2016 IEEE International Telecommunications Energy Conference (INTELEC 2016)

Austin, Texas, USA 23-27 October 2016



IEEE Catalog Number: ISBN:

CFP16INT-POD 978-1-5090-1878-9

Copyright © 2016 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 publication is a representation of what appears in the IEEE Digital Libraries. Some format issues inherent in the e-media version may also appear in this print version.

IEEE Catalog Number: CFP16INT-POD ISBN (Print-On-Demand): 978-1-5090-1878-9 ISBN (Online): 978-1-5090-1877-2

ISSN: 2158-5210

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 Web: www.proceedings.com



TABLE OF CONTENTS

Monday, 24 October 2016

Location

10:30 am - 12:00 pm Rectifiers and AC-DC Power Supplies San Antonio

10:30 am

TS01.1 A 3000 W Super High Efficiency Rectifier for Communications Power Supply 1
Qiong Wu, Mingming Liu, Jianping Zhou, Guangji Ma, ZTE Corporation

11:00 am

TS01.2 Active Rectifier System using Three-Phase Unfolder and Series Resonant Converters
Controlled in Synchronous Rotating Frame 9
W. Warren Chen, Regan Zane, Utah State University

11:30 am

TS01.3 Surge Immunity Test Analysis for Modern Switching Mode Power Supplies 16
Daniel Miller, Augsburg University of Applied Sciences; Ralph Kennel, Technical University of Munich;
Manfred Reddig, Augsburg University of Applied Sciences; Manfred Schlenk, Infineon Technologies AG

10:30 am - 12:00 pm Resilient and Efficient Communication Power Systems **Trinity A**

10:30 am

TS02.1 Realistic Assessment of Building Power Supply Resilience for Information and Communications Technologies Systems 22

Alexis Kwasinski, *University of Pittsburgh*

11:00 am

TS02.2 Modeling of Communication Systems Dependency on Electric Power during Nuclear Attacks 30 Vaidyanathan Krishnamurthy, Alexis Kwasinski, *University of Pittsburgh*

10:30 am - 12:00 pm Data Center Cooling **Trinity B**

10:30 am

TS03.1 Packaged Air Conditioner Incorporating Free Cooling Cycle for Data Centers 38

Naoki Futawatari, Hideki Tsukimoto, Yuji Kohata, Yosuke Udagawa, NTT Facilities Inc.; Yasuhiro Naito, Hitachi-Johnson Controls Air Conditioning, Inc.

11:00 am

TS03.2 The Importance of Refrigeration System Backup for High Power Density Data Centers 44
Zhen Wang, Qian Zhao, Mu Li, China Mobile Communications Corporation

11:30 am

TS03.3 Study on Power-Saving Effects in Direct-Use of Geothermal Energy for Datacenter Cooling Systems 49

Chisato Matsuda, Yousuke Mino, NTT Facilities Inc.

10:30 am - 12:00 pm Battery Applications

Grand Ballroom A

10:30 am

TS04.1 An Innovative Undergy Philips As Into Byr Aurito Rymaning Liu, 21E Corporation Throng

11:00 am

TS04.2 Modular and Intelligent Battery Control System for Electric Vehicles and Stationary Storage Systems 55

Norbert Grass, Fritz Ferner, Felix Nickl, University of Applied Sciences Georg Simon Ohm

1:30 pm - 3:00 pm DC-DC Converter Circuits and Topologies 1

Trinity A

1:30 pm

TS05A.1 A Reliability Assessment of Series-Stacked Servers with Server-to-Bus Differential Power Processing 62

Enver Candan, Andrew Stillwell, Robert C.N. Pilawa-Podgurski, University of Illinois at Urbana-Champaign

2:00 pm

TS05A.2 An Energy Recovery Clamp Circuit for an Isolated DC-DC GaN Converter 69

Rakesh Ramachandran, Morten Nymand, *University of Southern Denmark*

2:30 pm

TS05A.3 Sensitivity of Conversion Efficiency with Variable Load Assignment in Class-E Resonant Inverter and its Derivatives 74

Richard Jennings, Yashwanth Bezawada, Yucheng Zhang, *Old Dominion University;* Ruiyun Fu, *Mercer University*

1:30 pm - 3:00 pm Alternative Energy 1 **Trinity B**

1:30 pm

TS06A.1 Development of Reformed Ethanol Fuel Cell System for Backup and Off-Grid Applications – System Design and Integration 81

Pauli Koski, Valtteri Pulkkinen, Sonja Auvinen, Jari Ihonen, *VTT Technical Research Centre of Finland Ltd;* Henri Karimäki, Timo Keränen, Agnes Rydén, Thomas Tingelöf, *PowerCell Sweden AB;* Stefano Limonta, Diego Croci, Paolo Fracas, *Genport srl;* Martin Wichert, Gunther Kolb, *Fraunhofer ICT-IMM;* Roberto Magalhães, Frederico Relvas, Marta Boaventura, Adélio Mendes, *Universidade do Porto*

2:00 pm

TS06A.2 Fuel Cell with On-Site Hydrogen Generation for BTS Application 89

Rafael von Woyna, Siegfried Limmer, Christian Leu, Mark-Uwe Osswald, Kai Siemer, *Heliocentris Industry GmbH*

2:30 pm

TS06A.3 Solar PV based Retrofit Solution for Cell Phone Towers Powered by Diesel Generators 96

Deepak Chandran, Iris Energy; Vivek Agarwal, Indian Institute of Technology Bombay

1:30 pm - 3:00 pm

Grand Ballroom A

Powering Software Defined Networks 1

1:30 pm

TS07A.1 Powering Software Defined Networks with an Any Rack Capable Power Bus 104

Edward C. Fontana, GE Industrial Solutions

2:00 pm

TS07A.2 Security Considerations for Equipment Controllers and SDN 108

David Wilczewski, Emerson Network Power

3:30 pm - 5:00 pm

Trinity A

DC-DC Converter Circuits and Topologies 2

3:30 pm

TS05B.1 Wide Input Digital Peak Current Mode DC-DC Converter for DC Power Feeding System 113

Kazuhiro Kajiwara, *Nagasaki Institute of Applied Science;* Hidenori Maruta, Yuichiro Shibata, *Nagasaki University;* Nobumasa Matsui, *Nagasaki Institute of Applied Science;* Fujio Kurokawa, *Nagasaki University;* Keiichi Hirose, *NTT Facilities Inc.*

4:00 pm

TS05B.2 A Soft-Switched High Frequency Converter for Wide Voltage and Power Ranges 117

Alex J. Hanson, Rachel S. Yang, Seungbum Lim, David J. Perreault, Massachusetts Institute of Technology

3:30 pm - 5:00 pm

Alternative Energy 2

Trinity B

3:30 pm

TS06B.1 Comparing Ramp Rate Control Method for PV-Energy Storage Systems in

Cascaded and Parallel Architectures 125

Iman Mazhari, Babak Parkhideh, University of North Carolina at Charlotte

4:00 pm

TS06B.2 Transformer-Less 2 kW Non Isolated 400V DC/230 VAC Single Stage Micro Inverter 131

Fabrice Frebel, eFFiciency research; Paul Bleus, Olivier Bomboir, Daniel Rixhon, CE+T America Power, Inc.

3:30 pm - 5:00 pm

Powering Software Defined Networks 2

Grand Ballroom A

3:30 pm

TS07B.1 Real-Time Transactional Power Management in a Microgrid Mesh Network: The Enernet 137

Brian T. Patterson, EMerge Alliance; David E. Geary, Power Analytics Corporation

4:00 pm

TS07B.2 An Innovative Energy Management System for Telecom Energy Network 144

Weibo Li, Mingming Liu, Shaomin Zhang, ZTE Corporation

Wednesday, 26 October 2016

Location

8:30 am - 10:00 am AC Power Systems 1

San Antonio

8:30 am

TS08A.1 Feasibility Study of Existing 50/60 Hz Electrical Appliances for

HFAC Power Distribution Systems 148

W. Anand Fernando, University of Sydney; Dylan Dah-Chuan Lu, University of Technology, Sydney

9:00 am

TS08A.2 Performance Evaluation of Shunt Active Power Filter (SAPF) Connected to

Three Phase Four Wire Distribution Networks 156

Bharadwaj Kaka, Abhishek Maji, Indian Institute of Technology Kanpur

9:30 am

TS08A.3 Enhanced Current and Voltage Regulators for Stand-Alone Applications 165

Federico de Bosio, Michele Pastorelli, *Politecnico di Torino;* Luiz Antonio de Souza Ribeiro, *Federal University of Maranhao;* Francisco D. Freijedo, *Ecole Polytechnique Federale de Lausanne;* Josep M. Guerrero, *Aalborg University*

8:30 am - 10:00 am Components 1

Trinity A

8:30 am

TS09A.1 Effects of SiC Schottky Barrier Diodes on Switching Transient Performance of a

SiC MOSFETs-Based Bidirectional Switching Power Pole 171

Hussain Sayed, Ahmed Zurfi, Jing Zhang, University of Arkansas at Little Rock

9:00 am

TS09A.2 GaN on Silicon E-HEMT and Pure Silicon MOSFET in High Frequency Switching of

EV DC/DC Converter: A Comparative Study in a Nissan Leaf 175

Yosra Attia, Mohamed Youssef, University of Ontario Institute of Technology

9:30 am

TS09A.3 Comparison of the Performance of Gallium Nitride (GaN) Transistors in a Totem-Pole

Power Factor Controlled (PFC) Rectifier 181

Sven Bolte, Norbert Fröhleke, Joachim Böcker, Paderborn University

8:30 am - 10:00 am Battery Technologies 1 **Trinity B**

8:30 am

TS10A.1 TCO Analysis for Lithium Ion Batteries in BTS Applications 186

Kai Siemer, Daniel Wolf, Heliocentris Industry GmbH

- 1			
	m		

TS10A.2 Flow Batteries Operating at Remote Sites in Latin America 192

Mio Dart, Mike Giulianini, Redflow Limited

9:30 am

TS10A.3 Experimental Evaluation of the Energy Efficiency of a Grid-Connected NiMH Battery System 198

Ahmed Zurfi, Jing Zhang, University of Arkansas at Little Rock

8:30 am - 10:00 am

Grand Ballroom B

400 Vdc Distribution Systems 1

8:30 am

TS11A.1 A Service Provider's Decision to Move from 48 V to 380 V Powering: The Problem Statement,

Technical Assessment, Financial Analysis and Practical Implementation Plan 203

Robert Ambriz, Level 3 Communications; Michael Kania, Eltek

9:00 am

TS11A.2 Energy-Saving Effects of Super Computers by using On-Site Solar Power and

Direct HVDC Feeding Systems 210

Hiroya Yajima, Kenichi Usui, Toshiyuki Hayashi, Yasuyuki Ooi, Yoshiteru Yoshida, Keiichi Hirose,

Tadahito Aoki, NTT Facilities Inc.

9:30 am

TS11A.3 A Multi-Output HVDC System for Telecommunications Buildings 214

Taku Ishibashi, Tomohito Ushirokawa, Hidenori Matsuo, Takashi Takeda, NTT Facilities Inc.

10:30 am - 12:00 pm

Trinity A

Components 2

10:30 am

TS09B.1 Gate Driver Integrated Instantaneous Phase Voltage Measurement in

PWM Voltage Source Inverters 217

Michael Schubert, Lars Jebe, Rik W. De Doncker, RWTH Aachen University

11:00 am

TS09B.2 Analysis and Design of Integrated Common and Differential Mode Inductors 225

Carsten Henkenius, Norbert Fröhleke, Joachim Böcker, Paderborn University

11:30 am

TS09B.3 Integration for Bridgeless PFC Converter with Planar PCB Technique 231

Cheng Deng, Yeyu Zhong, Songlin Shen, Xiangtan University

10:30 am - 12:00 pm

Trinity B

Battery Technologies 2

10:30 am

TS10B.1 Passing the 15-Year Mark – An Analysis of Ni-Cd Battery Performance in

Remote Terminal Applications 236

Rodolphe Boulais, Stuart Lansburg, Saft

11:00 am

TS10B.2 A New Approach to Estimate SoH of Lead-Acid Batteries used in Off-Grid PV System 243

Alex França, Thais Tóssoli de Souza, Vitor T. Arioli, Sender R. dos Santos, Maria F.N.C. Rosolem, Pedro C.B. de Castro, Thiago C. do Nascimento, *CPqD*; Cesar Sobral Vieira, *Dresser-Rand Guascor do Brasil*

11:30 am

TS10B.3 Research of High-Power Lead-Acid Batteries for Data Center Application N/A

Hao-ming Li, Yan-chang Chen, Bao-qing Liu, Qing-feng Zhu, China United Network Communications Corporation Limited

10:30 am - 12:00 pm 400 Vdc Distribution Systems 2 **Grand Ballroom B**

10:30 am

TS11B.1 Model-Based Fault Current Estimation for Low Fault-Energy 380 VDC Distribution Systems 250

Leopold Ott, Julian Kaiser, Kilian Gosses, Yunchao Han, Bernd Wunder, Martin März, Fraunhofer Institute for Integrated Systems and Device Technology; Christian Strobl, E-T-A Elektrotechnische Apparate GmbH

11:00 am

TS11B.2 Ultracapacitor Application and Controller Design in 400 VDC-Powered Green Data Centers 258

Yuzhi Zhang, H. Alan Mantooth, Juan Carlos Balda, University of Arkansas

1:30 pm - 3:00 pm Base Station Cooling San Antonio

1:30 pm

TS12A.1 Free Cooling: A Complete Solution on Reducing Total Energy Consumption for

Telecommunication Base Stations 263

Ehsan Bitaraf Haghighi, Envirotainer Engineering AB

2:00 pm

TS12A.2 RBS Innovative Free Cooling 269

Fabio Pizzuti, Claudio Seguiti, Telecom Italia Spa

2:30 pm

TS12A.3 Experimental Liquid Cooled Base Station 272

David Nörtershäuser, Stéphane Le Masson, *Orange Labs*; Topi Volkov, Timo Galkin, Oskari Amper, Jari Huttunen, *Nokia Corporation*

1:30 pm - 3:00 pm DC-DC Converter Modeling and Analysis 1

Trinity A

1:30 pm

TS13A.1 Power Source Buffering using a Triangular Modular Multilevel Converter with Energy Storage 279

Alvaro Cardoza, Alexis Kwasinski, University of Pittsburgh

n -	^	\mathbf{a}	
/-	n		DM

TS13A.2 High Accurate and Low Loss Current Sensing Method with Novel Current Path Narrowing Method for DC-DC Converters and its Demonstration 287

Kazuki Itoh, Masakazu Muraquchi, Tetsuo Endoh, Tohoku University and JST-ACCEL

2:30 pm

TS13A.3 Development of Current Measurement Techniques for High Frequency Power Converters 293

Mehrdad Biglarbegian, Shahriar Jalal Nibir, Hamidreza Jafarian, Babak Parkhideh, *University of North Carolina at Charlotte*

1:30 pm - 3:00 pm

Trinity B

Microgrids and Energy Storage Management 1

1:30 pm

TS14A.1 Power Flow Controller for State of Charge Equalization of Embedded Storage Among

Different Distributed Nodes in a Communication Power System 300

Juyoung Jung, University of Texas at Austin; Alexis Kwasinski, University of Pittsburgh

2:00 pm

TS14A.2 Supercapacitor Calendar Aging for Telecommunication Applications 306

Hamid Gualous, *University of Caen Normandie;* Hicham Chaoui, *Tennessee Technology University;* Roland Gallay, *Garmanage*

2:30 pm

TS14A.3 Mixed Strategy Load Management Strategy for Wireless Communication Network Micro Grid 311

Rui Hu, Alexis Kwasinski, University of Pittsburgh, Andres Kwasinski, Rochester Institute of Technology

1:30 pm - 3:00 pm

Grand Ballroom B

400 Vdc Distribution Components 1

1:30 pm

TS15A.1 Evaluation Results of Appliance Coupler for 400V DC 319

Naoki Hanaoka, *NTT Facilities Inc.*; Kyohei Seki, Kouichi Kiryu, *Fujitsu Component Limited*; Tetsushi Tsumura, Keiichi Hirose, Yasuyuki Sugiyama, *NTT Facilities Inc.*

2:00 pm

TS15A.2 Approach and Basic Evaluation for the DC Circuit Breaker with Fault Current Limiting Feature 323

Masaaki Komatsu, Kushiro College

2:30 pm

TS15A.3 Investigation of Low-Voltage Solid-State DC Breaker Configurations for

DC Microgrid Applications 328

Witness A. Martin, Cheng Deng, Dimas Fiddiansyah, Juan Carlos Balda, University of Arkansas

3:30 pm - 5:00 pm DC-DC Converter Modeling and Analysis 2					
3:30 pm TS13B.1	Stability Analysis of Digital Feedback Gain Changeable Control Switching Power Control Kazuhiro Kajiwara, Nagasaki Institute of Applied Science; Hidenobu Tajima, Hidenori Maruta, Nagasaki University; Tadashi Suetsugu, Fukuoka University; Fujio Kurokawa, Nagasaki University; Keiichi Hirose, NTT Facilities Inc.	Converter 334			
4:00 pm TS13B.2	Dynamic Characteristics Analysis of DC-DC Converter for Server using Digital Current-Frequency Detector 339 Yudai Furukawa, Shintaro Nibu, Hidenori Maruta, Fujio Kurokawa, Nagasaki University; Keiichi Hirose, NTT Facilities Inc.; Ilhami Colak, Gelisim University				
•	- 5:00 pm ds and Energy Storage Management 2	Trinity B			
3:30 pm TS14B.1	Improved Designs of High Power Density Inverters for 380 Vdc based Microgrid Arch Ansel Barchowsky, Andrew Bulman, Brandon Grainger, Gregory Reed, <i>University of Pittsburgh</i>	itectures 344			
4:00 pm TS14B.2	A Hierarchical Control Scheme to Integrate the Telecom Backup Systems into Microsajjad M. Kaviri, Majid Pahlevani, Alireza Bakhshai, Praveen Jain, Queen's University	ogrid 351			
4:30 pm TS14B.3	Optimized Storage Battery Control in Hybrid Power Distribution System for Improving Energy Self-Consumption 357 Kazufumi Yuasa, Toyonari Shimakage, Norikazu Takeuchi, Yasuyuki Sugiyama, NTT Facilities In	с.			
-	- 5:00 pm Grand B Distribution Components 2	allroom B			
3:30 pm TS15B.1	Dual-Voltage Output Power Supply System Toward Parallel use of 380 Vdc and 48 Kenichi Usui, Tadatoshi Babasaki, Keiichi Hirose, Yoshiteru Yoshida, NTT Facilities Inc.	Vdc 363			
4:00 pm TS15B.2	99% Efficient Three-Phase Buck-Type SiC MOSFET PFC Rectifier Minimizing Life Cycle Cost in DC Data Centers 368 Lukas Schrittwieser, Johann W. Kolar, ETH Zurich; Thiago B. Soeiro, ABB Switzerland Ltd.				

Thursday, 27 October 2016

Location

8:30 am - 10:00 am Uninterruptible Power Supplies **Trinity A**

8:30 am

TS17.1 Compact Gate Drive Printed Circuit Board for Uninterruptible Power System 376

Akira Mima, Yuichi Mabuchi, Hiroshi Kamizuma, Daisuke Matsumoto, Yukio Hattori, Tetsuya Kawashima, Kinya Nakatsu, *Hitachi, Ltd.*

9:00 am

TS17.2 The Impact of a Single Module's MTBF Value in Modular UPS Systems:

Technique for its Assessment, Improvement and Final Validation 382

Leo Saro, Clemente Zanettin, SOCOMEC Group

8:30 am - 10:00 am
Communication Systems Cooling

Trinity B

8:30 am

TS18.1 A Hybrid Cooling System for Telecommunication Base Stations 390

Ehsan Bitaraf Haghighi, Envirotainer Engineering AB; Morteza Ghanbarpour, KTH Royal Institute of Technology

9:00 am

TS18.2 Combining Electrochemical and Phase Change Thermal Cold Storage in Telecom Applications 395

Daniel Wolf, HPS Home Power Solutions GmbH; Alexander Studniorz, Technische Universität Berlin;

Kai Siemer, Heliocentris Industry GmbH

9:30 am

TS18.3 Experimental and Theoretical Investigations of a Telecommunication Cabinet

Cooling Mode with Zero Electrical Consumption 402

Hasna Louahlia-Gualous, Caen Normandy University; Stéphane Le Masson, Orange Labs

8:30 am - 10:00 am Outside Plant Power Systems **Grand Ballroom A**

8:30 am

TS19.1 Quiet, Clean, and Reliable Outside Plant Power 408

Mark A. Johnson, GE Industrial Solutions

9:00 am

TS19.2 Remote Monitoring and Thermal Management of Macro Cell Site Enclosures 412

Michael Krzywosz, Emerson Network Power

9:30 am

TS19.3 400 VDC Remote Powering as an Alternative for Power Needs in

New Fixed and Radio Access Networks 419

Olivier Foucault, Didier Marquet, Stéphane Le Masson, Orange Labs