V, 7 mOhm SiC MOSFET Development for Dual-Side Sintered Power Modules in Electric Drive Vehicles	579
Monty Hayes, John Fruth, Aditya Neelakantan, Robert Campbell, Erich Gerbsch, Delphi Automotive Systems, USA; Jeffrey Casady, Brett Hull, Jon Zhang, Scott Allen, John Palmour, Wolfspeed, USA	
A Novel Spectral Control Method for an Automotive Gallium Nitride DC-DC Converter	585
Christian Korte, Eduard Specht, Stefan Götz, Porsche Engineering Group, D	

Control and Drive Strategies in Power Converters

 Digital Control of Hard Switched Converters by Phase Modulated Pulse Width Modulation PMPWM	592
Stefan Matlok, Bernd Eckardt, Bernd Seliger, Martin März, Fraunhofer Institute IISB, D	

Non-Linearities Compensation Technique for VSI Fed AC Drives600
Umberto Abronzini, Ciro Attaianese, Mauro Di Monaco, Giuseppe Tomasso, University of Cassino and Southern Lazio, I

Novel Control Scheme for the Internal Energies and Circulating Currents of Modular Multilevel Converter606
Yeqi Wang, Rainer Marquardt, University of the Federal Armed Forces Munich, D

Suitable Turn-Off Strategies for IGBTs with a High Desaturation Current During Short Circuit Failures Detected with the 2D-Short Circuit Detection Method612
Stefan Hain, Mark-M. Bakran, University of Bayreuth, D

Special Session: Capacitors

Ceramic Power Capacitors and Optimized Packaging619
Markus Koini, Javier Martinez, Markus Puff, EPCOS, AT

Ultra Capacitors – Capacitor Based Energy Storage622
Jan-Hendrik Ernst, Maxwell Technologies, D; Robert Lynds, Catalin Popescu, Mark Sutherland, Maxwell Technologies, USA

Review of Film Capacitor Trends and Design Changes as a Result of Improved Technologies in Power Electronics628
Ayse Kartal, EPCOS, D

New Concepts of Capacitor Designs in Power Electronics631
Thomas Ebel, FTCAP, D

SiC Modules Diodes

Design and Analysis of a Low-Inductive Power-Semiconductor Module with SiC T-MOSFET and Si IGBT in Parallel Operation636
Christian R. Müller, Infineon Technologies, D

1.7 kV High-Current SiC Power Module Based on Multi-Level Substrate Concept and Exploiting MOSFET Body Diode during Operation644
Slavo Kicin, Stanislav Skibin, Christof Bernhard, Enea Bianda, Francisco Canales, ABB Corporate Research, CH; Samuel Hartmann, Fabian Fischer, Pauline Morin, Robert Gade, ABB Switzerland, CH

All-SiC Module with 1st Generation Trench Gate SiC MOSFETs and New Concept Package651
Yoshinori Iwasaki, Mikiya Chounabayashi, Masayoshi Nakazawa, Susumu Iwamoto, Yasuhiko Oonishi, Motohito Hori, Hideaki Kakiki, Osamu Ikawa, Fuji Electric, J; Thomas Heinzl, Fuji Electric Europe, D

Robust SiC JBS Diodes for the Application in Hybrid Modules658
Lukas Kranz, Renato Amaral Minamisawa, Lars Knoll, Sven Matthias, Andrei Mihaila, Charalampos Papadopoulos, Athanasios Mesemanolis, Elena Mengotti, Giovanni Alfieri, Vinoth Kumar Sundaramoorthy, Enea Bianda, Munaf Rahimo, ABB Switzerland, CH

Power Converters with Wide Bandgap Devices III



Design and Performance of a 200 kHz GaN Motor Inverter with Sine Wave Filter664

Franz Stubenrauch, Norbert Seliger, University of Applied Sciences Rosenheim, D;
Doris Schmitt-Landsiedel, Technische Universität München, D



Reducing dv/dt of Motor Inverters by Staggered- Edge Switching of Multiple Parallel SiC Half-Bridge Cells673

Thomas Fuchslueger, Hans Ertl, Technical University of Vienna, AT; Markus A. Vogelsberger,
Bombardier Transportation Austria, AT

Highly-Reliable Flyback-Based PV Micro-Inverter Applying Power Decoupling Capability without Additional Components681

Hiroki Watanabe, Jun-Ichi Itoh, Nagaoka University of Technology, J

Compact Highly Efficient 3-kW MHz Inverter Based on SMT SiC MOSFETs689

Fabian Denk, Christoph Simon, Michael Heidinger, Rainer Kling, Wolfgang Heering, Karlsruhe Institute of Technology (KIT), D

System Reliability

Power Cycle Testing of Sintered SiC-MOSFETs694

Ralf Schmidt, Ronny Werner, Siemens, D; Jeffrey Casady, Brett Hull, Adam Barkley, Wolfspeed, USA

Synchronous Observing Methodology of Surface Images and Energy Data at Power Chip Destruction702

Toshiya Tadakuma, Akiko Goto, Teruaki Nagahara, Junji Yamada, Mitsubishi Electric Corporation, J

Active Current Trajectory Control (ACTC) – for Hot Swap, Capacitor Discharge, Circuit Breaker and Current Shaping706

Sebastian Uitz, Kenneth Kin Leong, Volodymyr Yakobniuk, Juan Sanchez, Gerald Deboy, Infineon Technologies Austria, AT

Impact of Humidity on Railway Converters715

Christian Zorn, Nando Kaminski, University of Bremen, D; Michel Piton, ALSTOM, F

Energy Storage and Power Quality Solutions

A Comparative Study on Si-SJ-MOSFETs vs. GaN-HEMTs Used for LLC-Single-Stage Battery Charger723

Lukas Keuck, Patrick Hosemann, Benjamin Strothmann, Joachim Böcker, University of Paderborn, D

Investigation and Optimization of the Accuracy of Current Sensors for High Voltage LFP-Batteries731

Simon Bischof, Thomas Blank, Marc Weber, Karlsruhe Institute of Technology (KIT), D

High-Efficiency UPS Protection for Industrial Applications738

Lorenzo Giuntini, Massimiliano Brioschi, GE Consumer & Industrial, CH

1.5 kW Digital Totem Pole PFC Design for Air-Conditioner and Performance Comparison Using IGBT, SiC and GaN	745
Wei Wu, Infineon Technologies, USA	

Advanced Si Power Semiconductors

Diode Parameters Design Simulation and Experimental Validation against Silver Migration Phenomena in High Voltage Switching Application	750
Mattia Gianfranco Gentile, Ettore Vittone, University of Turin, I; Paolo Mirone, University of Naples Federico II, I; Luigi Merlin, Vishay Intertechnology, I	

Reliability Improving of Power Semiconductor Discharge Switch by Means of LTJT Technology	756
Alexey Grishanin, Valentin A. Martynenko, Alexey Khapugin, Mikhail Malygin, Oleg Frolov, JSC Elektropriyemitel, RU; Konstantin Nishchev, Mikhail Novopolitsev, Ogarev Mordovia State University, RU	

New Generation Large Area Thyristor for UHVDC Transmission	761
Jan Vobecky, Karlheinz Stiegler, Marco Bellini, Urban Meier, ABB Switzerland, CH	

The Next Generation 4500 V / 3000 A BIGT Stackpak Modules	765
Franc Dugal, Andreas Baschnagel, Munaf Rahimo, Arnost Kopta, ABB Switzerland, CH	

STMicroelectronics' new Super-Junction Technology with Fast Intrinsic Diode Ideal for the Most Demanding High Efficiency Bridge Topologies and ZVS Phase-Shift Converters – Comparison Analysis in 2 kW AC-DC Switch Mode Power Supply	770
Alfio Scuto, Antonino Gaito, Giuseppe Sorrentino, Cristiano Gianluca Stella, STMicroelectronics, I	

Low Voltage AC/DC Over-Current Breaker with 650-V IGBTs	775
Jan Fuhrmann, David Hammes, Hans-Günter Eckel, University of Rostock, D	

An Advanced Si-IGBT Chip for Delivering Maximum Overall System Performance	783
Narender Lakshmanan, Thomas Radke, Mitsubishi Electric Europe, D	

High Energy Harvesting in High Current/Voltage Induction Heating Application Using the new Ultra Filed Stop IGBTs Technology	790
Leon Zhang, ON Semiconductor, CN; Vittorio Crisafulli, ON Semiconductor, D	

Automated Test Bench for the Measurement of Si-IGBT and SiC-MOSFET Hybrid Switches	796
Michael Meissner, Sebastian Fahlbusch, Klaus F. Hoffmann, Helmut Schmidt University – University of the Federal Armed Forces Hamburg, D	

New-Generation Trench Schottky Rectifiers (TSR) with Superior Electrical Performance	802
Wesley Chih-Wei Hsu, Jia-Jan Guo, Ju-Hsu Chuang, Yu-Hung Chang, Sung-Yin Wu, Liteon Semiconductor, TW	

A Technology Platform for Reverse-Conducting Integrated Gate Commutated Thyristors with 94 mm Device Diameter	806
Tobias Wikström, Maria Alexandrova, ABB Switzerland, CH	

Wide Bandgap Devices I

Measurement Scheme to Model an SiC MOSFET for Simulating its Switching Behaviors	811
Tatsuya Yanagi, Hiroyuki Sakairi, Hirotaka Otake, Naotaka Kuroda, Ken Nakahara, ROHM, J; Hiroaki Tanigawa, Keysight Technologies, J	
A Performance Comparison of SiC Power Modules with Schottky and Body Diodes	816
Christopher Schmidt, Martin Röblitz, SEMIKRON Elektronik, D	
Comparison between 1200 V 5th generation SiC MPS Diode and Silicon Power Diode in DC/AC Hybrid Circuit Breaker	824
Kenan Askan, Michael Bartonek, Eaton Industries, AT; Fabio Brucchi, Infineon Technologies, I	
Impact of Dynamic On-Resistance of High Voltage GaN Switches on the Overall Conduction Losses	832
Eduardo de Oliveira, Christian Nöding, Peter Zacharias, University of Kassel, D	
Calorimetric Measurement of Wide Bandgap Semiconductors Switching Losses	840
Sven Bolte, Lukas Wohlrab, Jehan Khan Afridi, Norbert Fröhleke, Joachim Böcker, University of Paderborn, D	
System Level Comparison of Si IGBTs and SiC MOSFETs	846
Levi Gant, Sujit Banerjee, Xuning Zhang, Gin Sheh, Monolith Semiconductor, USA; Andrew Lemmon, Ali Shahabi, The University of Alabama, USA	
Comparison of the Short Circuit Capability of Planar and Trench SiC MOSFETs	854
Douglas Pappis, Lucas de Menezes, Peter Zacharias, University of Kassel, D	
Characterization and Optimization of SiC Freewheeling Diode for Switching Losses Minimization Over Wide Temperature Range	863
Xuning Zhang, Levi Gant, Gin Sheh, Sujit Banerjee, Monolith Semiconductor, USA	
On Developing a dV/dt Rating for Commercial 650 V- and 1200 V-Rated SiC Schottky Diodes	870
Gang-Yao Wang, Edward Van Brunt, Thomas Barbieri, Brett Hull, Jim Richmond, John Palmour, Wolfspeed, USA	
SiC Power MOSFET with Monolithically Integrated Schottky Barrier Diode for Improved Switching Performances	876
Xiaoping Dai, Huaping Jiang, Changwei Zheng, Dynex Semiconductor, GB; Maolong Ke, Chinese Academy of Sciences, CN	
Dual On-State Gate Driver Concept for Improved Drive of Silicon Carbide MOSFETs	880
Sebastian Fahlbusch, Fabian Fisahn, Michael Meissner, Ulf Müter, Sebastian Klötzer, Klaus F. Hoffmann, Helmut Schmidt University – University of the Federal Armed Forces Hamburg, D	
High Speed, Thermally Enhanced, Small Footprint SiC Power Modules for Cost Sensitive Applications	888
Adam Barkley, Marcelo Schupbach, Scott Alan, Wolfspeed, USA	

Power Modules

A Power Cycling Test Bench Dedicated to the Test of Power Modules in a Large Range of Cycling Frequency	896
Francois Forest, Jean-Jacques Huselstein, Guillaume Pellecuer, University of Montpellier, F; Serge Bontemps, Microsemi PMP, F	
Resin Flow Simulation for Transfer Molding Technology	903
Ken Sakamoto, Yutaro Hanawa, Mitsubishi Electric Corporation, J	
Development of High Thermal Performance Automotive Power Module with Dual Sided Cooling Capability	909
Yangang Wang, Yun Li, Yaqing Ma, Shiwu Zhu, Mingliang Jiao, Jun Yu, Zhenlong Zhao, Chundong Wu, Yibo Wu, Paul Mumby-Croft, James Booth, Matthew Packwood, Steve Jones, Xiaoping Dai, Guoyou Liu, Dynex Semiconductor, GB	
Intelligent Power Modules with Common Footprint for both Single-phase and Three-phase AC Input Motor Drives	914
Jonathan Harper, ON Semiconductor, D	
Optimized Layout of 1700 V LoPak1 IGBT Power Module by Holistic Design Approach	918
Sven Matthias, Samuel Hartmann, Athanasios Mesemanolis, Raffael Schnell, Franc Dugal, Arnost Kopta, ABB Switzerland, CH; Leonel Soberano, Dandy Jaducana, Jean-Marc Renard, IMI Philippines, PH; Andra Irace, Michele Riccio, University of Napoli, I	
Paralleling of LinPak Power Modules	925
Andreas Baschnagel, Daniel Prindle, Silvan Geissmann, Fabian Fischer, Samuel Hartmann, Raffael Schnell, Gontran Pâques, Arnost Kopta, ABB Switzerland, CH	
A New Generation of 600 V Intelligent Power Module for Consumer and Industrial Motor Drive Applications	930
Bumseung Jin, Kang Yoon Lee, SungDae Shin, Geun-Hyoung Lee, David Jo, Taesung Kwon, Fairchild Korea Semiconductor, ROK	
Super Mini DIIPM™ for Automobile	935
Naoki Ikeda, Hiroyuki Hata, Hongbo Zhang, Mitsubishi Electric Corporation, J	

Cooling Systems

Thermal Characterization Analysis of IGBT Power Module Integrated with a Vapour Chamber and Pin-Fin Heat Sink	939
Yiyi Chen, Yuying Yan, Bo Li, Wei Gong, University of Nottingham, GB; Fang Qi, Yangang Wang, Steve Jones, Dynex Semiconductor, GB	
Silicone-Based Enablers for Thermal Management in Power Electronics	947
Thomas Seldrum, Marin Demulier, Vincent Delsuc, Dow Corning Europe, BE	
Innovative Design in IGBT Cold Plate	952
Chihwei Wei, Larry Lin, Kevin Wu, Amulair Thermal Technology, TW	

Reliability of the Direct Cooling Type Cold Plate with Ni Clad Layer	957
Kazuhiko Minami, Atsushi Otaki, Ichiro Ota, Showa Denko, J	
Testing, Selecting, and Applying Metallic Thermal Interface Materials for Harsh Environment Applications	960
David Saums, DSA LLC, USA; Timothy Jensen, Indium Corporation, USA	
Two-Phase Liquid Cooling for Electric Vehicle IGBT Power Module Thermal Management	969
Itxaso Aranzabal, Inigo Kortabarria, Inigo Martinez de Alegria, University of the Basque Country (UPV/EHU), ES; Nicola Delmonte, Paolo Cova, University of Parma, I	
Evaluation of Leadframe Power Modules for Automotive Drive Applications	974
Bao Ngoc An, Maurizio Kempf, Michael Meisser, Horst Demattio, Benjamin Leyrer, Thomas Blank, Marc Weber, Karlsruhe Institute of Technology (KIT), D; Johannes Kolb, Schaeffler Technologies, D	
Exploring Novel Second Level Cooling Methods for Low Profile IPMs	982
Khatri Danish, Okawa Katsumi, Rajeev Krishna Vytla, Jin Pei, Infineon Technologies Americas, USA	
 Reliability	
Inverter Power Module Lifetime Estimation for HEV and EV	987
JeHwan Lee, HanGeun Jang, SangChul Shin, KiYoung Jang, JinHwan Jung, Hyundai Motors, ROK	
The Enhanced Reliability of the Double Sided Cooled Package with Integrated Internal Isolation	993
Inpil Yoo, Marina Schmitz, Infineon Technologies, D	
Determination of State-of-Health and Remaining Lifetime of Power Modules	999
Jörg Franke, Christian Herold, Lukas Tinschert, Josef Lutz, Technical University Chemnitz, D	
Shoot Through and Avalanche Behavior of High Speed Fet Converter	1003
Florian Kapaun, Rainer Marquardt, University of the Federal Armed Forces Munich, D	
Reliability Investigation on SiC based Diode and MOSFET Modules Developed for High Power Conversion in Medical X-Ray Applications	1009
Alexander Otto, Rainer Dudek, Sven Rzepka, Fraunhofer Institute ENAS, D; Mohamad Abo Ras, Tobias von Essen, Berliner Nanotest & Design, D; Markus Bast, Armin Hindel, Ronald Eisele, FuE-Zentrum FH Kiel, D; Ulf Mütter, Helmut-Schmidt University, D; Arne Lunding, Philips Medical Systems, D	
Mission Profile Based Reliability Evaluation of Building Blocks for Modular Power Converters	1017
Frederik Hahn, Markus Andresen, Giampaolo Buticchi, Marco Liserre, Christian-Albrechts University, D	
Thermal Calculation Methodology for Lifetime Estimation of Semiconductor Devices in MMC Application	1024
Yijun Ye, Josef Lutz, Guang Zeng, Technical University of Chemnitz, D; Rodrigo Alvarez, Pablo Correa, Siemens, D	

Thermal Management and Packaging I

In-Situ Transient Testing of Run-in and Degradation Effects of Thermal Interface Sheets in Power Switch Assemblies	1030
Gabor Farkas, Zoltan Sarkany, Attila Szel, Mentor Graphics, HU	
Material Design and Process Conditions of Pressureless Sintered Silver for 200/-40 °C Thermal Cycling Reliability	1038
Tomofumi Watanabe, Naoya Nakajima, Masafumi Takesue, Bando Chemical Industries, J	
Performance Comparison of fast Silicon and Silicon Carbide Devices Used with Conventional PCBs and Embedded into PCBs	1042
Peter Zacharias, Juliane Hinze, University of Kassel, D	
Power Electronic Package for Double Sided Cooling Utilizing Tile-Level Assembly	1048
Maximilian Schmid, Johannes Pforr, Gordon Elger, Technical University of Applied Sciences Ingolstadt, D	
Packaging Solutions for Mitigating IGBT Short-Circuit Instabilities	1055
Paula Diaz Reigosa, Francesco Iannuzzo, Frede Blaabjerg, Aalborg University, DK	
Thermo-Mechanical Optimisation of Press-Pack IGBT Packaging Using Finite Element Method Simulation	1062
Michael Varley, Ashley Plumpton, Robin Simpson, Chas Tonner, Dynex Semiconductor, GB	
Thermal Impedance Matrix Characterization of Co-Packed Discrete IGBT and Diode	1070
Alberto Salinaro, ON Semiconductor, D; Hans-Peter Hoenes, ON Semiconductor, D	
The Effect of 3 mol% Y₂O₃ doped ZrO₂ on the Flexural Strength of AlN Ceramics	1074
Jong Seol Yoon, Ki Soo Jun, Kyong Hwan Kim, KCC Corporation, ROK	
HT Lead-free and Sinter Materials for WBG Power Semiconductors	1078
Tetsu Takemasa, Jinting Jiu, Minoru Ueshima, Senju Metal Industry, J; Soichi Sakamoto, Sinjo Nagao, Katsuaki Sukanuma, Osaka University, J	
Passive and Active Two-Phase Cooling for Power Electronics Applications	1082
Devin Pellicone, Advanced Cooling Technologies, USA	
Feasibility Study, Combining High-Power MOSFETs in a Power Module Using Advanced Thermal Management	1087
Martin Schulz, Maximilian Slawinski, Infineon Technologies, D	
DC-DC Converters	
Hybrid Power Cell using Si IGBT & SiC MOSFET	1090
Benoit Péron, Joseph Magniez, Centum Adetel, F	
Application of a Buck-Boost Converter for Highly Dynamic Power Smoothing in Industrial Applications	1098
Jochen Staiger, Swen Bosch, Heinrich Steinhart, HTW Aalen, D	

High Power Density GaN Interleaved Bidirectional Boost Converter with Extended Cooling Capability	1106
Konstantin Siebke, Thorben Schobre, Niklas Langmaack, Regine Mallwitz, Technical University Braunschweig, D	
Single-Ended Boost DC-DC Converter Cascade System for High Boost Rate and High Efficiency in Residential Fuel-Cell System	1113
Ryoga Kiguchi, Yasuyuki, Nishida, Chiba Institute of Technology, J	
An Isolated Bidirectional DC-DC Converter for Energy Storage Systems	1117
Mofakkharul Islam, Bebro Electronic, D; Masuma Nasrin, Independent University Bangladesh, BD; Abul Bashar Sarkar, Kempten University of Applied Sciences, D	
Modeling of ZVS DC-DC Converter for Charging and Voltage Balancing of Energy Storage Elements	1123
Nikolay Hinov, George Kraev, Dimitar Arnaudov, Gergana Vacheva, Technical University of Sofia, BG	
Modeling of Multiphase Converter for Charging of Energy Storage Elements	1130
Dimitar Arnaudov, Nikolay Hinov, Stoyan Vuchev, Ivan Nedyalkov, Technical University of Sofia, BG	
Advanced Power Converters for Energy Storage Systems for Light Traction Vehicles	1137
Miroslav Hruška, Skoda Electric, CZ; Martin Schulz, Infineon Technologies, D	
Compact Diode-Less Bidirectional GaN Based Buck Converter for Mobile DC-DC Applications	1143
Sebastian Klötzer, Ulf Müter, Sebastian Fahlbusch, Klaus F. Hoffmann, Helmut Schmidt University – University of the Federal Armed Forces Hamburg, D	
Seven Reasons why Power Designers Should Implement 48 V to 1 V Direct Conversion	1151
Bob Cantrell, Martin Hägerdal, Ericsson Power Modules, SE	
Inductor Current Mapping Analog Controllers for Power Inverters and DC/DC Converters	1153
Alexei V. Nikitin, Avatekh, USA; Ruslan L. Davidchack, University of Leicester, GB	
 Power Converters for Efficiency and Renewable Energy	
Analysis of a Novel Buck-Buck Single Stage LED-Ballast	1162
Alexander Pawellek, Thomas Dürbaum, Friedrich-Alexander University Erlangen, D	
Energy Efficient, GHz Excited Plasma Lighting System	1169
Kamil Kompa, Slawomir Niespodziany, KOMPA Sp. z o.o., PL	
Constant Current Paralleling Controller for Mid-Power LED	1174
Michael Heidinger, Christoph Simon, Fabian Denk, Wolfgang Heering, Rainer Kling, Karlsruhe Institute of Technology (KIT), D	
A Novel Mains Operated LED Driver Using a GaN AC Switch	1182
Othman Ladhari, Léo Sterna, Pierre Perichon, Dominique Bergogne, CEA-Léti, F	
Electronic Ballast for Gas Discharge Lamp Based on Input-Series Output-Series Resonant Converter	1186
Kaspars Kroics, Janis Zakis, Riga Technical University, LV	

Control Loop Design for Closed-Loop Class-D Amplifiers with 4th Order Output Filter	1193
Franz Maislinger, Hans Ertl, Technical University of Vienna, AT; Goran Stojcic, Florian Holzner, Bernecker + Rainer Industrie-Elektronik, AT	
Novel Gate Driver Technology for the Series Connection of Power Semiconductors	1201
Johannes Kemper, Panasonic Industrial Devices Europe, D; Boris Fiedler, Max Planck Institute D; Klaus F. Hoffmann, Helmut Schmidt University, D	
Redundant Operation Mode of the Three-Level Advanced-Active-Neutral-Point-Clamped Converter for Wind Energy Application	1207
Sidney Gierschner, David Hammes, Yves Hein, Hans-Günter Eckel, University of Rostock, D	
Implementation of Extended Kalman Filter for PMSG Considering the Dynamics of the Mechanical System	1214
Mohamed Abdelrahem, Christoph Hackl, Ralph Kennel, Technical University of Munich, D	
Evolution of Bidirectional Power Architectures	1222
David Bourner, Vicor Corporation, USA	
Modular and Compact 1 MW Inverter in One 19" Rack for Storage and PV	1227
Patrick Hercegfı, Stefan Schönberger, Fraunhofer Institute ISE, D	
A New Step Towards the Power Electronics Design Automation	1232
Lyubomir Kerachev, André Andreta, Yves Lembeye, Jean-Christophe Crébier, Université Grenoble Alpes, F	
 Passive Components and New Materials	
Comprehensive AC Performance Analysis of Ceramic Capacitors for DC Link usage	1240
Kirill Klein, Eckart Hoene, Klaus-Dieter Lang, Fraunhofer Institute IZM, D	
High Performance DC Link Capacitor/Bus Sourcing Dual Infineon HybridPACK™ Drive Inverters for EV Applications	1247
Michael A. Brubaker, Terry Hosking, Wayne Liu, SBE, USA; Tomas Reiter, Infineon Technologies, D; Carsten Wüst, David Kuschnarew, hofer eds, D	
An Evaluation Circuit for DC-Link Capacitors Used in a Single-Phase PWM Inverter	1256
Kazunori Hasegawa, Ichiro Omura, Shin-ichi Nishizawa, Kyushu Institute of Technology / National Institute of AIST, J	
IGBT Switching Behavior with Parallel Surge Arrester for Medium Voltage Application	1261
Fabian Hohmann, Mark-M. Bakran, University of Bayreuth, D	
Using Powder Materials to Replace Air-Gaps for Fringing Flux Reduction	1268
Paul Winkler, Wulf Günther, Acal BFi Germany, D	
Partial Discharge of Inductives in a High Frequency Application	1274
Michael Schmidhuber, Herbert Jungwirth, SUMIDA Components Modules, D	

Design of Inductive Components for Triangular Current Mode (TCM) Inverters up to 500 kW1278
Tobias Appel, Spezial-Transformatoren Stockach, D; Jan Fuhrmann, Hans-Günter Eckel, University of Rostock, D

Study of the Influence of an Air Gap on Dimensional Resonance in MnZn-Ferrite Cores1285
Wolfgang Hauser, Manfred Albach, Friedrich-Alexander University Erlangen, D

A Novel Approach to Calculate the Reluctance of Air-Gaps in Ferrite Cores1293
Erika Stenglein, Manfred Albach, Friedrich-Alexander University Erlangen, D

Inductive Components for Solar Power Conversion in a Harsh Next Decade Environment1301
Michael Schmidhuber, SUMIDA Components Modules, D; Marco Jung, Fabian Schnabel, Fraunhofer Institute IWES, D

Systemsimulations with EMI-Filter in an Automotive HighVolt Environment1306
Stefan Scheffler, Stefan Weber, EPCOS, D; Christoph Keller, Konstantin Spanos, Robert Bosch, D

Sensors, Metering, Diagnostics

Current Measurement Device for High and Fast Changing Currents1311
Felix Himmelstoss, Karl Edelmoser, University of Applied Science Technikum Vienna, AT

Measurement of Current and Magnetic Field in a Power Electronic Building Block using Coupled Inductors1316
Jan Hannig, Patrick Deck, Christian Peter Dick, TH Köln – University of Applied Sciences, D

Comparative Analysis of the Measurement Techniques to Characterize SiC-Power-Modules1324
Christian Schulte-Overbeck, Zhiyu Cao, Faheem Khan, Fahad Hussain, Srujan Grandhi, Denis Weiss, AEG Power Solutions, D

Open-Loop Hall-Cell Current Transducers with Integrated Sigma-Delta Modulators1332
Fabrice Salvi, David Jobling, Pierre Turpin, LEM Switzerland, CH

Magneto-resistive Sensors for Angle, Position and Speed Measurement in Small-and Micro-sized actuators1338
Rolf Slatter, René Buß, Sensitec, D

Insulation Health State Monitoring of Traction Machines Based on Online Switching Transient Exploitation1346
Markus A. Vogelsberger, Bombardier Transportation Austria, AT; Clemens Zoeller, Thomas M. Wolbank, Hans Ertl, Technical University of Vienna, AT

Comparison of Fundamental Active and Reactive Power Determination Methods in Single-Phase Systems1352
Swen Bosch, Heinrich Steinhart, Aalen University of Applied Sciences, D

Practical Experience with EMI of Radio-Communication System Versus Power Electronics Based on the SiC1359
Jan Leuchter, University of Defence, CZ

Wide Bandgap Devices II

Short Circuit Capability of 650 V Normally Off GaN E-HEMT and MOSFET-HEMT Cascode	1366
Douglas Pappis, Kevin Göbel, Peter Zacharias, University of Kassel, D	
Advantages of Using 650V SiC MOSFETs in High-Frequency DC-DC Converters	1374
Giuseppe Sorrentino, Antonino Gaito, STMicroelectronics, I	
Cross Conduction of GaN HFETs in Half-Bridge Converters	1378
Jan Böcker, Carsten Kuring, Sibylle Dieckerhoff, Technical University Berlin, D; Oliver Hilt, Joachim Würfl, FBH Ferdinand-Braun-Institute Berlin, D	
Design Rules for Paralleling of Silicon Carbide Power MOSFETs	1386
Salvatore La Mantia, Luigi Abbatelli, Carlo Brusca, Maurizio Melito, Massimo Nania, STMicroelectronics, I	
Influence of an Emitter Sense Pin on the Switching Behavior of SiC BJTs in Standard Discrete Housings	1392
Christian Bödeker, Melanie Adelmund, Nando Kaminski, University of Bremen, D; Ranbir Singh, GeneSiC Semiconductor, USA	
Designing Manufacturable and Reliable Printed Circuit Boards Employing Chip Scale eGaN® FETs	1399
Michael de Rooij, Alana Nakata, Efficient Power Conversion Corporation, USA	
Impact of Circuit Carrier Technologies on MHz-switching of GaN Half-Bridge Circuits	1407
Norbert Seliger, Franz Stubenrauch, University of Applied Sciences Rosenheim, D; Christian Brendel, Dr. Johannes Heidenhain, D; Doris Schmitt-Landsiedel, Technical University of Munich, D	

Thermal Management and Packaging II

MMC AlSiC as Alternative for Molybdenum in Power Press-Pack Semiconductor Design. Investigations of Electric Conductivity Properties of AlSiC	1416
Alexey Grishanin, Valentin A. Martynenko, Vyacheslav Eliseev, Anton Samoylov, JSC Electroviptyramitel, RU; Konstantin Nishchev, Mikhail Novopol'tsev, Ogarev Mordovia State University, RU	
Sintered Ag Joints on Copper Lead Frame TO220 by Pressure Sintering Process with Improved Reliability and Bonding Strength	1420
Ly May Chew, Wolfgang Schmitt, Jens Nachreiner, Heraeus Germany, D	
A New Alternative Non-Pressure Silver Sinter Process by Using IR	1426
Wolfgang Schmitt, Ly May Chew, Robert Miller, Anna Wolf, Heraeus Germany, D	
High Reliability Large Area Substrate Solder Interconnect by Embedded Mesh Technique	1432
James Booth, Michael Varley, David Slack, Paul Mumby-Croft, Steve Jones, Xiaoping Dai, Dynex Semiconductor, GB; Karthik Vijay, Indium Corporation, GB	
Transient Current Distribution with Paralleling Dies and Paralleling Half Bridges in Multichip Power Modules	1439
Helong Li, Wei Zhou, Fang Qi, Daohui Li, Yangang Wang, Steve Jones, Xiaoping Dai, Dynex Semiconductor, GB	

Influence of the Power Semiconductor Packaging on the Failure Characteristic for Safety-Critical Applications1444
Michael Gleißner, Mark-M. Bakran, University of Bayreuth, D; Hussein Khalid, Mitsubishi Electric Europe, D

Double Side Sintered IGBT + FRD, 650 V/ 200 A, in a STO247 Package for High Performance Automotive Applications1452
Francois LeHenaff, Alpha Metals Lötssysteme, D; Gustavo Greca, Paul Salerno, Jeffrey Durham, Monnir Boureghda, Alpha Assembly Solutions, USA; Anna Lifton, Apha, NL; Jean Claude Harel, Satyavrat Laud, Renesas Electronics, USA; Weikun He, Mentor Graphics, GB

Control of Power Electronic Converters

Reactive Power Operation of a Single Phase AC-AC DAB Converter1457
Martin Jagau, Michael Patt, Technologienetzwerk Allgäu, D

Use of FPGAs to Develop Energy-Saving DC-DC Control1461
Ben Jeppesen, Intel FPGA, GB; Ge Gao, Imperial College London, GB; Jason Katcha, Half Moon Ventures, USA

Comparison of Three Model Based Junction Temperature Control Systems to Increase the Lifetime of IGBT-Power-Modules1469
Julian Wölfle, Maximilian Nitzsche, Nathan Tröster, Martin Stempfle, Jörg Roth-Stielow, University of Stuttgart, D

A New Modulation Technique to Control the Switching Losses for Single Phase Three-Level Active-Neutral-Point-Clamped-Inverters1477
Johannes Ruthardt, Julian Wölfle, Matthias Zehelein, Jörg Roth-Stielow, University of Stuttgart, D

Comparison of FPGA Based Control Strategies (DDSRF-PI vs. State-Space Control) for Grid Connected Inverters under Grid Disturbances1485
Emanuel Mittwede, Johannes Kern, Stefan Schönberger, Benjamin Stickan, Fraunhofer Institute ISE, D

STNRGPF01: A New Driver for Interleaved PFC Based on Mixed Signal Control1491
Sebastiano Messina, Marco Torrasi, Giuseppe Di Caro, STMicroelectronics, I

Quasi-Constant Frequency Secondary Side Controlled Flyback Concept with Variable ON-Time1495
Arash Pake Talei, Kin Kenneth Leong, Gerald Deboy, Giuseppe Bernacchia, Infineon Technologies Austria, AT; Alexander Connaughton, Graz University of Technology, AT

Sensorless Control of a Bridgeless PFC Using a Low Pass Filter Model and a Linear PR Controller1503
Felipe López, Paula Lamo, Francisco Azcondo, Alberto Pigazo, University of Cantabria, ES

Optimised Modulation of Five-Phase Open-End Winding Drive1509
Milan Darijevic, Siemens, D; Ivan Zoric, Martin Jones, Liverpool John Moores University, GB

Characterizing the Conducted EMI Performance of a Power Module Through Passive Measurement1517
Yu Liu, Infineon Technologies, D; Sergey Kochetov, BMW, D; Thomas Smazinka, Fraunhofer Institute IISB, D; Andreas Lindemann, Otto-von-Guericke-University, D

A New Approach for Digital Controlled Power Supplies Regarding Pulsed Plasma Nitriding Systems1524
Lisa Franke, Lutz Zacharias, Mirko Bodach, Ringo Lehmann, Westsächsische Hochschule Zwickau, D; Andreas Böhm, Plasmanitriertechnik Dr. Böhm, D

Power Supplies, Control and Drive

Combination of Forward-Voltage Measurement and Short-Circuit Detection for High-Voltage RC-IGBTs1531
Patrick Münster, Daniel Lexow, Dennis Cordt, Hans-Günter Eckel, University of Rostock, D

Gate Driver IC for GaN GIT for High Slew Rate and Cross Conduction Protection1537
Aaron Qingwei Cai, Herreria Arnel Carrera, Sin Ban How, Panasonic Industrial Devices Semiconductor Asia, SG; Siek Liter, Nanyang Technological University, SG

Gate Drivers for Medium Voltage Applications1545
Sokchea Am, Pierre Lefranc, David Frey, Rachele Hanna, Benoit Sarrazin, University Grenoble Alpes, G2Elab, F

Diode Effects Bring Lifetime Risks to Series Resistors1553
Wolfgang Frank, Infineon Technologies, D

FPGA Based Control of an Three Level Neutral Point Clamped Inverter1558
Markus Schaefer, Martin Hofmann, Sebastian Raab, Ansgar Ackva, University of Applied Sciences Würzburg-Schweinfurt, D

Investigation of Magnetical Coupler Immunity Against External High Frequency and Density Magnetic Field1564
Bernhard Strzalkowski, Analog Devices, D

Ultra Linear Switching Rectifiers (ULSRs) for High-Quality Regulated 3-Phase AC to DC Conversion1568
Alexei V. Nikitin, Avatekh, USA; Arlie Stonestreet II, Kyle D. Tidball, Ultra Electronics ICE, USA; Ruslan L. Davidchack, University of Leicester, GB

Start-Up Operation of Active Three-Phase Third Harmonic Injection Rectifiers1576
Markus Makoschitz, AIT Austrian Institute of Technology, AT; Michael Hartmann, Schneider Electric, AT; Hans Ertl, Technical University of Vienna, AT

State-of-the-Art GaN Power IC-based 150 W AC-DC Adapter1584
Tom Ribarich, Stephen Oliver, Navitas Semiconductor, USA

Which Should Be Chosen in Three-Phase Diode Rectifier, Single-Bridge or Double-Bridge?1591
Ryu Kawakubo, Yasuyuki Nishida, Chiba Institute of Technology, J

Digital Control of Active Resistance Emulation in Three Phase Rectifiers with Current Injection Principle	1599
Radoš Vreljakovic, Predrag Pejovic, School of Electrical Engineering, RS; Milan Darijevic, Siemens, D	

Power Inverters

Noise Mitigation in HV Tests Sourced by A Static Frequency Converter by Means of Changing PWM Signal's Carrier Frequency	1605
Mazen Alzatari, Janusz Szczechowski, ABB, D	

Novel Active Ripple Filtering Schemes Used In Little Box Inverter	1609
Rajesh Ghosh, Mudiyula Srikanth, Schneider Electric, IN; Radoslava Mitova, Miao-Xin Wang, Schneider Electric, F; Damir Klikic, Schneider Electric, USA	

Experimental Study of Si- and SiC-Based Voltage Source Inverters	1617
Klaus Sobe, Infineon Technologies Austria; Fabio Brucchi, Infineon Technologies, I	

Double-Loop Controlled Grid-Connected Inverter	1624
Dimitriy Nitkin, Sergey Dyakin, Yury Skorokhod, Transconverter, RU; Sergey Volskiy, Moscow State Aviation Institute Technical University, RU	

Design and Realization of a 100 kHz – 100 kW Series Resonant Inverter with SiC-MOSFETs Connected in Parallel for a High Frequency Induction Heating Application	1630
Yildiray Baskurt, Haldun Karaca, Dokuz Eylul University, TK	

AC-Sweep Analysis and Verification of an AC Power Source with Virtual Output Impedance for Validation of Grid Connected Components	1636
Peter Jonke, Markus Makoschitz, Biswas Sumanta, Johannes Stöckl, AIT Austrian Institute of Technology, AT; Hans Ertl, Vienna University of Technology, AT	

Technological Possibilities of New Silicon-Carbide Mosfets in Power-Inverter for the Inductive Energy Transfer	1643
Martin Warkentin, Thomas Vossnagen, Faical Turki, Paul Vahle, D	

Five-Level Cascaded Flying-Capacitor Converter	1648
Sidney Gierschner, David Hammes, Hans-Günter Eckel, University of Rostock, D; Max Beuermann, Siemens, D	

A Generalized Approach to the Analysis and Control of Modular Multilevel Converters	1655
Patrick Himmelmann, Marc Hiller, Karlsruhe Institute of Technology (KIT), D	

On Energy Balancing for a Full-Bridge MMC with Distributed Energy Storage Devices	1663
Gerrit Henke, Mark-M. Bakran, University of Bayreuth, D	

Comparison and Evaluation of Modular Multilevel Converter Topologies for Li-Ion Battery Systems	1671
Matthias Luh, Thomas Blank, Marc Weber, Karlsruhe Institute of Technology (KIT), D	

Improved Efficiency Power Converters

Progress of High Power Multilevel Converters: Combining Silicon and Silicon Carbide	1679
Christopher Dahmen, Rainer Marquardt, University of the Federal Armed Forces Munich, D	
Direct Torque Control with Variable Level Discretization for Automotive Drives	1686
Eduard Specht, Christoph Aschauer, Christian Korte, Stefan Goetz, Porsche Engineering Group, D	
Analysis and Modeling of Efficiency Curve Dip in VRM with Low Output Inductance	1694
Ann Starks, Zhiyang Chen, ON Semiconductor, USA	
EMI Considerations on MHz Inverters	1702
Christoph Simon, Fabian Denk, Michael Heidinger, Rainer Kling, Wolfgang Heering, Karlsruhe Institute of Technology (KIT), D	
Analysis of the Impact of Silicon Carbide Modules in Wind and Traction Applications	1710
Itziar Kortazar, Igor Larrazabal, David Ortega, Ingeteam, ES; Mrinal Das, Wolfspeed, USA	
High Efficiency LLC-Based AC-DC Converter for Wide Load Voltage Range Applications	1714
Navid Daniali, Euro Engineering, D	
A Novel Approach to Reduce Losses in Boost PFC Stage of a 90 W-Adapter	1720
Eva Schmidt, Daniel Kübrich, Thomas Dürbaum, Friedrich-Alexander University Erlangen, D	
How the Heck do I Measure a Gate Drive Slewing at 70 kV/Us?	1726
Bart Schroder, Cleverscope, NZ	
Thyristor Rectifier for Permanent Magnet Wind Generators	1733
Ionut Trintis, Morten Risskov Knudsen, Peter Mongeau, Stig Lund Pallesgaard, Philip C. Kjaer, Vestas Wind Systems A/S, DK; Sébastien Touzard, Nabil Meziti, Semikron SARL, F	
Evaluation of an Isolated DC-DC Converter for a Micro Inverter	1740
Naoki Koike, Shinichiro Nagai, Pony Electric, J	
STMicroelectronics Super-Junction and UltraFAST MOSFET vs IGBT Technologies in Low Power Motor Drives	1746
Carmelo Parisi, Gaetano Belverde, Alessio Corsaro, STMicroelectronics, I	
Active Switch Impact on CCM Totem-Pole PFC Efficiency	1751
Matt O'Grady, Ke Zhu, Jonathan Dodge, John Bendel, United Silicon Carbide, USA	
Dc Bus to Industry a New Way Towards Energy Efficiency	1757
Andre dos Santos Lima, Aderaldo Racarte Guedes, Antonio Alisson Alencar Freitas, Edilson Meneiro Sá Jr., Fernando Luiz Marcelo Antunes, Federal University of Ceara, BR	

Automotive, Traction and Aerospace

The Highest Power Density IGBT Module in the World for xEV Power Train	1761
Akihiro Osawa, Keiichi Higuchi, Akio Kitamura, Daisuke Inoue, Yoshikazu Takamiya, Souichi Yoshida, Hiromichi Gohara, Masahito Otsuki, Fuji Electric, J	

J1-Series Modules with Integrated Cooler for Electric and Hybrid Vehicles	1767
Tatsuya Kawase, Mikio Ishihara, Noburu Miyamoto, Kazuaki Hiyama, Shinsuke Godo, Mitsubishi Electric Corporation, J	
Power MOSFETs for Low Voltage and High Current Automotive Applications – 48 V Bus Systems	1771
Rajagopalan Jagannathan, Marco Atzeri, Hans-Peter Hoenes, ON Semiconductor, D	
Electrothermal Stresses in SiC MOSFET and Si IGBT 3L-NPC Converters for Motor Drive Applications	1778
Zarina Davletzhanova, Olayiwola Alatise, Jose Ortiz Gonzalez, Sylvia Konaklieva, Roozbeh Bonyadi, University of Warwick, GB	
High Efficiency and Ruggedness Intelligent IGBT Technology for EV/HEV	1786
Vittorio Crisafulli, ON Semiconductor, D	
Highly Integrated Power Unit Based on Double Sided Cooling IGBT Module	1792
Yun Li, Shiwu Zhu; Yaqing Ma, Yangang Wang, Mingliang Jiao, Chundong Wu, Zhenlong Zhao, Jun Yu, Dynex Semiconductor, GB	
Efficiency Increasing by a Variable DC Link Voltage in Combination with a Bang-Bang Controlled Inverter for an Automotive Application	1798
Magnus Böh, Andreas Lohner, Noureddine El Amrani, TH Köln – University of Applied Sciences, D	
Magnetic Leakage Azimuth Pattern of a 7 kW Wireless Electric Charging System in Different Environments	1803
Leandro Percebon, Daniel Kuerschner, Qualcomm CDMA Technologies, D	
Innovations for IGBT Based Power Modules in HEV Drivetrain Applications	1811
Thomas Geinzer, Alexander Schwarz, Martin Gleich, Infineon Technologies, D	
Estimation of the Losses in Si and SiC Power Modules for Automotive Applications	1814
Dounia Oustad, Menouar Ameziani, Dominique Lhotellier, VEDECOM, F; Stéphane Lefebvre, Meckael Petit, ENS Cachan, F	
DC/DC-Converter with Optimised Power Density for Integration of Multifunctional Fuel Cell Systems in Modern Aircraft Application	1822
Mathias Warncke, Sebastian Fahlbusch, Klaus F. Hoffmann, Helmut Schmidt University – University of the Federal Armed Forces Hamburg, D	
 High Performance Power Electronics	
Influence of Different Switching Frequencies and Modulation Techniques on IPMSM and Inverter Losses Optimizing the Overall Drive Train Efficiency	1830
Martin Stempfle, Yuying Han, Julian Wöfle, Nathan Tröster, Jörg Roth-Stielow, University of Stuttgart, D	
Finite Control Set Model Predictive Control of a PMSM Fed by a Multilevel Inverter	1835
Cristian Vargas, Simon Feuersänger, Mario Pacas, University of Siegen, D	
Current Control Delay Reduction for FPGA-Based Servodrive	1843
Lev Rassudov, Aleksander Balkovoi, Moscow Power Engineering Institute, RU	

Optimal Compensation Capacitors Maximizing Coreless Inductive Power Transfer1849
Yohan Wanderoid, Adrien Morel, Romain Grezard, Gael Pillonnet, Dominique Bergogne, CEA-Léti, F;
Hubert Razik, Université Claude Bernard Lyon, Laboratoire Ampère, F

Switching Loss Minimization Using Two-Configuration Predictive Control for a Thermo-Hydraulic Linear PMSG1856
Daniel Bernet, Karlsruhe Institute of Technology (KIT), D; Robert Seifert, Technical University of Dresden, D

Energy Storage Battery Protection System with Externally Triggered Melting Fuses1864
Mitja Koprivšek, ETI, SI

Approach of Optimization of Power Leveling System Using Multi-energy Storage Devices1871
Toshihiro Shimao, Koji Kato, Keisuke Nakano, Yoichi Ito, Sanken Electric, J; Hitoshi Haga, Nagaoka University of Technology, J; Kenji Arimatsu, Katsuhiko Matsuda, Tohoku Electric Power, J

Single-Phase PWM-Based Unity Power Factor Rectifier with Adaptive Predictive Current Control1878
Swen Bosch, Jochen Staiger, Heinrich Steinhart, Aalen University of Applied Sciences, D

Software Tools and Applications

Design of Test-system for EMC Investigations of Systems with Magnetron1884
Dong Quang Huy, Jan Leuchter, University of Defence, CZ

Development of LabVIEW Models for Resonant Power Converters1890
Nikolay Hinov, Tsveti Hranov, Technical University of Sofia, BG

A Novel Detailed Analysis of the Flyback Converter Utilizing a Transformer with Nonlinear Magnetizing Inductance1894
Panagiotis Mantzanas, Thomas Dürbaum, Friedrich-Alexander University Erlangen, D

eDesignSuite: A New Design Tool for Digital Power Solutions1902
Carmelo Giuseppe Viccica, Marcello Palano, Natale Porto, STMicroelectronics, I

MMC-Based Multi-Port DC Hub for Multiterminal HVDC Grids1909
Epameinondas Kontos, Haris Papadakis, Michalis Poikilidis, Pavol Bauer, Delft University of Technology, NL

Direct-Model Predictive Control for Fault Ride-Through Capability Enhancement of DFIG1917
Mohamed Abdelrahem, Ralph Kennel, Technical University of Munich, D

AutoCrear™ – a Novel Software Tool for Automatic Creepage and Clearance Analysis1925
Michael Martinek, Jürgen Pröll, Oxana Kleinöder, e-laborate Innovations, D; Günther Greiner, Friedrich-Alexander University Erlangen-Nürnberg, D

Power-Hardware-In-Loop Setup for Power Electronics Tests1933
Giovanni De Carne, Marius Langwasser, Xiang Gao, Giampaolo Buticchi, Marco Liserre, Christian-Albrechts University, D

Ensuring Fast Turn-Around Times for a Programmable Digital Power Controller1940
Markus Schnell, Jörg Oehmen, Infineon Technologies, D

A New Optimization Algorithm for Power Electronics Using the Mixed Integer Linear Programming Method1947
Marco Schilling, Tobias Reimann, Technical University Ilmenau, D; Ulf Schwalbe, ISLE Steuerungstechnik und Leistungselektronik, D

Novel Efficient and Reliable Network Simulation by Means of Lipschitz Constants1955
Carsten Kuring, Technical University Berlin, D; Julian Dobusch, Thomas Dürbaum, Friedrich-Alexander University Erlangen, D

Fully Automated Testing of “AVL E-Storage BTE 1200 V” with Parallelized Hardware-in-the-Loop Systems 1963
Selimcan Deda, Guenter Prochart, Roland Greul, AVL LIST, AT

Keynotes

Long Distance Charging Solutions for BEVs: from now to 2030N/A
Robert Lassartesses, Renault, F

The Smart Future of Power Electronics and its ApplicationsN/A
Hans Krattenmacher, SEW-Eurodrive, D

Evolution in Topologies as a Result of New Devices and Enabling TechnologiesN/A
Ionel Dan Jitaru, Rompower, USA

Manuscripts which were handed in late

A Scaled PIN Diode SPICE Model for Power System Optimization.....1974
Mehrdad Baghaie Yazdi, James Victory, ON Semiconductor, D; Dongsoo Kim, ON Semiconductor Korea, ROK