



**28TH ANNUAL INTERNATIONAL
TELECOMMUNICATIONS ENERGY
CONFERENCE**



**INTELEC 2006 - PROVIDENCE
SEPTEMBER 10 - 14, 2006**



**RHODE ISLAND CONVENTION CENTER
PROVIDENCE, RHODE ISLAND USA**

**SPONSORED BY THE POWER
ELECTRONICS SOCIETY OF THE
INSTITUTE OF ELECTRICAL AND
ELECTRONIC ENGINEERS**

**Copyright © 2006 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 republications permission, write to IEEE Copyrights Manager, IEEE Operations Center, 445 Hoes Lane, Piscataway, New Jersey USA 08854. All rights reserved.

IEEE Catalog Number: 06CH37806
ISBN: 1-4244-0430-4
Library of Congress: 88656128

Additional Copies of This Publication Are Available from:

IEEE Service Center
445 Hoes Lane
Piscataway, NJ 08854
IEEE Service Center
445 Hoes Lane
Piscataway, NJ 08854
Phone: (800) 678-IEEE
 (732) 981-1393
Fax: (732) 981-9667
E-mail: customer-service@ieee.org

TABLE OF CONTENTS

INTELEC® 2006 TECHNICAL PROGRAM

MONDAY, SEPTEMBER 11, 2006

SESSION 1: OPENING PLENARY

Chair: Marc Durocher

1.1 Keynote

P. Thonis, *Verizon Communications*

1.2 Telecommunications Power System Reliability and Survivability Under Extremely Abnormal Situations

C. Romano, *Verizon Communications*

1.3 Data Centers Go Green

P. Marcoux, *American Power Conversion Corporation*

SESSION 2: ISOLATED CONVERTERS

Chair: Josef Drobnik

2.1 A Hybrid Type DC-DC Converter with New Control Strategy for a Micro-Fuel Cell Power Supply System

1
O. Matsuo, M. Tuji, H. Matsuo, *Nagasaki University*; K. Kobayashi, Y. Sekine, *Shindengen Electric Mfg. Co.*

2.2 The Wave of the Future in High Density PC Converters

7
A. Elbanhawy, *Fairchild Semiconductor*

2.3 Design, Control and Simulation of a High-Efficiency Low-Cost DC-DC Converter for High Current Applications

11
H. Kanaan, *Saint Joseph University*; K. Al-Haddad, *École de Technologie Supérieure*

SESSION 3: BATTERY MANAGEMENT SYSTEMS

Chair: Ed Silverman

3.1 Decreasing Owning Costs of MV/LV Substations Backup Batteries

19
J-D. Desanti, G. Schweitz, *EDF R&D*

3.2 Consideration for High Reliability Energy Sources for Nigeria Telecommunication Limited

25
S. Orokunle, *NITEL*; J. Gropper, *ORMAT*

SESSION 4: WORKSHOP:

CRISIS MANAGEMENT – KATRINA DAMAGE ASSESSMENT

Chair: Marc Durocher

SESSION 5: ISOLATED CONVERTERS II

Chair: Mark Jacobs

5.1 Consideration for Abnormal Phenomenon in Common-Source Type Active-Clamped Forward Converter with Self-Driven Synchronous Rectifier	30
K. Fukushima, T. Hashimoto, T. Ninomiya, <i>Kyushu University</i> ; T. Segawa, <i>Impulse, Inc</i>	
5.2 An Improved Current-Driven Method for Synchronous Flyback AC/DC Converters	35
X. Xie, J. Zhang, C. Zhao, Z. Qian, <i>Zhejiang University</i>	
5.3 Analysis and Design of Half-Bridge DC-DC Converters with Current Tripler Rectification	40
L. Yao, I. Batarseh, <i>University of Central Florida</i> ; H. Mao, <i>Emerson Network Power</i>	

SESSION 6: NICKEL BATTERY SYSTEMS

Chair: Rod Shane

6.1 Sodium Nickel Chloride Battery Performance in A Stationary Application.....	47
L. Gaillac, D. Skaggs, N. Pinsky, <i>Southern California Edison</i>	
6.2 Nickel-Metal Hydride Technology – A Solution for Niche Telecom Power Applications	51
S. Lansburg, J. McDowall, <i>Saft America, Inc</i>	
6.3 NiMH vs NiCd Batteries under High Charging Rates.....	59
J.C. Viera, M. González, J.C. Antün, J.C. Campo, F.J. Ferrero, M. Valledor, <i>Universidad de Oviedo</i>	

SESSION 7: MONITORING

Chair: William McCoy

7.1 Ground Fault Detection by Differential Monitoring of the Float Current	65
Z. Noworolski, U. Reskov, <i>Polytronics Engineering Ltd</i>	
7.2 DC Power Plant Monitoring Configuration and Acceptance Testing.....	70
T. B. Bailey, <i>Emerson Network Power</i>	
7.3 A New Advanced Management Solution for Telecom Infrastructure Equipments and Buildings	76
V. de Blas, J. López, J. Manso, A. Molleda, P. Robledo, J. A. Segador, <i>Emerson Network Power</i>	

POSTER SESSION

P01 Comparison of Different Solutions for Emergency and Standby Power Systems for Commercial Consumers	84
<i>D. Salomonsson, L. Söder, Royal Institute of Technology</i>	

P02 Intrinsic Vulnerabilities of the Power Systems Supporting Communication Networks and Expert Strategies of Defense	92
<i>K. Rauscher, R. Krock, J. Runyon, P. Hayden, Bell Labs, Lucent Technologies</i>	

P03 New Converter Architectures with Multi-Interleaving Technique for Future Microprocessors	100
<i>D. Garinto, Indonesia Power Electronics Center</i>	

P04 Optimal Configuration Analysis of a Microgrid-Based Telecom Power System	107
<i>A. Kwasinski, P. T. Krein, University of Illinois at Urbana-Champaign</i>	

SESSION 8: NON-ISOLATED CONVERTERS

Chair: Praveen Jain

8.1 A Novel PWM Soft Switching DC-DC Converter	115
<i>L. Shi, L. Chen, C. Yin, North China Electric Power University</i>	

8.2 An LED Drive Circuit with Constant-Output-Current Control and Constant-Luminance Control	121
<i>M. Nishikawa, Y. Ishizuka, H. Matsuo, Nagasaki University; K. Shigematsu, Ansoft Japan</i>	

8.3 A Fast Response Current-Compensation Circuit for POL	127
<i>Y. Kawanami, Y. Ishizuka, H. Matsuo, Nagasaki University; K. Ito, Sanken Electronics, Ltd, M. Ueno, Nagasaki University and Sanken Electronics, Ltd</i>	

SESSION 9: BATTERY STANDARD AND CONTINUATION OF NICKEL BATTERY SYSTEMS

Chair: George Zguris

9.1 The IEEE Standards Association Stationary Batteries Committee	132
<i>B. Cotton, Data Power Monitoring Corp</i>	

9.2 Do You Want to Know More? RFID Tags on Stationary Batteries	137
<i>H. K. Giess, Oerlikon Stationary Batteries Ltd</i>	

9.3 Field Experience with Large Nickel Metal Hydride (NiMH) Batteries in Stationary Applications	143
<i>M. M. Moorthi, Stationary Solutions Cobasys</i>	

SESSION 10: ENVIRONMENTAL ISSUES

Chair: Zbig Noworolski

10.1 A New Tool for Evaluating and Designing the Thermal Environment in Telecom Central Offices	150
M. K. Herrlin, <i>ANCIS Incorporated</i>	
10.2 The Telecommunications Act of 1996 - Analysis A Decade Later. The Rise and Fall of Universal Solutions, Inc	155
M. R. Moore, <i>Moore & Moore Solutions, Inc</i>	
10.3 Simplified Air-Conditioning for Telecommunication Switches	169
S. Le Masson, J. Gautier, D. Nörtershäuser, <i>France Telecom</i>	

TUESDAY, SEPTEMBER 12, 2006

SESSION 11: RESONANT CONVERTERS I

Chair: Zbig Noworolski

11.1 Active Clamp Converter with Full Resonant Switching	174
M. E. Jacobs, <i>Slater and Matsil</i>	
11.2 A Novel Precise Design Method for LLC Series Resonant Converter	181
T. Liu, Z. Zhou, A. Xiong, J.Zeng, J.Ying, <i>Delta Power Electronics Center</i>	
11.3 A New Passive Valley Fill Dimming Electronic Ballast with Extended Line Current Conduction Angle.....	187
J. Lam, P. K. Jain, <i>Queen's University</i>	

SESSION 12: SOLAR / PHOTOVOLTAIC APPLICATIONS

Chair: Subhas Chalasani

12.1 Sollan-Dimsol R&D Project, Solar and Renewable Energy in France Telecom	194
D. Marquet, M. Aubrée, O. Foucault, <i>France Telecom R&D</i>	
12.2 Small Photovoltaic Module with Rectangular Cells for Reducing Output Degradation Caused by Spot Dirt	202
S. Kobayashi, H. Kobayashi, K.Yamada, T. Yachi, <i>Tokyo University of Science</i> ; T. Iino, <i>NTT Facilities, Inc.</i>	

SESSION 13: POWER PLANT ARCHITECTURE

Chair: Tim Cortes

13.1 High Demands on Cellular Networks – High Demands on Surge Protective Devices	208
R. Bissmeier, <i>Phoenix Contact GmbH & Co. KG</i>	
13.2 A Remote Power Node for Span Powering	212
M. L. MacDonald, <i>Emerson Network Power</i>	
13.3 An End-User's Guide to Selecting AC/DC Power Plant Architecture Bulk vs. Distributive	217
M. R. Moore, <i>Moore & Moore Solutions, Inc</i>	

SESSION 14: RESONANT CONVERTERS II

Chair: Dusty Becker

14.1 Multi-output LLC Resonant Converters with Symmetrical Auxiliary Output Structures	226
L. Hang, Y. Gu, Z. Lu, Z. Qian, <i>Zhejiang University</i>	
14.2 The Design Consideration Comparisons of Two Clamping Modes Over Current Protection for LLC Converter	231
C. Zhao, X. Xie, X. Wu, J. Zhang, Z. Qian, <i>Zhejiang University</i>	
14.3 Evaluation of Conducted Noise of Resonant Switched Capacitor Converter	236
M. Shoyama, F. Deriha, T. Ninomiya, <i>Kyushu University</i>	

SESSION 15: ULTRA CAPACITORS

Chair: Patrick Ng

15.1 Ultra™ Capacitors for Short Duration Backup of DSL Cabinets	241
C. Ashton, <i>Qwest</i>	
15.2 Fuel Cells and Ultracapacitors: A Proven Value Proposition Versus Incumbent Technologies	248
B. Maher, <i>Maxwell Technologies</i> ; J. Dogterom, T. Fisher, <i>Hydrogenics Corporation</i>	

SESSION 16: NETWORK RELIABILITY

Chair: Ed Silverman

16.1 Balancing Power Availability with Energy Efficiency	252
D. Sundmark, <i>Telus</i>	
16.2 Return-on-Investment (ROI) for Electronic Prognostics in High Reliability Telecom Applications	260
S. M. Wood, <i>C&D Technologies</i> ; D. L. Goodman, <i>Ridgetop Group, Inc</i>	
16.3 Impact of Distributed Energy Resources on the Reliability of Critical Telecommunications Facilities	263
D. G. Robinson, <i>Sandia National Laboratories</i> ; D. Arent, <i>National Renewable Energy Laboratory</i> , L. Johnson, <i>Sprint Nextel</i>	

SESSION 17: POWER FACTOR CORRECTION (PFC)

Chair: Al Cioffi

17.1 PFC Design for High Power Density Application	270
X. Xin, J. Zeng, H. Ye, A. Qiu, J. Ying, <i>Delta Power Electronics Center</i>	
17.2 A Proposal for a New Generation Power Converter With Pseudo-Derivative Control	275
W. Phipps, R. Duke, <i>University of Canterbury</i> ; M. J. Harrison, <i>Eaton Powerware Ltd</i>	
17.3 Higher and Lower Power Single-Stage AC-DC Converters	280
S. Li, S. Bassan, G. Moschopoulos, <i>University of Western Ontario</i>	

**SESSION 18: WORKSHOP:
FUTURE ENERGY REQUIREMENT FOR TELECOM SYSTEMS**

Chairs: Rod Shane and George Zguris

SESSION 19: NETWORK QUALITY

Chair: Michael Le Blanc

19.1 Study on Field Demonstration of Multiple Power Quality Levels Supply in Sendai287

K. Hirose, T. Takeda, *NTT Facilities*; S. Muroyama, *NTT-BTI*

19.2 Power Quality Assurance by Using Integrated Power System.....293

T. Takeda, A. Fukui, A. Matsumoto, K. Hirose, *NTT Facilities*; S. Muroyama, *NTT-BTI*

19.3 AC Power Backup Without Single Point of Failure301

D. M. Rixhon, P. J. M. Bleus, *CE+T sa / IEEE*

SESSION 20: POWER FACTOR CORRECTIONS (PFC) II

Chair: Murray MacDonald

20.1 A Novel Soft-Switching Circuit for an AC-DC Converter with a Four-Winding Reactor305

R. Araki, O. Matsuo, M. Tuji, H. Matsuo, *Nagasaki University*; H. Ota, *Fuji Hitachi Power Semiconductor Co. Ltd*

20.2 Comparison of Different Schemes for VRM Application310

M. Orabi, M. El-Zanaty, *South Valley University, Aswan*

20.3 Dynamic Characteristics of Pulse Rate Control of a POL Converter.....318

I. Nishikawa, Y. Ishizuka, H. Matsuo, *Nagasaki University*; J. Saito, *Sanken Electronics Ltd*, M. Ueno, *Nagasaki University and Sanken Electronics Ltd*

SESSION 21: LEAD ACID (VRLA) BATTERIES

Chair: Frank Fleming

21.1 An Enhanced Dynamic Battery Model of Lead-Acid Batteries Using Manufacturers' Data324

N. Medora, A. Kusko, *Exponet Failure Analysis Associates, Inc*

21.2 Float Life Expectancy of VRLA-Batteries Based on High Temperature Float Tests Impact of Discharge Rate, Design and Test Parameter332

F. Kramm, *Deutsche EXIDE GmbH*

21.3 Development of High-Rate Discharge Stationary VRLA Battery337

T. Tsujikawa, K. Yabuta, T. Matsushita, *NTT Facilities, Inc*

21.4 Reference Electrode Measurements, Field Experience, Use and Analysis.....343

A.G. Cannone, W. P. Cantor, *TPI*; D.O. Feder, *EESS, Inc*

SESSION 22: UPS SYSTEMS & RELIABILITY

Chair: Martin Malek

22.1 A Novel Charging Solution for High Power UPS Application	350
<i>L. Fang, Y. Kang, S. X. Duan, X. Wei, Huazhong University of Science & Technology</i>	
22.2 Novel & Practical Digital Parallel UPS System Based on CAN_BUS	355
<i>Y. Kang, X. Chen, M. Yu, Huazhong University of Science & Technology, H. Shan, Huazhong University of Science & Technology and Hubei Automobile Industrial Institute</i>	
22.3 Reliability Estimation of Uninterruptible Power Supply Systems: Boolean Truth Table Method	360
<i>M. K. Rahmat, S. Jovanovic, K. L. Lo, University of Strathclyde</i>	

WEDNESDAY, SEPTEMBER 13, 2006

SESSION 23: NON-ISOLATED CONVERTERS II

Chair: Dusty Becker

23.1 Dynamics of Input-Voltage-Feedforward-Controlled Buck Converter	366
<i>M. Karppanen, T. Suntio, Tampere University of Technology; M. Sippola, Efore Oyj</i>	
23.2 Analysis of the Load Interactions in Constant-Current-Controlled Buck Converter	374
<i>M. Hankaniemi, T. Suntio, Tampere University of Technology; M. Sippola, Efore Oyj</i>	
23.3 Power Converter with Gradient Power Architecture and Non-Uniform Current Sharing	380
<i>J. A. Abu Qahouq, L. Huang, Intel Corporation</i>	

SESSION 24: LITHIUM BATTERY SYSTEMS

Chair: Patrick Ng

24.1 Residual Capacity Estimation of Stationary Lithium-Ion Secondary Cells in Telecommunications Systems Using a Brief Discharge	388
<i>T. Matsushima, NTT Facilities Inc; T. Horie, NTT-BTI</i>	
24.2 How Depth of Discharge Affects the Cycle Life of Lithium-Metal-Polymer Batteries	395
<i>T. Guena, P. Leblanc, AVESTOR</i>	
24.3 High Energy Li-Ion Batteries Combined with Compact Power Systems for Outdoor BTS: Technical and Economical Decision Making from Field Test to Deployment	403
<i>J. Brunarie, SAFT SA; E. Olsson, Delta Energy Systems</i>	

SESSION 25: ENVIRONMENTAL ISSUES: THERMAL MANAGEMENT

Chair: Ernie Farren

25.1 Operational Vibration Test – An Alternative to NEBS Seismic Test for Telecom Power Equipment411
B. Serban, Emerson Network Power

25.2 Telecommunications Power Plant Damage Assessment Caused by Hurricane Katrina -Site Survey and Follow-Up Results419
A. Kwasinski, W. W. Weaver, P. L. Chapman, P. T. Krein, University of Illinois at Urbana-Champaign

25.3 Firming Up the Framing; Why and How to Stiffen the Telecommunications Cabling Infrastructure427
D. McMenamin, Dan McMenamin & Associates, Inc

SESSION 26: SOFT-SWITCHING CONVERTERS

Chair: Don Davidson

26.1 A New ZVT-PWM Converter with Reduced Circulating Current Losses.....437
X. Gao, G. Moschopoulos, S. Bassan, University of Western Ontario

26.2 A Zero-Voltage Switching Three-Port Isolated Full-Bridge Converter.....442
H. Al-Atrash, M. Pepper, I. Batarseh, University of Central Florida

26.3 A Wide Band-Width Design of a Self-Oscillating Resonant Converter via a Novel Discrete Time Model Criterion.....450
M. Z. Youssef, P. K. Jain, Queen's University

SESSION 27: LITHIUM BATTERY SYSTEMS II / FUEL CELL

Chair: Subhas Chalasani

27.1 Active Filtering of Input Ripple Current to Obtain Efficient and Reliable Power from Fuel Cell Sources456
W. Shireen, H. Nene, University of Houston

27.2 Enclosure Space Reclamation ABCs462
W. Bydeweg, Emerson Network Power

SESSION 28: WORKSHOP: ENERGY REDUCTION

Chair: John Lam

28.1 Using Energy-Efficient Technologies to Lower Operational Costs In High-Density Environments.....468
P. Gross, K. L. Godrich, EYP Mission Critical Facilities

THURSDAY, SEPTEMBER 14, 2006

SESSION 29: CONTROL & SIMULATION I

Chair: Lilly Huang

29.1 A Dual-Loop Digital Controller for Switching DC-DC Converters472
M. Shi, J. Sun, P. Enjeti, *Texas A&M University*

29.2 A Novel Digital Control for DC/DC Converters to Improve Steady-State Performances477
V. Boscaino, G. M. Di Blasi, P. Livreri *Università degli Studi de Palermo*; F. Marino, M. Minieri, *STMicroelectronics*

29.3 Small Signal Modeling and Control Design for New Extended Duty Ratio, Interleaved Multiphase Synchronous Buck Converter481
B. Oraw, R. Ayyanar, *Arizona State University*

SESSION 30: FUEL CELLS

Chair: Murray MacDonald

30.1 Trial Assessment of PEM Fuel Cells for Backup Power in Telco Networks489
M. J. Ross, M. Durocher, T. Beaird, *Verizon*

30.2 Metal Hydride Fuel Cells, A New and Practical Approach for Backup and Emergency Power Applications494
K. Fok, *Ovonic Fuel Cell Company*

30.3 Extended Run Fuel Cell Backup Power: Solving the Hydrogen Problem500
H. Koyama, *Ida Tech, LLC*

30.4 Reducing Cost and Decreasing CO2 Emission Using a Shared-Distribution Fuel Cell System503
T. Iino, *NTT Facilities*; S. Kobayashi, H. Kobayashi, K. Yamada, T. Yachi, *Tokyo University of Science*

SESSION 31: INNOVATIONS IN POWER SYSTEMS

Chair: Charles Gamelin

31.1 Improving HomePlug Power Line Communications with LDPC Coded OFDM508
C. Hsu, N. Wang, W-Y. Chan, P. Jain, *Queen's University*

31.2 SPICE-Based Automated Software Network Analyzer515
N. Pongratananukul, *National Semiconductor*

31.3 Applied Digital Control for Localization of the Maximum Power of Photovoltaics Generators521
P. Vieira Junior, D. M. da Silva, M. P. do Nascimento, *Federal University of Pará*; P. I. G. Palheta, P. S. F. Filho, *Centro Federal de Educação*; A. R. Costa, *Manaus Energia*, J. G. Siqueira, *Universidade do Estado do Amazonas*;

31.4 Modular Conventional Protection and Its Enhancement through Electronic Circuit Breaker Systems527
J. Hewetson, P. Meckler, *E-T-A GmbH*

SESSION 32: CONTROL & SIMULATION II

Chair: Steve Roy

32.1 Stability Comparison of Voltage Mode and Peak Current Mode Control for Bus Converter in On-Board Distributed Power System533

S. Abe, T. Ninomiya, *Kyushu University*; M. Hirokawa, *TDK Corporation*; T. Zaitso, *TDK Innovate, Inc*

32.2 Optimal Feedback Control of Switch-Mode Power Converters538

M. E. Jacobs, *Slater & Matsil*

32.3 Design and Analysis of High Performance Control Strategy for UPS with Repetitive Control.....548

M. Chen, W. Yao, M. Li, Z. Qian, *Zhejiang University*; X. Yuan, *GE (China) Research & Development Center Co.*

SESSION 33: FUEL CELLS II

Chair: George Zguris

33.1 Field Applications: Fuel Cells as Backup Power for Italian Telecommunication Sites552

A. Tomasi, *SGS Future s.r.l.*; M. Concina, M. Grossoni, *Telecom Italia*; P. Caracino, *Pirelli Labs*; J. Blanchard, *ReliOn*

33.2 Fuel-Cell Based Back-Up Power for Telecommunication Applications: Developing a Reliable and Cost-Effective Solution560

M. L. Perry, E. Strayer, *UTC Power*

33.3 Benchmarking Hydrogen Fuel Cell as an Alternative Back-Up Power for the Telecommunications Industry.....568

D. B. Canavan, *Emerson Network Power*; J. J. Dogterom, *Hydrogenics Corporation*; J. McDougall, *Bell Canada*

33.4 Suitability of Fuel Cell Technology for Electricity Utility Standby Power Applications575

T. Jacobs, *Eskom*; J. Beukes, *University of Stellenbosch*

SESSION 34: NON-ISOLATED CONVERTERS

Chair: Marc Durocher

34.1 Different Frequency Instabilities of Averaged Current Controlled Boost PFC AC/DC Regulators.....582

M. Orabi, *South Valley University*; A. El Aroudi, *Universitat Rovira I Virgili*

34.2 A State Space Modeling Approach of a Single-Stage Three Level Resonant AC/DC Converter Operating in Discontinuous Conduction Mode590

M. S. Agamy, P. K. Jain, *Queens University*

34.3 Optimized Design of Distributed Power Systems for High Efficiency, High Power Density and Low EMI Noise597

F. C. Lee, S. Wang, M. Xu, B. Lu, C. Wang, P. Kong, *Virginia Tech*

SESSION 35: CLOSING PLENARY

Chair: Dan McMenamin