2015 IEEE 11th International Conference on Power Electronics and Drive Systems
IEEE PEDS 2015

The Sydney Hilton Hotel, Sydney, Australia
9 – 12 June 2015
Conference Programme
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<th>10 June (Wed)</th>
<th>11 June (Thu)</th>
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<td>0830 - 0900</td>
<td>Arrival Coffee (Level 2)</td>
<td>APEHIA-II</td>
<td>ADEI-I</td>
<td>ADEM-I</td>
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<td>0900 – 1030</td>
<td>0900 – 1230 Opening Ceremony and Plenary Session (Level 2)</td>
<td>DGSG-II</td>
<td>HSSS-I</td>
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<td>1030 – 1100</td>
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<td>1300 – 1500</td>
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<td>1530 – 1700</td>
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<td>1800 – 1930</td>
<td>1800 – 1930 Welcome Reception (Zeta Back Bar)</td>
<td>APEPSG-VI</td>
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<td>1900 – 2100</td>
<td>1900 – 2100 Conference Dinner (Level 3 Ballroom)</td>
<td>APEPSG-VII</td>
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APEHIA-II: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems II
APEHIA-III: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems III
APEHIA-IV: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems IV
APEHIA-V: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems V
APEPSG-I: Applications of Power Electronics in Power System and Generation/FACTS I
APEPSG-II: Applications of Power Electronics in Power System and Generation/FACTS II
DGSG-I: Distributed Generation and Smart-Grid I
DGSG-II: Distributed Generation and Smart-Grid II
DGSG-III: Distributed Generation and Smart-Grid III
HSSS-I: Hard-Switching and Soft-Switching Static Power Converters and UPS I
HSSS-II: Hard-Switching and Soft-Switching Static Power Converters and UPS II
MDMC-I: Motion Drives and Motion Control I
MDMC-II: Motion Drives and Motion Control II
MDMC-III: Motion Drives and Motion Control III
MDMC-IV: Motion Drives and Motion Control IV
MDMC-V: Motion Drives and Motion Control V
MDMC-VI: Motion Drives and Motion Control VI
MSPE-I: Modelling & Simulation in Power Electronics I
PEET-I: Power Electronic Emerging Technologies I
PEET-II: Power Electronic Emerging Technologies II
PQHS-I: Power Quality Issues, Harmonic Problems and Solutions I
PQHS-II: Power Quality Issues, Harmonic Problems and Solutions II
PQHS-III: Power Quality Issues, Harmonic Problems and Solutions III
PS-I: Poster Session I
PS-II: Poster Session II
PSPC-I: Power Semiconductors, Power integrated circuits and Passive Components I
PSPC-II: Power Semiconductors, Power integrated circuits and Passive Components II
RET-I: Renewable Energy Technologies I
RET-II: Renewable Energy Technologies II
WBGD-I: (Special Track) Wide Bandgap Power Semiconductor Devices and Technologies I
WBGD-II: (Special Track) Wide Bandgap Power Semiconductor Devices and Technologies II
WBGD-III: (Special Track) Wide Bandgap Power Semiconductor Devices and Technologies III
Registration Desk

The conference registration desk is located on

<table>
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<tr>
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<th>Level</th>
<th>Time</th>
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<tr>
<td>9 June 2015</td>
<td>Level 4</td>
<td>0930am – 1700pm</td>
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<td>10 June 2015</td>
<td>Level 2</td>
<td>0900am – 1700pm</td>
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<td>11 – 12 June 2015</td>
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<td>0900am – 1700pm</td>
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The Conference Venue

Hilton Sydney
488 George Street, Sydney NSW 2000 Australia
Tel: +61-2-9266-2000 Fax: +61-2-9265-6065

Conference Social Events

Welcome Reception: 9 June 2015 @ 6pm – 7:30pm  Zeta Back Bar
(Entrance via level 4 air bridge)

Conference Buffet Dinner: 11 June 2015@7pm – 9pm  Level 3 Ballroom
Travel Information

Transport from Sydney Airport to Conference Venue

By Train to Town Hall Station
Sydney Airport is located just 13 minutes by train from the city. There are train stations located at both the International and Domestic terminals, which operate as part of the Airport Link train service. The Domestic terminal train station is located directly between T2 and T3 terminals and is accessible from within the terminals from the Arrivals level. The International terminal train station is located at the northern end of the terminal and is accessible from the Arrivals level. Airport surcharge fee on train fare applies.

By Taxi to Hilton Sydney
Each terminal has its own sheltered taxi rank with supervisors on hand during peak times to ensure a smooth flow of taxis for travellers. Kerbside supervisors can also organise taxis with baby capsules, wheelchair access, five-seaters and maxi taxis for larger groups or station wagons for large amounts of baggage.

The estimated fare from airport to Sydney City is $45 - $55 (one way). Remember passengers pay for any bridge or road tolls on top of the fare (these fares are in Australian dollars and are based on non-peak traffic conditions). A $4.00 airport toll is payable by all passengers taking a taxi from any of Sydney Airport’s taxi ranks.

Australian Immigration and Custom Clearance

All arriving passengers (if not using SmartGate clearance) must complete an Incoming Passenger Card and present their passport to the custom officers on arrival before collecting their baggage. SmartGate gives eligible travellers the option to self-process through passport control. It provides a secure, efficient way to clear through passport control. You are eligible to use SmartGate to self-process through Australia's passport control if you hold an ePassport from the following countries and are aged 16 years or over: Australia, Canada, Ireland, New Zealand, Singapore, United Kingdom and United States of America.

Please note the items required to be declared on the custom form, in particular food of any kinds, currency of A$10,000 or above, and any wildlife products. If you are in doubt, declare your goods or ask one of the custom officers for advice.
Welcome Message from General Chairs

On behalf of the PEDS2015 Conference Committee, we are honored and delighted to welcome you to the 11th IEEE International Conference on Power Electronics and Drive Systems at Sydney, Australia. I believe we have chosen a venue that guarantees a successful technical conference amid the culture and scenery of Down Under. Australia is also home to many fine universities with academic strengths in power electronics, drive systems and renewable energy applications. There is no doubt that the PEDS2015 will be an event which catalyzes professional networking, new friendships and happy memories, in addition to technical knowledge sharing and discussion.

For those of you who are attending PEDS conference for the first time, let us share with you the brief history and the vision of the PEDS Management Committee on the promotion of the art of power electronics and industry applications. The PEDS is an IEEE power electronics-related conference which was initiated in 1995 by an IEEE entity of both technical and regional in its outlook and functions: the IEEE IAS/PELS Joint Chapter of IEEE Singapore Section. Through the vast MGA networks, we brought you to Singapore and we also bring PEDS to the IEEE world. To date, the biennial PEDS has been held jointly with other IEEE sister Sections in Singapore, Hong Kong, Bali, Bangkok, Kuala Lumpur, Taipei, Kitakyushu and now in Sydney.

The success of this conference depends ultimately on the many people who have worked with us in planning and organizing both the technical programme and supporting social arrangements. In particular, we thank the Technical Program Chairs for their dedicated hard work in organizing the technical programme; the Technical Programme Panel for their thorough and timely reviewing of the papers, and the Organizing Committee Chairs in charting and executing the organization of the conference and have contributed to the fine details of important aspects in the local arrangements.

King J. Tseng,
Nanyang Technological University, Singapore

Don Mahinda Vilathgamuwa
Queensland University of Technology, Australia
Message from Technical Programme Chairs

Power Electronics and Drives System (PDES) technology has been continuously growing as in cutting edge, state-of-art, emerging spanning across being foundation block, supporting pillar and technology-enabler for up-tick in applications such as renewable energy systems, smart grids, electro-mobility, green buildings and many more.

PDES conference was originated from Singapore two decades ago. Since then, PDES makes its way to various countries around the world, including the most recent in Japan (PDES2013), is to provide regular forums for industrial and academic researchers to share their latest contributions to knowledge capital in power electronics and drives systems, and opportunities to network with each other. PDES is a world-wide recognized technical conference. This year 2015, we are glad to have international participants of more than 20 countries, a third of them from Europe and United States and the other two thirds from Asia Pacific, mainly Australia, China, Japan and Taiwan. PDES2015 technical programme has been organized into 12 topic areas; exploring novel devices, discovering advanced power electronics and drives technologies and applying system solutions in home appliance, industry, aerospace and automotive.

We would like to express my heartiest gratitude to all my technical programme panel members who have contributed tremendously to the peer-review process for more than 450 IEEE-qualified manuscripts. Over 200 high quality papers have been selected for presentation in the 4-day conference, congratulations! All-in-all, the technical programme is the fruit of the PDES 2015 conference as well as all the authors, many of them have been loyal and consistent supporters of the PDES series of conferences.

We wish all PDES 2015 conference delegates an enjoyable experience.

Yen Kheng Tan  
Singapore University of Technology and Design, Singapore

Dave Dorrell  
University of Technology Sydney, Australia
PEDS 2015 Conference Committee

Conference Advisory Board
Norbert Cheung, Hong Kong
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Dave Dorrell, University of Technology Sydney, Australia

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Fai Choy Leong, Singapore Polytechnic, Singapore

Local Arrangement
Faz Rahman, University of New South Wales, Australia

Committee Members
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Errol Chopping, Charles Sturt University, Australia
Joe Zhu, University of Technology Sydney, Australia
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Yanuarsyah Haroen, Indonesia
Jung I. Ha, Korea
Boyong He, China
Hiang-Kwee Ho, Singapore
J. Holtz, Germany
Chih-Fang Huang, Taiwan
Qin Huang Alex, USA
R. S. Y. Hui, Hong Kong
John Y. Hung, USA
Iqbal Husain, USA
Thomas M. Jahns, USA
Praveen Jain, UK
Juri Jatskevich, Canada
K. Jezernek, Slovenia
M. K. Kazimierczuk, USA
Ralph Kennel, Germany
J. Kolar, Switzerland
Matsuse Kouki, Japan
Jason Lai, USA
Yen-Shin Lai, Taiwan
Loi Lei Lai, UK
Tsorng-Juu Liang, Taiwan
Yi-Lu Liu, USA
Pascal Lorenz, France
Robert D. Lorenz, USA
Dongsheng Ma, USA
Udaya Madawala, New Zealand
Nobuyuki Matsui, Japan
Ned Mohan, USA
Gabriel Rincón-Mora, USA
M. Nakaoka, Japan
Chem Nayar, Australia
T. Ninomiya, Japan
Shigeru Okuma, Japan
Boon Teck Ooi, Canada
Dr. S. Paramasivam, India
Z. Qian, China
Alex Ruderman, Kazakhstan
Dierk Schroeder, Germany
H. Sekiya, Japan
P. C. Sen, Canada
Jul-Ki Seok, Korea
M. Shoyama, Japan
T. Suetsugu, Japan
Seung-Ki Sul, Korea
Paolo Tenti, Italy
C. K. Michael Tse, Hong Kong
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Lixiang Wei, USA
Bin Wu, Canada
Tsai-Fu Wu, Taiwan
J. Daan Van Wyk, USA
Dehong Xu, China
Dian Guo Xu, China
Longya Xu, USA
Abdul H B M Yatim, Malaysia
Zhengming Zhao, China
Georges Zissis, France

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<tr>
<th>Year</th>
<th>Conference Venue</th>
<th>Organised by</th>
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| 1995 | Singapore        | Ramesh Oruganti  
*National University of Singapore* |
| 1997 | Singapore        | Yung C. Liang  
*National University of Singapore* |
| 1999 | Hong Kong        | Norbert C. Cheung  
*The Hong Kong Polytechnic University* |
| 2001 | Bali             | Yanuarsyah Haroen  
*Bandung Institute of Technology* |
| 2003 | Singapore        | Sanjib K. Panda  
*National University of Singapore* |
| 2005 | Kuala Lumpur     | Zainal Salam  
*Universiti Teknologi Malaysia* |
| 2007 | Bangkok          | Sukumvit Phoomvuthisarn  
*Chulalongkorn University* |
| 2009 | Taipei           | Tian-Hua Liu  
*National Taiwan Univ. of Science and Technology* |
| 2011 | Singapore        | Sanjib K. Panda  
*National University of Singapore* |
| 2013 | Kitakyushu       | Tadashi Suetsugu  
*Fukuoka University* |
| 2015 | Sydney           | Yung C. Liang  
*National University of Singapore*  
David Tien  
*Charles Sturt University* |

Celebrating 20 years of great PEDS conference!
Tutorial Sessions

Date/Time: Tuesday, 9 June 2015/09:30 – 17:30 hrs
Venue: Rooms 1 and 2 @ Level 4

IEEE PEDS 2015 offers the following tutorial sessions free of charge, provided that you have already registered with the conference technical sessions. The tutorial sessions do not provide any tea breaks or lunch.

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<tr>
<th>Time</th>
<th>Speakers</th>
<th>Title</th>
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<tbody>
<tr>
<td>09:30 AM – 12:30 PM</td>
<td>Ralph Kennel</td>
<td>Predictive Control - A Simple and Powerful Method to Control Power Converters and Drives</td>
</tr>
<tr>
<td>09:30 AM – 12:30 PM</td>
<td>Mahinda Vilathgamuwa, Geoff Walker, Shantha Gamini</td>
<td>Photovoltaic Power Converters</td>
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<tr>
<td>02:30 PM – 05:30 PM</td>
<td>Petar. J. Grbović</td>
<td>Power Electronics Today and Tomorrow - <em>Issues and Solutions</em></td>
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<tr>
<td>02:30 PM – 05:30 PM</td>
<td>Shantha Gamini</td>
<td>Electrical Drives for More Electric Ships and Aircrafts – A Review on State of the Art Technologies, Trends and Challenges</td>
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For more details, please view the conference website: http://www.rpsonline.com.sg/peds/tutor.html
Technical Paper Abstracts and Presentation Schedule

**Plenary Session**
Date/Time: Wednesday, 10 June 2015/09:30 – 12:30 hrs
Venue: Stateroom @ Level 2
Session Chair: Sanjib K. Panda, National University of Singapore, Singapore

330  **Gallium Nitride Power Electronic Devices and Circuits: A Review**  
  *Graham E. Town*  
  *Department of Engineering, Macquarie University, Australia*

Abstract- Gallium-nitride is an emerging power semiconductor technology with considerable promise for applications requiring compact and efficient power conversion at competitive cost. In this paper gallium-nitride power electronic devices, circuits, and applications are reviewed and compared in terms of device specifications, circuit topologies, and cost.

67  **Analysis and Simulation of the Proactive Hybrid Circuit Breaker**  
  *Oliver Cwikowski, Mike Barnes, Roger Shuttleworth and Bin Chang*  
  *The University of Manchester, UK*

Abstract– High Voltage Direct Current (HVDC) short circuit protection is a fundamental requirement for any HVDC transmission system. Presently, all point-to-point links are protected using circuit breakers on the AC side of the converters. In order to enable HVDC grids, a more advanced protection system must be developed. HVDC circuit breakers are one solution for the protection of future HVDC grids. Several designs have been proposed for DC circuit breakers but few are suitable for Voltage Source Converter (VSC) applications. To date, only a few industrial prototypes have been developed, which are seen to be suitable for the VSC HVDC applications. This paper presents analysis and simulations on one of these prototypes, the Proactive Hybrid circuit Breaker (PHCB). Equations are derived from a state-space analysis of the circuit breaker. A model of the circuit breaker is suitably parameterized for a +/- 300 kV VSC system in PSCAD. Fault simulations are then performed and compared to the equations developed in a state space analysis. Discussion is then given to the design and testing of the Load Commutation Switch (LCS).

275  **An optimization-based control strategy for modular multilevel converters: design and implementation**  
  *Nikola Stanković (1), Gilbert Bergna(2), Amir Arzandé (1), Erik Berne(3), Philippe Egrot(3), Jean-Claude Vannier(1)*  
  (1)GeePs Laboratory, CentraleSupélec, France  
  (2)SINTEF Energy Research, Trondheim, Norway  
  (3)Laboratory of Electrical Equipment, EDF R&D, France*

Abstract- In this paper we present an optimization-based procedure for designing a reference circulating current which stabilizes the internal dynamics of a modular multilevel converter. This procedure relies on unconstrained convex optimization and it takes into account conflicting performance requirements such as reducing the oscillating components of circulating current and arm voltages. Tracking of such a reference signal is ensured by a robust tracking controller with gains chosen in order to attenuate the measurement noise. Since we were interested in implementation of the control algorithm by using a digital simulator, the design procedure is carried...
out in the discretetime domain. Effectiveness of the proposed strategy is confirmed on a prototype of three-phase modular multilevel converter with five sub-modules per arm and RL load.

228 Photovoltaic Based Active Generator: Energy Control System Using Stateflow Analysis
Aimie Nazmin Azmi (1, 2), Mohan Lal Kolhe (1),
(1)Faculty of Engineering & Science, University of Agder, Norway
(2)Fakulti Kejuruteraan Elektrik, Universiti Teknikal Malaysia Melaka, Malaysia

Abstract- At present, most of the grid connected photovoltaic (PV) systems are operating at maximum power points and injecting power in uncontrolled way. Thus, active generator will be a good solution to support instantaneous power balance, frequency control and maintaining the power quality with controllable power injection. This new mode of active generator needs innovative power management. The new proposed energy control system for active generator might help to manage the energy within the micro-grid environment. In this work, the focus is to manage the energy among the PV based active generator, load and interconnected grid and energy controller architecture for that purpose is presented. It considers availability of the solar resources, storage system and load requirements. If there is lack of energy from the active generator, then the grid supplies remaining energy. For architecture of energy controller, Stateflow ® model is used. It uses available energy information from PV array, battery storage with super-capacitors and load requirements for managing the energy flow and it provides control signals to the power conditioning devices, which are used for integrating the sources. The presented energy management algorithm will be useful for the future smart grid system and also for building integrated PV based active generator system and demand side management.

Session APEHIA-I: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems I
Date/Time: Wednesday, 10 June 2015/13:30 – 15:00 hrs
Venue: Room 2 @ Level 2
Session Chair: Don Mahinda Vilathgamuwa, Queensland University of Technology, Australia

29 Model Predictive Control of Six-Phase Variable Frequency Electrically Excited Starter Generator for More Electric Aircraft
Mohammed Alnajjar and Dieter Gerling
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Abstract- This paper proposes a predictive control strategy for the voltage stability of a six-phase electrically excited starter generator for the aircraft DC power system. The starter generator is a synchronous machine coupled to the aircraft engine, and it is connected to 270V DC bus via a dual three- phase voltage source inverter that utilizes the DC output power. In the generation mode, the external excitation is used so that the output voltage can be kept at the set point by adjusting the excitation current. The control system is designed based on an analytical model of the synchronous machine at different load conditions and at different rotor speeds using Model Predictive Control. In the Model Predictive Control, the voltage vector to be applied to the machine is determined based on the minimization of the cost function. The control unit takes into consideration the variations of the system parameters to achieve an improved performance during the transients so that the DC voltage is kept within the boundaries defined by the aircraft standards. The harmonic content of the generator current is analyzed for different electrical frequencies.
192 Electrolytic Capacitor-less Single-stage Boost Three-phase Inverter for Variable-speed AC motor System
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(1)Key Laboratory of Radar Imaging and Microwave Photonics, Ministry of Education,
(2)College of Automation Engineering, Nanjing University of Aeronautics and Astronautics, China

Abstract- This paper presents a single-phase to three-phase adjustable-speed drive (ASD) system, which consists of a diode rectifier and a single-stage boost inverter without electrolytic capacitors (E-caps). The system has no shoot through issues and gains high reliability due to the shoot-through zero state regulation method. By using E-caps-less topology, the life time can be greatly increased. By properly designing the tapping position of the inductor, the system has a high boost inversion gain and can ride-through grid voltage sags. By using the proposed harmonic injection method, the system can realize high input power factor and small dc-link ripple voltage, simultaneously. Experimental results of the electrolytic capacitors-less single-stage boost inverter (E-caps-less SSBI) based single-phase to three-phase ASD system are obtained to verify the actual performances.

220 An Energy Efficient 48Vdc Bipolar ELVDC LED Lighting System in a High-Rise Building
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(1)School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore
(2)Berkeley Education Alliance for Research in Singapore, CREATE TOWER, Singapore

Abstract-This paper discusses an energy-efficient LED lighting distribution system in high-rise buildings based on 48Vdc bipolar ELVDC distribution nano-grid fed from a centralized AC/DC converter. The paper first introduces the LED lighting system performances and its associated challenges. It then introduces the preference for ELVDC distribution system in the built environment. The paper then presents the mathematical model of the two different ELVDC distribution systems: the unipolar and the bipolar systems and their associated electrical component models. An approximated analysis was done using a constant power load model on the two distribution systems with voltage drop and power loss as the main indices. Simulations were carried out to determine the voltage level and system efficiencies at each node point. Experimental results of the two ELVDC LED lighting systems are verified and are compared with theoretical results. The 48Vdc bipolar ELVDC distribution system has reduced voltage drop and better system efficiency compared to the 24Vdc unipolar system.

258 Proportional-Resonant Controlled NPC Converter for More-Electric-Aircraft Starter-Generator
Hossein Dehghani Tafti(1), Ali I. Maswood(2), Ziyou Lim(3), Gabriel H. P. Ooi(4) and Pinkymol Harikrishna Raj(5)
(1, 2, 4, 5)School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore
(3)Energy Research Institute, Interdisciplinary Graduate School, Nanyang Technological University, Singapore

Abstract- More electric aircraft (MEA) technology is achieved by exchanging various mechanical and pneumatic elements of a conventional aircraft with their equivalent electrical devices in order to increase the reliability and decrease the maintenance. This paper proposes a proportional resonant (PR) controller together with the adaptive space vector modulation (ASVM) technique for the more
electric aircraft (MEA) starter-generator neutral-point clamped (NPC) converter. The proposed controller is implemented in the stationary (αβ) frame where the calculated reference voltages of the PR controller can be directly fed into the ASVM. Hence, the main objectives of the proposed controller are to reduce the computational complexity and the steady state error by decreasing the required number of framework transformations units. On top of that, the ASVM technique provides a proper DC-link capacitor voltage balancing with improved output power quality. The dynamic performance of the proposed controller is evaluated under both initial starting interval and generating mode.

418 Research on Phase-shifted Full-bridge Converter Applied in the Anode-supply of Hall Electric Propulsion

Xiaobin He, Yu Dong, Chong Lu, Tao Liu, Ke Gao and Shichao Liu
Shanghai Institute of Space Power-Sources, Shanghai, China

Abstract- With the rapid development of hall electric propulsion, higher requirement for improving power and efficiency of power processing units was created. We introduce a kind of phase-shifted full-bridge soft switch technology, which is applied in anode-supply of hall electric propulsion. In the paper, the advantages of phase-shift full bridge converter in high voltage and high power anode-supply area are illustrated, as well as the working principle of this converter. This paper focuses on the problem of duty cycle loss and the condition of leading and lagging leg to achieve ZVS in the high power situation. Also the condition of the achievement for soft switch is verified by simulation analysis and the experiment results. Finally the demands of parameter selection for phase-shifted full-bridge converter in high power situation are presented.

Session DGSG-I: Distributed Generation and Smart-Grid I

Date/Time: Wednesday, 10 June 2015/13:30 – 15:00 hrs
Venue: Room 5+6 @ Level 2
Session Chair: Mohan Lal Kolhe, University of Agder, Norway

26 Circuit Analysis Approach for determining Voltage Stability Index

Syed Ali Abbas Kazmi (1), Syed Faraz Hasan (2) and Dong Ryeol Shin (1)
(1) College of Information and Communication Engineering Sungkyunkwan University, South Korea
(2) School of Engineering and Advanced Technology Massey University, New Zealand

Abstract- Voltage Stability Index (VSI) is a commonly used performance indicator for electrical distribution networks. A high value of VSI at each node implies an overall stable distribution network. A variety of methods are available in literature to determine VSI of a distribution network connected in radial configuration. However, very little has been done to determine SI for loop-connected distribution networks. This work uses circuit analysis approach to find an expression of VSI for the loop configuration. The derived expression is then used to analyze a section of Korean distribution network. Changes observed in VSI the presence of line-to-ground faults have also been discussed.

202 Dynamic Power Demand Allocation and Battery Energy Compensation Control Of a Mobile Microgrid System

(1) Singapore Polytechnic
(2) University of Melbourne
(3) ST Kinetics Ltd
Abstract- This paper reports the design and implementation of a laboratory scale DC microgrid system that optimizes the overall fuel efficiency of multiple generators of possibly different performance characteristics through a combination of high efficiency custom-built AC/DC converters, integrated battery storage for load smoothing and a control system for the management of critical and non-critical loads.

269 Emulation of Synchronous Machine for Frequency Stability Improvement in Microgrids

*Pablo F. Frack, Rik W. De Doncker, **Pedro E. Mercado, Marcelo G. Molina

*Institute for Power Generation and Storage Systems E.ON ERC, RWTH Aachen University, Germany

**Instituto de Energia Electrica Universidad Nacional de San Juan, Argentina

Abstract- Micro-grids (MG) are expected to be low inertia grids especially due to the deployment of power electronics used to connect distributed generation (DG) units. This issue brings consequences on the grid dynamics, reducing the frequency stability margins. To this end, the emulation of synchronous machines has been proposed as a possible alternative. This paper explores the benefits of this concept comparing the dynamic performance with respect to the conventional droop control.

326 Impact of Grid Background Harmonics on Inverter-Based Islanding Detection Algorithms

M. A. Elgendy, D. J. Atkinson, M. Armstrong and S. M. Gadoue

School of Electrical and Electronic Engineering - Newcastle University, Newcastle Upon Tyne, UK

Abstract- The capability of islanding detection has become a requirement for grid connection of inverters utilized in distributed generation (DG) systems. The parallel RLC resonant circuit comprised, as a local load, in the standard test of islanding detection schemes offers lower impedance for higher frequency harmonics. With the presence of such a parallel RLC circuit, the full power balance between the distributed generation and local load will never be satisfied when the voltage at the point of common coupling is slightly distorted. In this paper, the performance of grid-connected inverter during islanding detection routine test is analyzed with sinusoidal and marginally distorted grid voltage. The results presented in this paper show that grid background harmonics may have significant impacts on inverter control and islanding detection algorithms.

383 Overload Management of Autonomous Microgrids

Ehsan Pashajavid, Farhad Shahnia, and Arindam Ghosh

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Abstract- Load-shedding is a mechanism to prevent overloading of the autonomous microgrids (MG). To minimize load-shedding, extra support can be provided by the embedded floating batteries in the autonomous MG. Furthermore, two islanded neighboring MGs can be interconnected to support each other. For this, the state of charge (SOC) of the floating batteries should be above the minimum SOC and extra generation capacity needs to be available in the distributed energy resources (DER) of the neighboring MG. In this paper an overload management strategy based on these two options is presented. This strategy needs to decide the connection time of the floating batteries as well as the interconnection time of the two neighboring MGs. It should also decide when the battery to be disconnected or the two interconnected MGs to be isolated. This
paper focuses on a decentralized approach based on monitoring the frequency of the MGs. The proposed strategy is validated by PSCAD/EMTDC simulations.

Session PEET-I: Power Electronic Emerging Technologies I
Date/Time: Wednesday, 10 June 2015/13:30 – 15:00 hrs
Venue: Room 3 @ Level 2
Session Chair: Dylan Lu, University of Sydney, Australia

160 A Reconfigurable and Fault Tolerant Drive Topology with Redundant Power Supply
Binqiang Si (1, 2) and Jihong Zhu (3)
(1) School of Automation Science and Electrical Engineering, Beihang University, China
(2) Beijing Research Institute of Precise Mechatronics and Controls, China
(3) Department of Computer Science and Technology, Tsinghua University, China

Abstract- In this paper, we propose a novel reconfigurable and fault-tolerant drive topology with redundant power supply, aiming to improve continued operation of the motor drive systems in many high reliability applications. The drive topology can isolate open-circuit and short-circuit faults in power supplies, power devices or switches. Then, it can reconfigure the drive topology from independent H-bridge to star-type by reconfigurable switches and power devices, according to the fault type and the fault tolerant truth tables. As a result, it minimizes the impact of faults on the motor drive system, and continues the fault tolerant operation. Its fault-tolerant capabilities and effectiveness are verified by a transient co-simulation method.

218 An Isolated DC Power Supply Free Compact GaN Inverter Module
Yasufumi Kawai, Shuichi Nagai, Osamu Tabata, Hideaki Fujiwara, Noboru Negoro,
Hiroaki Ueno, Masahiro Ishida, and Nobuyuki Otsuka
Automotive & Industrial Systems Company, Panasonic Corporation, 3-1-1 Yagumo-naka-
machi, Moriguchi City, JAPAN

Abstract- A low-cost and small size inverter module is required for a low-power motor system. In this work, we developed a compact GaN inverter module that is composed of GaN-GIT power devices and DBM (Drive-by-Microwave) gate drivers. The fabricated compact 5kW GaN inverter module successfully reduced its footprint for the gate drivers by 55% because it doesn’t require an isolated DC power source. The fabricated inverter module successfully realized 5.0kW motor drive and achieved the higher power conversion efficiency over a 96% under a low-output power (<1.0kW) due to the no threshold offset voltage of the GaN-GIT power device.

288 Loss Estimation and Validation of the SCALDO Implementation
Kosala Gunawardane(1), Nihal Kularatna(2), D. Alistair Steyn-Ross(2)
School of Engineering, Auckland University of Technology, Auckland, New Zealand(1)
School of Engineering, The University of Waikato, Hamilton, New Zealand(2)

Abstract- A low frequency supercapacitor circulation technique coupled with a commercial low dropout regulators (LDO), namely the supercapacitor assisted LDO (SCALDO), can achieve significantly high end-to-end efficiency (ETEE) for linear regulators. The ETEE could be closer to the efficiencies of practical switching regulators, but without having the negative aspects of switching regulators such as RFI/EMI issues and the use of bulky inductors.
In these supercapacitor assisted linear regulator topologies, the efficiency improvement compared to linear regulators is given by a special figure of merit, efficiency improvement ratio, which can be in the range of 1.33 to 3 depending on the SCALDO configuration.

Compared to the six different possible loss elements in a switching regulator, in the SCALDO technique losses are mainly contributed by equivalent series resistance of the supercapacitor, RDS (on) of the switches, parasitics in the PCB traces and losses due to paralleling of the supercapacitor with a small buffer capacitor in addition to the losses of the LDO stage. This paper presents a Laplace transform-based analytical solution to estimate the losses during the four phases of SCALDO technique with an example for a 12V-to-5V SCALDO converter.

321 A Modified Cascaded Multilevel Converter Topology for High Power Bidirectional Inductive Power Transfer Systems With The Reduction Of Switching Devices and Power Losses
Bac Xuan Nguyen (1, 3), Don Mahinda Vilathgamuwa (2), Gilbert Foo (1), Peng Wang (1, 3), Andrew Ong (1)
(1) School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore
(2) School of Electrical Engineering and Computer Science, Queensland University of Technology, Brisbane, Australia
(3) Energy Research Institute @ NTU, Nanyang Technological University, Singapore

Abstract- Several power converters have been proposed for Inductive Power Transfer (IPT) systems to generate high frequency current to excite the primary side inductive coils/tracks. This paper proposes a modified cascaded multilevel converter (MC) topology based bidirectional IPT (BIPT) system with reduced number of power electronic components and low converter losses. The proposed topology is suitable for high power – low to medium voltage IPT applications. The simulation results are presented to demonstrate the feasibility of the proposed system.

376 A Simple Open-Circuit Fault Detection Method for a Fault-Tolerant DC/DC Converter
John Long Soon and Dylan Dah-Chuan Lu
School of Electrical and Information Engineering, The University of Sydney, Australia

Abstract- This paper presents a two-switch step-down converter topology with fault tolerant capability. The proposed fault detection method uses the source-to-ground voltage of the floating MOSFET to identify the fault. If an open-circuit fault on the MOSFET occurs, the source voltage will become zero. The micro-controller which detects the fault will activate an alternative path through another MOSFET to maintain converter output regulation. The redundancy concept which is applied to this topology uses the same output inductor and capacitor to operate the converter in buck mode during normal operation and in buck-boost mode after fault. Experimental results are reported to confirm the design and demonstrate the fault tolerant operation.

Session PSPC-I: Power Semiconductors, Power Integrated Circuits and Passive Components I
Date/Time: Wednesday, 10 June 2015/13:30 – 15:00 hrs
Venue: Room 4 @ Level 2
Session Chair: Yen Kheng Tan, Singapore University of Technology and Design, Singapore

173 Wide-Supply-Voltage-Range Buck-Boost Single-Inductor Dual-Output DC-DC Converter with Pulse-Frequency-Modulation Control
Liang-Hong Lin, Hung-Hsien Wu and Chia-Ling Wei  
Department of Electrical Engineering National Cheng Kung University, Taiwan  

Abstract- An integrated pulse-frequency-modulation controlled buck-boost single-inductor dual-output dc-dc converter with wide supply voltage range is proposed. In addition, the all-comparator feedback control technique is used, which means that error amplifiers are replaced by comparators to monitor the output voltage. By using this technique, the converter can achieve fast transient response, and has no stability problem. Moreover, no external compensation components are needed. In fact, the proposed PFM-controlled converter is suitable for low-power applications, such as powering biomedical sensing chips. The proposed converter chip was fabricated by a 0.35-μm CMOS process, and its input voltage range may range from 1.8 V to 4.2 V. There are two outputs in the proposed converter, 1.8 V and 3.3 V, and their maximal output currents are 120 mA and 90 mA. The load-regulations of these two outputs are 0.0066 %/mA and 0.008 %/mA, and the cross-regulations are 0.001 %/mA and 0.0004 %/mA.

247 A New Enhanced Noise Tolerance Technique for a 600V High Voltage IC  
Masaharu Yamaji(1), Akihiro Jonishi(1), Takahide Tanaka(1), Hitoshi Sumida(1) and Yoshio Hashimoto(2)  
(1) Fuji Electric Co. Ltd.  
(2) Shinshu University.

Abstract- A new 600V high-voltage IC (HVIC) featuring a high noise tolerance is proposed. The purpose of the proposed HVIC is to achieve the high noise tolerance without an increase of the fabrication cost. The basic device concept is to arrange a P-separation layer around the high-side control part, which is called a new self-shielding structure, to reduce a hole current injection under the condition of negative transient voltage noise. By applying the new self-shielding structure in the HVIC, more than 3x higher noise tolerance (-95V/1 μs) and 20% die shrink can be obtained compared with a conventional HVIC, without additional fabrication process. This means the noise tolerance of the fabricated HVIC with proposed structure is high enough to be applied to over 600V/50A class power conversion applications.

348 A Systematic Comparison of Various Thermal Interface Materials for Applications with Surface-Mounted (DirectFET™) MOSFETs  
Georges Engelmann, Tizian Senoner, Hauke van Hoek, Rik W. De Doncker  
Institute for Power Electronics and Electrical Drives, RWTH Aachen University Germany

Abstract- Increasing power densities of power electronics with reduced volume requires increased efforts in cooling as little surface and material are available for thermal conduction. A systematic comparison of the thermal resistance of a wide selection of thermal interface materials (TIMs) ranging from solid Al2O3 to elastomeric interface materials as well as thermal greases is investigated in this work. In contrast to the ideal testing conditions used by the TIM manufacturers, a practical application setup using a surface-mounted MOSFET (DirectFET™) pressed on a heatsink is used. Thereby, additional influences on the thermal resistance due to surface finish or non-homogeneous pressure are considered in the results. The effective contacting area as well as different pressure levels are investigated. On the basis of a B6C converter bridge, it will be shown, how the proper choice of TIM affects the mechanical and thermal design of a converter.

387 Partial Discharge Inception Voltage of Pressurized Gas Insulation Encapsulation Used for High-Temperature and High-Voltage Power Module
Hiroshi Mitsudome, Keisuke Koyanagi, Akihiro Imakiire, Masahiro Kozako, Masayuki Hikita and Zarel Valdez
Department of Electrical and Electronics Engineering Kyushu Institute of Technolog, Japan
Universite de Toulouse; UPS, INPT; LAPLACE CNRS; LAPLACE, France

Abstract- This paper deals with the gas pressure and temperature dependence of partial discharge inception voltage (PDIV) of a developed gas-insulated power module as a high temperature and high voltage package. Increasing the gas pressure and temperature in the developed power module increases and decreases PDIV, respectively. Furthermore, the result of decreasing PDIV with increasing temperature is discussed by taking PD light emission image and simulating electrical field around the contact between a springs electrode and Si3N4 dielectric chip which simulates SiC-SBD.

446 A New Super-Junction VDMOS Realizing Fast Reverse Recovery
Bo Yi, Xinjiang Lyu, Xingbi Chen
State Key Laboratory of Electronic Thin Films and Integrated Devices, University of Electronic Science and Technology of China, UESTC Chengdu, China

Abstract- In this paper, the authors propose a new Super-Junction VDMOS structure to realize fast reverse recovery of its body diode. In the proposed SJ-VDMOS, the P-pillar of the drift region is surrounded by a thin SiO₂ which prevents the injection of electrons from both the drain and the N-pillar region into the P-pillar region. Thus the stored charges are reduced. A diode D₀ integrated outside the edge terminal is used to conduct the electrons collected at the interface of the bottom polysilicon/SiO₂ generated during the turning-off state of the VDMOS to prevent pre-breakdown. Besides, a Schottky diode in parallel with the body diode is also integrated to further reduce the reverse recovery charges (Qᵣᵣ). Simulation results show that the proposed SJ-VDMOS obtains the lowest Qᵣᵣ = 54 nC without any lifetime control which reduces the total switching power loss in an inverter system to about 48 µJ for a 500 V SJ-VDMOS @ I = 1.6 A.

Session PS-I: Poster Session I
Date/Time: Wednesday, 10 June 2015/16:00 – 17:00 hrs
Venue: Poster display area @ Level 4
Session Chair: Yung C. Liang, National University of Singapore, Singapore

20 PMU based Islanding Detection Method for Large Photovoltaic Power Station
Qian Cao, Furong Liu, Guorong Zhu, Wei Chen
Automation, Wuhan University of Technology, China

Abstract- With the application of synchronous phasor measuring units (PMU) and the development of wide area measurement system (WAMS) on power systems, islanding detection of large photovoltaic (PV) power station can be implemented based on communication and embed islanding detection function on central management unit (CMU), instead of on PV inverters. This paper discussed an islanding detection method based on synchronous phasor measurement technology or on WAMS which collects the frequencies of photovoltaic power station and the connected utility. The discussed method can release the conflict in satisfying national code demands for large photovoltaic power station: low voltage ride through (LVRT) and islanding detection. The frequency difference between photovoltaic power station and the utility is main index to distinguish islanding. The paper developed simulations using MATLAB/Simulink to discuss frequency performance of grid in power mismatch result from load shedding, generator tripping, and islanding events. Simulation results show that the frequency performance of PV stations have difference with
those in synchronous machine power system. The criteria rule of islanding detection and threshold setting for algorithm are discussed to provide guide for PV station applications.

27 Modelling of LCRC Adaptive Impedance Matching Circuit in Narrowband Power Line Communication
Pin Rui Chin, Arthur Kok Ming Wong, Kiing Ing Wong and Nader Barsoum
Department of Electrical and Computer Engineering Curtin University Sarawak, Malaysia
Department of Electrical and Electronic Engineering University Malaysia Sabah

Abstract- Power line communication technology is the wired communication technology that performs data transmission from a transmitter to a receiver using the existing electrical wiring. Even though the noise level and impedance mismatch problems of power line communication can be controlled by using a band-pass filter and an impedance matching circuit, respectively, the impedances in a power line are time and location variant. Therefore, these problems are still the main concern in power line communication. In this paper, an adaptive impedance matching circuits are proposed to allow maximum power transfer in the system at all time. The circuit is based on LCRC (inductor-capacitor-resistor-capacitor) filter, to achieve simple circuit configuration while retain high impedance matching resolution.

45 A Simple Control Scheme for a Single Stage Flyback with Low Harmonic Distortion
Sen-Tung Wu, Jian-Min Wang, Pang-Jung Liu
National Taiwan University of Science and Technology, Taiwan
National Formosa University, Taiwan
Department of Electrical Engineering, National Taipei University of Technology, Taiwan

Abstract- This paper would like to propose a simple control technique which is capable of facilitating the adaptation of single-stage flyback (SSF) converters to the application of light sources of low-power LEDs. The average current mode has several advantages, such as an I/O current ripple that is only 1/2 of the critical conduction mode (CRM). This helps extend the lifetime of output capacitors while lowering the value of input EMI capacitance. Based on this, the present paper operates an SSF converter in the CCM. In addition, there are some extra circuits at the output. Two of them are the sample-and-hold (S/H) circuits, the other one is zero-point detecting circuit. They help to access the output voltage and the average value of feed forward voltage. Moreover, the extra circuits also contribute the system from being influenced by 120Hz ripple and reduce harmonic distortion of the input current.

53 Matrix Converter Control Study of Doubly-fed Induction Wind Turbine Generator System
Xinyan Zhang (1), Weiqing Wang (1), Dagui Liu (1), Haiyun Wang (1), Xuan Cao (2), Shan He (1)
(1)Electrical Engineering School of Xinjiang University of China
(2)Electronic Information Schoool of China Civil Aviation University, China

Abstract- The one of the challenges faced by the large-scale development and use wind energy is the on grid requirement made by the power company. We use matrix converter to connect the rotor of the doubly-fed induction wind turbine generator system (DFIG) and the power grid. The indirect space vector modulation strategy and the constant switch frequency power control based on the matrix converter were proposed. The simulation model under the Matlab/Simulink software was built. The simulation curves were obtained. The simulation results proved that the matrix converter
can be used in the DFIG and the proposed control method can realize the average power and the reactive power decoupled control. The simulation also verified that the control structure is simple, the control need not the PI control. The machine parameters have little influence to the control and the harmonics content is minor. The on grid power energy quality requirement about the wind power can be satisfied.

57 Development of Mixed Signal ESC System on chip  
Jaehyun Park, Kyeongchan Ra, Younggwon Lee, Sungjoon Park  
Hyundai MOBIS R&D Center

Abstract- The automotive industry has been experiencing explosive growth in the use of electronics. With this growth comes a demand to use the electronics as efficiently as possible, and the automotive electronics engineer is faced with a myriad of choices. In many automotive applications, an application-specific IC provides the most effective implementation. However, the decision to use an Application Specific Integrated Circuit is just the first of many decisions. Not only must a type of ASIC be selected, but the engineer must also be aware of the system-level design tradeoffs which will make the ASIC most effective. In addition, the engineer must also choose the design tools to be used and the most suitable interface with the ASIC supplier. This paper outlines the major choices, and provides guidelines for selecting the best ASIC solution for a particular application.

92 Cogging Torque Estimation of IPMSMs with Concentrated Winding Based on Spatial Distribution in Inductance  
Takumi Kakimoto, Masaru Hasegawa and Atsushi Matsumoto  
Dept. of Electrical Chubu University, Japan

Abstract- This paper proposes a new cogging torque estimation of IPMSMs with concentrated winding, which is based on spatial distribution of inductance estimation. In general, IPMSMs with concentrated winding is known to realize high efficient drives by shortening stator windings in exchange for large torque ripple development. To solve this problem, this paper proposes the cogging torque estimation technique based on spatial harmonics components of the stator inductances. The proposed method in this paper based on the principle that the cogging torque in IPMSMs have the significant relationship to the spatial distribution. Finally, this paper shows some feasible results for numerical simulation incorporating an IPMSM behavior model obtained by FEM analyses.

98 Inverter Output Power Density Increasing Technologies for EV/HEV Applications  
Liu Jun, Sun Wei, Tai Xiang, Su Wei, Gu Lingyun  
Institute of Electrical Engineering, Chinese Academy of Sciences, Key Laboratory of Power Electronics and Electric Drive, Beijing Engineering Laboratory of Electrical Drive System & Power Electronic Device Packaging Technology, Beijing, China

Abstract- We applied advanced heat dissipating technology to reduce the heat resistances of the key devices to increase the output power density of the inverter. The IGBT modules were direct water-cooled, and the integrated DC-link capacitor was ndirect water-cooled. We conducted the simulation and the test, which proved that reducing the heat resistances was effective to improve the output density of the inverter. The power density of the self-developed inverter was 14.8kw/L, and the power-to-weight ration reached to 10.5KW/Kg.
101 Model Characterization and Automatic Parameters Testing of High Frequency Transformers
Yuang-Shung Lee and Tzu-Heng Shao
Department of Electrical Engineering, Fu-Jen Catholic University

Abstract- This paper proposed a fast and precise automatic transformer electrical characteristic measurement system which based on the S parameters measurement methods and using the Labview constructed testing system. The validity of the experiments and parameters identification is further verified by using both mathematical model and simulation software verification.

105 3D Temperature Field Calculation of Mine-used Flame-proof Integrative Variable-speed System
Jie DING (1, 2), Ping ZHANG (1), Jianghong LI (2)
(1)College of Civil Engineering and Mechanics, Xiangtan University, P. R. China
(2) CSR Research of Electrical Technology & Material Engineering, P.R. China

Abstract- Mine-used flame-proof variable-speed system consists of highly integrated converter and motor, and works in harsh environments. The closed internal structure of the system makes its cooling extremely important and renders the calculation of its temperature field a necessity. However, for such a system, because the cooling condition and geometric structure of the motor are not entirely symmetrical, the general symmetric model for motor temperature analysis cannot be used. In order to solve this problem, a complete three-dimensional geometric model was developed and upon which, a high quality grid model was obtained. A mathematical model of the cooling water and the flow channel was derived from the solution of coupled three-dimensional flow and heat transfer. The heat exchange model among air gap, stator and rotor was obtained using equivalent thermal conductivity coefficient, and the local energy non-conservation problem caused by the use of heat dissipation coefficient was overcome by user-defined functions. The control equations were solved with given assumptions and boundary conditions. The temperature field of the motor and the converter power module was obtained; and the flow properties of cooling water and the distribution of convection heat transfer coefficient were analyzed. Comparisons between experimental data and calculation results were done to prove the validity of the proposed method that provides the theoretical basis for the thermal design of mine-used flame-proof variable-speed system.

108 Simulation and Optimization of an Eddy Current Position Sensor
Josef Passenbrunner*, Gerald Jungmayr*, Martin Panholzer †, Siegfried Silber ‡ and Wolfgang Amrhein*
*Institute for Electrical Drives and Power Electronics, Johannes Kepler University, Austria
†Center for Surface- and Nanoanalytics, Johannes Kepler University, Austria
‡Linz Center of Mechatronics GmbH, Austria

Abstract- Position measurement is a major topic for the control of nearly every moving or rotating device. The demand for reliable and affordable position measurement systems is high. This paper presents the design of an eddy current position sensor and explains the working principle, which is based on injection locking of coupled oscillators. Thereby, the stability and the characteristic of the sensor are dependent on the combination of the used components. To investigate the complex dependency of the parameters, a single-axis sensor was analyzed by a coupled magnetic 2D finite element and an analog electronic simulation. To achieve a stable operation, a high linearity and a high sensitivity an optimization of the sensor was conducted. The suitability of the simulation results were verified by measurements on an implemented sensor.
117 Hardware-in-loop Simulation and Application for High-power AC-DC-AC Rolling Mill Driving System
Yu Zhang, Juan Tan, Jian Wang, Jianghong Li
CSR Zhuzhou Institute Co., Ltd., P.R.China

Abstract- Hardware-in-loop (HIL) Simulation is an excellent verification tool for controllers operated under high voltage & power conditions. In this paper, aim to high-power AC-DC-AC rolling mill driving converter system, a HIL simulation platform based on dSPACE simulator was built. With the real-time simulator, a virtual field operation environment was constructed for converter controller debugging and test, which could completely satisfy the requirements of AC-DC-AC rolling mill driving system products functions and performances verifying, reducing the products development depending on test resource greatly. The simulation platform has applied in rolling mill converter development, shortening the products development cycle and decreasing the cost largely.

126 Low Frequency Noise Measurements as a Characterization Tool for Reliability Assessment in AlGaN/GaN High-Electron-Mobility Transistors (HEMTs)
Miao Zhao, Xinyu Liu, Ke Wei, Zhi Ji
Microwave devices and integrated circuits department, Key Laboratory of Microelectronics Device & Integrated Technology, Institute of Microelectronics of the Chinese Academy of Sciences

Abstract- AlGaN/GaN High-Electron-Mobility Transistors (HEMTs) have received considerable attention for the material advantages. Even though some improvements were achieved recently by various approaches, GaN-based devices are still far to be as reliable as other devices. The low frequency noise measurement technology is a powerful tool to study the most frequent causes of failure in compound semiconductors. In this paper, low frequency noise measurements were performed on AlGaN/GaN high-electron-mobility transistors (HEMTs) under different bias over the entire frequency range of 1Hz- 100kHz. The transistor parameters and the drain noise spectra were presented. The noise spectra exhibited frequency dependence on the biasing point, and the drain current noise measurements are performed to analyze the origins of noise in channel or access regions.

134 Wide Range Dimmable LED Lighting System with Fault Compensation Protocol
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Department of Electrical and Computer Engineering, National University of Singapore, Singapore
National University of Singapore (Suzhou) Research Institute, China

Abstract- Light emitting diodes (LEDs) are more widely acceptable as the light source in many applications due to its high life expectancy and high energy efficiency. They can also be operated by switching circuit to produce desirable dimming effect. This paper describes the development of a wide range dimmable LED lighting system with two-stage PWM multiplexing control to dim the output luminance between 18% and 100% without flickering. Furthermore, the proposed system also incorporates fault diagnosis and compensation protocol to allow the system to continue functioning even with a faulty LED string. The laboratory hardware prototype demonstrates the abilities of the proposed system.
153 Development of a Switch Mode Assisted Linear Amplifier for Use as a High Fidelity Voltage Source
Shawn D. Nielsen, Geoffrey R. Walker and Michael L. Bailey
Queensland University of Technology

Abstract- Frequency Domain Spectroscopy (FDS) is one of the major techniques used for determining the condition of the cellulose based paper and pressboard components in large oil/paper insulated power transformers. This technique typically makes use of a sinusoidal voltage source swept from 0.1 mHz to 1 kHz. The excitation test voltage source used must meet certain characteristics, such as high output voltage, high fidelity, low noise and low harmonic content. The amplifier used; in the test voltage source; must be able to drive highly capacitive loads. This paper proposes that a switch-mode assisted linear amplifier (SMALA) can be used in the test voltage source to meet these criteria. A three level SMALA prototype amplifier was built to experimentally demonstrate the effectiveness of this proposal. The developed SMALA prototype shows no discernable harmonic distortion in the output voltage waveform, or the need for output filters, and is therefore seen as a preferable option to pulse width modulated digital amplifiers. The lack of harmonic distortion and high frequency switching noise in the output voltage of this SMALA prototype demonstrates its feasibility for applications in FDS, particularly on highly capacitive test objects such as transformer insulation systems.

157 AlGaN/AlN/GaN MOS-HEMTs with Al2O3 Gate Dielectric Formed by Using Ozone Water Oxidation Technique
C. S. Lee(1), H. Y. Liu(1), W. C. Hsu(2), T. T. Wu(1), H. S. Huang(1), S. F. Chen(1), Y. C. Yang(1), B. C. Chiang(1), and H. C. Chang(1)
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(2)Institute of Microelectronics, Department of Electrical Engineering, National Cheng-Kung University, Tainan

Abstract- This work presents Al0.3Ga0.7N/AlN/GaN metal-oxide-semiconductor high electron mobility transistors (MOS-HEMTs), grown on the Si substrate, with high-k Al2O3 gate dielectric. The present AlGaN/AlN/GaN MOS-HEMT design (the control Schottky-gate HEMT) has showed two-terminal gate-drain breakdown voltage (BV_{GD})/turn-on voltage (V_{on}) of -146.6/1.12 (-96.4/0.98) V, maximum extrinsic transconductance (g_{m,max}) of 167.3 (124.2) mS/mm, saturated IDS density at V_{GS} = 0 V (I_{DSS}) of 701.4 (538.2) mA/mm, maximum IDS density (I_{DS,max}) of 927.9 (646) mA/mm, A_{V} of 211.8 (172.5), unity-gain cut-off frequency (f_{T}) of 16.8 (11) GHz, maximum oscillation frequency (f_{max}) of 18.8 (14) GHz, 2.4-GHz output power (P_{out}) of 17.2 (15.7) dBm, power gain (G_{S}) of 14.1 (13.4) dB, and power-added efficiency (PAE) of 32.2% (27.4%). Consequently, superior improvements of 52.2% in BV_{GD}, 43.6% in I_{DS,max}, 34.7% g_{m,max}, and 52.7%/34.3% in f_{T}/f_{max} are achieved as compared with a control HEMT device.

165 Improvement of Power Density Spoke Type Permanent Magnet Generator
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(3)Electrical Technology Section, Universiti Kuala Lumpur-British Malaysian Institute, Malaysia
Abstract—This paper discusses on the improvement of power density of hollow rotor compared to conventional spoke type Permanent Magnet Generator (PMG). The objective of this research is to propose a rotor structure that could improve the power density by maximizing the flux linkage of the machine. In this research the Finite Element Analysis (FEA) is used to simulate the characteristics of the hollow rotor spoke type PMG at various speed. The result shows that the hollow-rotor topology has higher back electromagnetic force and output voltage compared to conventional spoke type PMG. In addition, the hollow-rotor spoke type motor has higher output power compared to conventional spoke type PMG. In summary, this paper provides an overview of the performance of the hollow-rotor spoke type topology that contributes high power density.

170 Soft Switching Hybrid Converter with Low Circulating Current
Bor-Ren Lin, Hui-Ru Chen and Yu-Bin Nian
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Abstract—In this paper, a new hybrid dc-dc converter with low circulating current within the freewheeling interval, wide range of zero voltage switching (ZVS) and reduced output inductors is presented. The proposed hybrid circuit includes two three-level pulse-width modulation (PMW) converters and a series resonant converter with shared power switches in lagging leg. Series resonant converter is operated at fixed switching frequency (close to series resonant frequency) to extend the ZVS range of power switches at lagging leg. The output of series resonant converter is connected to the secondary sides of three-level converters to produce a positive rectified voltage instead of zero voltage. Hence, the output inductance can be reduced. The reflected positive voltage is used to decrease the circulating current to zero during the freewheeling interval. Therefore, the circulating current losses in three-level converters and series resonant converter are all improved. Finally, experiments are presented for a 1.44kW prototype circuit converting 800V input to an output voltage 24V/60A.

181 Magnitude Detection and Phase Synchronization of Unbalanced and Distorted Grid Voltage with Novel Extended PLL Loop Filter
Mian Wang, Dongchang Qu, Zhaohui Sun and Guozhu Chen
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Abstract—In grid-connected power electronic systems, a fast and accurate tracking method of fundamental grid voltage is required to synchronize the converters with the mains. The Synchronous Reference Frame (SRF) based voltage magnitude and phase detection method is able to track three phase balanced grid voltage. But its performance is very poor when the grid-voltage is unbalanced and/or distorted. Improved SRF based detection methods can partially achieve either fast post-fault resynchronization or steady-state unbalanced and distorted voltage rejection. However, its overall performance is not satisfying. This paper proposes a novel detection method based on SRF Phase-Locked Loop (PLL), in which a Low Pass Filter (LPF) and a Phase Sequence Separator (PSS) are combined to reach a tradeoff between fast detection speed and steady-state detection accuracy. Simulation including comparison of traditional methods and the proposed one under different grid fault conditions has been performed. The results validate the correctness and effectiveness of the proposed strategy.

184 An Improved DC-Bus Signaling Control Method in A Distributed Nanogrid Interfacing Modular Converters
Dongchang Qu, Mian Wang, Zhaohui Sun and Guozhu Chen

IEEE PEDS 2015 Conference Programme
Abstract- Nanogrid is an advanced concept which is under the frame of microgrid aiming at providing a smart power supply structure for future personal house or single building. In a DC-Bus based nanogrid, modularity is important to realize the flexible plug and play of renewable sources and load. This paper presents an improved DC-Bus Signaling (DBS) control method based on modular converters interfacing renewable sources, energy storage and the utility grid. The smooth transition between grid-connected and islanding modes can be achieved without variations of the control scheme under the proposed strategy. Simulation has been performed on the Matlab-Simulink platform to verify the feasibility and superiority of the proposed control method.

186 An Improved Nearest-Level-Modulation of Modular Multilevel Converter - TATCOM
Wenjian Zhao, Kun Yang and Guozhu Chen
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Abstract- Modular Multilevel Converter (MMC) is considered a promising topology in medium and high voltage class STATCOM for its scalability, modularity, low THD, etc. However, the output THD of MMC-STATCOM increases due to the reduction of sub-module number in medium voltage class. To solve this problem, an improved Nearest-Level-Modulation aiming to create more output voltage level is introduced in this paper. Neither does it require increasing the sub-module number nor affects the circulating current compared with the earlier publications. The stability and controller of the proposed modulation is also analyzed and presented. Rigorous MATLAB-Simulink Simulation is carried out to verify the feasibility of the proposed modulation.

190 FPGA Control and Implementation of a Multiphase-Interleaved PWM Inverter for a Segmented PMSM
Hsung-Hao Hsu and Ying-Yu Tzou
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Abstract- This paper proposes a digital PWM control technique for a segmented permanent magnet synchronous motor with multi-phase interleaved PWM inverters. A segmented motor with its segmented stator windings can be connected and excited by segmented PWM converters using multiphase interleaved PWM techniques. A phase shedding control strategy is developed for efficiency optimization when operating in light load condition. A digital PWM modulator with adjustable switching frequency and phase shift has been realized with FPGA. Analysis oriented simulation has been carried out for the loss analysis of the multiphase interleaved PWM inverter. Experimental verification has been carried out to show the improvement of the proposed digital PWM technique.

191 Modeling of Five-Phase Dual Stator-Winding Induction Generator with Third Harmonic Injection
Haozhe Liu, Feifei Bu, Wenzin Huang, Haijun Xu, Feng Hong and Yufei Zhou
Nanjing University of Aeronautics and Astronautics

Abstract- In this paper, the model of the third- harmonic-injected five-phase dual stator-winding induction generator (FPDWIG) is presented. There are two sets of five-phase concentrated stator windings in this generator. One is called as the control winding, the other is termed as the power winding. For improving the power density, the third harmonics are injected in this generator. With the consideration of the differences of the fundamental and third harmonic spaces, the model
of the third-harmonic-injected FPDWIG is built in the rotating d1-q1-d3-q3 arbitrary reference frame. The dynamic equivalent circuits of FPDWIG in the rotating d1-q1-d3-q3 arbitrary reference frame are given. Based on this method, FPDWIG simulating model is built in the MATLAB/SIMULINK and the simulation results is given for verification.

196 Flux Weakening Control of IPMSM Used for xEV Traction  
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Infineon Integrated Circuit (Beijing) Co. Ltd.  
Infineon Technologies Australia Pty. Ltd.

Abstract- This paper analyzes the practical operation limits of an IPMSM and proposes a speed control strategy which is suitable for real engineering implementation. Given a specific IPMSM which is used for low-speed EV traction, operation limits are pre-calculated according to motor parameters. Subsequently, a speed control strategy is implemented. Both speed and torque are used to find out d/q-axis current reference. Maximum torque per ampere (MTPA) control is used below base speed, and flux-weakening control is used for the operation above base speed. Test results are shown and analyzed to prove the effectiveness of the proposed control method.

206 Harmonic Characteristic of Active Distributed Network  
Yun Li and Jie Zhang  
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Abstract- In active distribution network, the DGs are power electronic devices to transfer electrical energy into AC power grid and. High-efficiency power electronic devices mainly use PWM technology which would cause voltage and current harmonics, these harmonics will influence the ADN’s harmonic characteristics. In this paper, with 3-phase voltage source PWM converter, models of ADN’s harmonic source according to the mechanism of harmonics are built; the harmonic characteristics are analyzed, such as the principle of harmonic distribution, line impedance, and composition of harmonic, as well as the ADN is in off-grid status. And simulation results verify the analysis. Power quality issues of connection point when multiple DG inverters connected to LV network are presented in field measurements and some related problems are discussed.

287 Control of DC-DC Converter in Photovoltaic System using Time-Delay Estimation  
Jinwook Kim, Chulsang Hawng, Gilsung Byeon, Gyeong-Hun Kim and Engsang Kim  
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Abstract- Because a conventional DC-DC converter system has small variation in the input voltage, it is sufficient to use Proportional-Integral (PI) controller with fixed gains. However, in Photovoltaic (PV) systems, the operating conditions such as irradiation and ambient temperature are time-varying. In these circumstances, when the operating conditions change abruptly or the uncertainties become large, the conventional PI controller cannot assure the best performance in controlling the DC-DC converter of PV systems. For the maximum power extraction from PV systems, in addition to the performance of Maximum Power Point Tracking Power module, that of DC – DC converter is also important. To enhance the control performance of the DC-DC converter in PV systems, a controller using time-delayed information is presented. The proposed controller intentionally utilizes time-delayed information of the given system and control input to eliminate the unknown system dynamics and unexpected disturbance. By doing these actions, the controller can show robust performance to the abrupt change in the operating conditions. Through computer simulation,
the validity and effectiveness of the proposed controller are evaluated by comparing with conventional PI controller.

Session PS-II: Poster Session II
Date/Time: Wednesday, 10 June 2015/17:00 – 18:00 hrs
Venue: Poster display area @ Level 4
Session Chair: Yung C. Liang, National University of Singapore, Singapore

211 Investigation on Transmission Efficiency for Magnetic Materials in a Wireless Power Transfer System
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Abstract- This paper provides the complete progresses of designing, simulating and constructing of a wireless power transfer (WPT) system. Moreover, investigations on the transmission efficiency for different magnetic materials under varying operating frequencies in the designed wireless power transfer system were conducted. After building a contactless power transfer system with a large inductor as a current source, a set of magnet cores with similar specifications but different sizes were applied to the system. Then, the operating frequency varied from 10 KHz to 140 KHz. The voltage and current of the primary and second side of the WPT system were measured by voltage and current probes. Thus, power and transmission efficiency against varying operating frequencies for different magnetic materials were obtained and analyzed. It showed that within the selected range of switching frequency, the efficiency of the system is proportional to the frequency and increasing with operating frequency. Additionally, among four selected magnetic material, the ferrite has the best performance.

214 Performance Comparison of LVRT Techniques for DFIG Wind Turbine Under Asymmetrical Voltage Sags
Aimeng Wang, Wenyuan Xi (1) and Yazan Alsmadi (2)
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(2)Electrical and Computer Engineering Department, The Ohio State University, Columbus

Abstract- The low voltage ride through(LVRT) requirements are usually defined by the grid codes at the point of common coupling(PCC). The voltage dip types experienced at the doubly-fed induction generator(DFIG) terminals are different from the conditions at the PCC due to the characteristics and limitations of the network. This paper first analyzes the fault characteristics experienced at the terminal of the wind turbine. Second, the performance of the crowbar circuit under severe asymmetrical grid faults are analyzed. Meanwhile, the operation behaviors of several LVRT control strategies under mild asymmetrical grid faults are given by simulation with the Matlab/Simulink. Then the performance of the approach by using stator damping resistor(SDR) are further analyzed based on the simulation results. This paper aims to give help on choosing or redesign reasonable LVRT control strategies under asymmetrical grid faults.

215 Novel Parallel ZVS Converters with Shared Power Switches for Medium Power Applications
Bor-Ren Lin, Sheng-Zhi Zhang and Chung-Wei Chu
Abstract- A new DC/DC converter with parallel circuits is presented for medium voltage and power applications. There are five pulse-width modulation (PWM) circuits in the proposed converter to reduce current stress at low voltage side for high output current. These five circuits have the same power switches so that the switch counts are reduced compared with the conventional parallel converters. In order to reduce the converter size, conduction loss and voltage stress of power semiconductors, the series connections of power MOSFETs with high switching frequency instead of IGBTs with low switching frequency are adopted. Thus, the voltage stress of MOSFETs is clamped at half of input voltage. The switched capacitor circuit is adopted to balance input split capacitor voltages. Asymmetric PWM scheme is adopted to generate the necessary switching signals of MOSFETs and regulate output voltage. Based on the resonant behavior at the transition interval of power switches, all MOSFETs are turned on under zero voltage switching (ZVS) from 50% load to 100% load. The circuit configuration, operation principle, converter performance and design example are discussed in detail. Finally, experimental verifications with a 1.92kW prototype are provided to verify the performance of the proposed converter.

219 Force Control for the Fingers of the Piano Playing Robot— A Gain Switched Approach
Yen-Fang Li and Chun-Wei Huang
Dept. of Elec. Eng., Ming-Hsin University of Science and Technology, Taiwan

Abstract- In this paper, a force controller design is considered for the fingers of the piano playing robot with a gain switched controller. Music playing robot is one kind of the service robots. In addition to playing music with the score, for a service robot, the robot, can play sweet sounds. In order to play a melodious music sound like musician, besides the robot can play the right note and right rhythm, the punching force of the fingers are controlled just right while the robot playing. In the proposed system, the finger is driven by a cylindrical linear motor. To play sounds of light, heavy, slow and anxious, the punching force of the finger is tuned according to the music score by controlling the cylindrical linear motor. Considering the playing requirements and load characteristics, the force controller is designed by a gain switchable controller to achieve the functions of force controllable and fast response. Also, the sound spectrum analysis is applied to analyze the quality of the robot’s playing for the key punching and the force controlling in the viewpoint of frequency domain. Based on the sound spectrum analysis for a musician playing, the force controller of the finger is designed to lead the robot playing is closing to human playing. Through the FPGA-based implementation, each finger of the robot owns its independent control loop with parallel control structure designing to get the finger’s action rapidly and precisely. From the experiments of the prototype, the results have given the verification about the practical control method and the realizable Implementation.

226 The Study of The Output Voltage Characteristics Using Delta-Sigma Modulation Full Bridge Inverter with Sampling Interval Non-Uniformity
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(2)University of Malaya, Kuala Lumpur, Malaysia
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Abstract- The inverter using PWM modulation method performs switching operation by comparing the reference signal and the carrier signal for each fixed period, thus large switching noise components on every integral multiple of the carrier frequency are generated. On the other hand, the inverter using delta-sigma modulation circuit, large noise components do not occur, and this is advantage for clearing noise regulations. About delta-sigma modulation circuit, it has been assumed that the control is performed at predetermined sampling intervals, in practice, it should be necessary to investigate the effect of the sampling interval variations.
This paper investigates the impact of the inverter output voltage characteristics. In the case, there is non-uniform component to the sampling interval of full bridge inverter using delta-sigma modulation scheme.

253 Analysis of Induction Motor Drives under Sensor Faults with Mine Hoist Load Diagram
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Abstract- Field Oriented Control (FOC) of induction motor drive is more popular in process and manufacturing industries as it controls the motor as desired. To perform FOC, Variable Voltage Variable Frequency (VVVF) operation of an inverter, connected in the stator or rotor circuit (in case of wound rotor) of the machine, is mandatory. For VVVF control, the rotor speed and stator currents have to be measured by sensors and the measured signals have to be fed back to the controllers. The proper operation of the control system depends on the feedback signals from sensors. When sensors are undergone a fault, the stability of control system, may be designed for an industrial process, is disturbed and hence the reliability of the system is decreased. The fault in speed sensors may be open circuit fault, omission fault, gain, bias, and saturation. In this paper three different speed controllers like PI Controller, Fuzzy Logic Controller (FLC), Fuzzy Pre compensated Proportional Integral Controllers (FPPI) are used in the speed control loops of FOC and analyze their performances under sensor faults. A 30-hp induction motor drive is considered with mine-hoist load diagram as case study.

256 Design and Analysis of Hybrid Solar-Wind Energy System Using CUK & SEPIC Converters for Grid Connected Inverter Application
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Abstract- This paper introduces, design and analysis of hybrid solar wind energy system using CUK and SEPIC converter. This design lets the two sources to supply the load individually or concurrently depending on the availability of the energy sources. The proposed design employs a switch mode CUK converter and a switch mode SEPIC converter. The designed CUK and SEPIC converters are then employed to run a singlephase full-bridge grid connected inverter for residential application. The proposed design is mathematically modeled which is simulated via PSIM software and finally the results are presented to confirm the effectiveness of this hybrid system.
Quasi Z-source Inverter with Improved Incremental Conductance MPPT for Rapidly Varying Solar Irradiation

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Abstract- The photovoltaic (PV) energy and its conversion into electrical energy has a raising importance in the renewable energy marketplace. It is essential to harvest the maximum power from the PV arrays since they have very low conversion efficiency. This process requires the power electronic converter as the power conditioning device. The quasi Z-source inverter is chosen as power conditioning device because of its capability of boosting and DC to AC conversion in single stage. An improved incremental conductance maximum power point tracking algorithm is developed with the aim to prevent the bewilderedness during rapidly changing solar irradiation. This algorithm controls the shoot-through duty cycle of the inverter to attain the maximum power point of the PV array. A novel modified space vector pulse width modulation technique with four shoot-through states is proposed for the inverter to control the inverter. Simulation and experimental results are provided to establish the performance of the proposed system. The comparison with the conventional algorithm is also presented.

Research and Implement of PMSM Regenerative Braking Strategy based on Controllable Rectification

Hui Qi, Yixiao Zhang and Ningyuan Gao

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Abstract- Based on the topology of back-to-back converter, a regenerative braking strategy used for Permanent Magnet Synchronous Motor (PMSM) is presented in this paper. According to this strategy, without dc link braking resistor, PMSM can operate in four-quadrants stably, and switch in different quadrants continuously. Based on Model Reference Adaptive System (MRAS) theory, a rotational inertia online observer is designed, and an energy manager strategy is obtained using the observed inertia value. The strategy is verified in Matlab/Simulink. Then in a 4kW PMSM experiment platform, the regenerative braking strategy is implemented. The results of experiment show that the regenerative braking strategy can be used in PMSM forward and reverse operation effectively, which is the foundation of the further industrial application.

Speed Control of PMSM with Hall Sensors using DSP TMS320F2812

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Abstract- In this paper, speed control of Permanent Magnet Synchronous Motor (PMSM), also known as sinusoidal BLDC motor, using Hall effect sensors is described. Normally, sensors like optical encoders or resolvers are necessary for applying sinusoidal commutation to such type of motor as they have more resolution. However, these sensors are costly and cannot be employed for low cost operations. The proposed approach for sinusoidal commutation uses rotor position information available from Hall sensors to apply sine PWM pulses for the inverter switching. The modulation index in this method is changed using PI controller for speed control of PMSM. The method has been tested successfully on a setup of 400W PMSM motor using Texas Instrument (TI) DSP controller TMS320F2812. Experimental results indicate that the motor drive developed in this paper exhibits satisfactory performance.
331 Harmonic Reduction for 12-Pulse Four Star Thyristor Rectifier with Active Auxiliary Circuit
Jingfang Wang, Shiyan Yang, Wei Yang
Department of Electrical Engineering and Automation Harbin Institute of Technology Harbin, China

Abstract- 12-pulse four star thyristor rectifiers are widely used in electro-chemical industries, but large lower-order harmonics are included in the input currents. In order to reduce the harmonics to an acceptable level, a dc-side compensation strategy to reduce the harmonic of input line current in 12-pulse four star thyristor rectifier is proposed. According to the proposed strategy, a new active auxiliary circuit is added to the dc side of the 12-pulse thyristor rectifier and injects a specific triangular current. The specific triangular current shapes the distorted input line current as sine wave approximately. The active auxiliary circuit consists of a single transformer, a single PWM rectifier and a buck converter. Analysis of the proposed scheme is examined and simulation results are shown.

337 Commutation Torque Ripple Reduction in Brushless DC Motor using Modified SEPIC Converter
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Abstract- Brushless DC Motor (BLDCM) drives, widely used in high performance applications where torque smoothness is essential, suffers from severe torque ripples. For BLDC motors, torque ripple is an important origin of acoustic noise, vibration and speed fluctuation. In this paper, a dc-dc Modified Single Ended Primary Inductor Converter (MSEPIC) and a switch selection circuit is employed in front of the inverter in order to obtain the desired commutation voltage resulting in reduced commutation torque ripple. The theoretical analysis and computer simulation, using MATLAB/ Simulink environment, are given to illustrate the proposed method and the performance is compared with conventional system. And the experimental results are also provided for verification of the BLDC drive system.

343 Analog Controller for Home Application of Photovoltaic System using Interleaved DC-DC Converter and Single-phase Inverter
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E & E Dept., Assiut University, Assiut, Egypt
Ube National College of Technology, Japan
Kyungnam University Masan, Kyungnam, South Korea

Abstract- This paper presents analog design, and implementation of a photovoltaic system using an interleaved dc-dc converter cascaded with a single-phase inverter for home application. Maximum Power Point Tracking (MPPT) algorithm is incorporated into the developed controller of the interleaved dc-dc converter to maximize the obtained power from the PV array. The interleaved dc-dc converter is compared with the regular boost converter topology. The interleaved dc-dc converter results in a reduced filter size due to the reduction in the ripple content at the input and the output terminals of the converter. Designing of a closed loop analog controlled single-phase inverter with Sinusoidal Pulse Width Modulation (SPWM) is implemented and tested in the lab for AC stand-
alone load. Moreover, experimental investigations presented give the utility of such a control approach.

344  **Analysis of Two Phase Switched Reluctance Motor with Flux Reversal Free Stator**

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Abstract- This paper outlines performance prediction of 6/3 Switched Reluctance Motor (SRM) with flux reversal free stator. The performance analysis of the motor is done under both electrical and mechanical aspects. In electrical regards, the electromagnetic analysis is done in static and dynamic conditions. This predicts the flux path, flux distribution and elimination of flux reversal in the stator, which act as the main concern with the vibration that leads to acoustic noise. The mechanical traits, simulates the motor in both structural and thermal aspects. The vibration analysis is done in modal as 2D and 3D for predicting the natural frequency of motor while the thermal analysis predicts the temperature rise in the motor.

351  **Control of PMSG Wind Turbines Based on Reduced Order Resonant Controllers Under Unbalanced Grid Voltage Conditions**

Shuhui Dong, Yonggang Li, Aimeng Wang, Wenyuan Xi
State Key Laboratory of Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Baoding, China

Abstract- The effective control of permanent magnet synchronous generator(PMSG) based wind energy conversion systems(WECS) under unbalanced grid voltages is important to improve the grid-connected operation ability. This paper applies the proportion integral plus reduced order resonant integrator(PIROGI) controller to the PMSG grid-side converter, which can achieve zero current error control in the positive synchronous rotating reference frame without any decomposition of positive and negative-sequence currents. The double supply frequency oscillations of DC-link voltage and the output active power caused by the lose control of negative-sequence current can be well restrained. A PI-ROGI based control scheme implemented in the positive synchronous rotating reference is designed. Furthermore, the simulation results using Matlab/simulink demonstrate the effectiveness of the proposed control scheme on improving the operational performance of PMSG under asymmetrical grid faults.

364  **Design Methodology of P-Res Controllers with Harmonic Compensation Technique for Modular Multilevel Converter Fed from Partially Shaded PV Array**

Ramya G, Ramaprabha R
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Abstract- This paper enlightens the control and modeling of modular multilevel converter (MMC) with LCL filter. The PResonant (P-Res) controller with current control approach is analyzed. The main objective in this approach is to improve the effect of the resonance peak of LCL filter. The P-Res controller is intended with an analytical methodology for better frequency response and reduced harmonic content. The unregulated supply from renewable energy source is also controlled by DC link controller for the proper functioning of the system. The system is simulated using MatLab and the results are presented. The effectiveness of the controller is verified experimentally.
365  **Switching Loss and THD analysis of Modular Multilevel Converter with different Switching Frequency**  
**Ramya G and Ramaprabha R**  
**SSN College of Engineering, Kalavakkam, Chennai, India**

Abstract - The usage of solar photovoltaic (PV) system in grid connected system becomes more popular nowadays. The major problem in using solar PV system is its instability and dependence of output energy. In order to stabilize the energy output and to get the smoothened profile, the power converter must be connected to the output of the PV panel. For this purpose the modular multilevel converter (MMC) is considered in this work. Moreover the system will not require a line frequency transformer due to the high voltage and high power capacity of MMC. The modular multilevel converter is considered due to this high efficiency and low harmonic distortion. The filters are connected between the converter and network to make the system efficient with no oscillation at the output side. The switching loss and total harmonic distortion (THD) is analyzed for different frequency. The simulation is carried out using MatLab and the results are presented. The results are verified experimentally.

366  **A Static PV Array Architecture to Enhance Power Generation under Partial Shaded Conditions**  
**S. Malathy and R. Ramaprabha**  
**Department of Electrical and Electronics Engineering, SSN College of Engineering, Rajiv Gandhi Salai, Kalavakkam, Chennai, India**

Abstract - It is a well documented fact that partial shading increases mismatch losses and reduces the output of a photovoltaic (PV) system. The reduction in output is not proportional to the shaded area but depends on various other factors like the location of the shaded panel within the array, the interconnection among the panels and the shade geometry. The mismatch losses can be reduced either by altering the interconnection scheme or the location of panels in accordance with the shade. These dynamic methods require more number of sensors, switches and a sophisticated control algorithm. This work proposes a static shade tolerant network which enhances the output under shaded conditions by dispersing the shade all over the array. A generalized algorithm to determine the location of panels within the array is also presented. The proposed algorithm and the network are tested for different array sizes and shading conditions in MatLab-Simulink environment and the results are presented.

373  **Robust Control of Parallel Buck Fed Buck Converter Using Hybrid Fuzzy PI Controller**  
**S. Vinod, Dr. M. Balaji, Dr. M. Prabhakar**  
**Research scholar, Jerusalem college of engineering, Anna University, India, Faculty SSN College of Engineering, Anna University, India, Faculty VIT University, India.**

Abstract - This paper presents development and control of buck fed buck converter topology for high current application. For high current application like DC welding, single converter structure may cause complete system failure if the semiconductor switch fails. Hence, to improve reliability, parallel DC-DC converter structure is proposed in this paper. This arrangement ensures load sharing between the converters when operated in closed-loop mode. Simulation results obtained from the closed-loop configuration with a conventional controller (PI) show good steady-state response. When an intelligent controller like fuzzy controller is used, the same system exhibits better dynamic response. In this paper, the advantages of both these controllers are utilized by judiciously choosing
the appropriate controller action at required time intervals. The required time intervals are decided based on the error between the desired and actual value. In other words, fuzzy controller is initiated during the initial time intervals to get quick dynamic response while PI controller comes into action at a later stage to reduce the steady-state error. Simulation results show significant improvement when this hybrid combination of Fuzzy-PI controller is introduced.

391 Enforcement of ELC using Reduced Dump Load for Micro Hydropower Plant with the Interpretation of Switching Transients and Vibrations
Ramraj Panda, R. Raja Singh and Thanga Raj Chelliah
Department of Water Resources Development & Management, Indian Institute of Technology Roorkee, India

Abstract- Development of decentralized power generation for rural electrification has improved by the concept of micro hydropower plants. Generally in isolated areas self-excited synchronous or asynchronous generators are used and it had be continually haunted by voltage and frequency regulation issues due to the variation of consumer loads. Employing electronic load controller in the system regulates the generator output, but it could produce more energy wastage with less efficiency, leading to reduction in machine life. This limitation in the existing ELC can be overcome by reducing dump loads. In this paper, the performance of reduced dump load (20%) on a synchronous generator is analyzed experimentally. The effect of electro-thermal aging has been examined to estimate the lifetime of stator windings. Additionally, characteristics of switching effects in course of main load and dump load under various load points are discussed. Therefore, the objective of this paper is to reduce the power losses and to increase the life span of the generator through decreasing the thermo-electromechanical stresses using reduced dump load strategy.

401 Analysis of Energy Optimal Controlled Induction Motor Drives under Sensor fault
Arun Dominic D and Thanga Raj Chelliah
Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, India

Abstract- The part load efficiency of induction motor can be improved by adjusting the motor excitation in accordance with load and speed. For the speed control of induction motor drives under part load, adjustment of stator flux is done by the controllers that obtain stator currents and speed as feedback signals. This method of improving efficiency during part load by flux adjustment is called energy optimal control and the present paper investigates the effects of sensor faults in energy optimal controlled induction motor drives.

404 Evolutionary Algorithm Based In-Situ Efficiency Determination on Induction Motors for the Implementation of Energy Conservation Schemes
Radha Thangaraj and Thanga Raj Chelliah
Department of Water Resources Development and Management, Indian Institute Technology Roorkee, India

Abstract- Induction motor (IM) is considered as a major consumer of electrical power in any process industries. Efficiency and power factor of such machines are considerably reduced at light loads. Enhancement of cost effective energy conservation (EC) technology plays a significant role in these machines operating at light loads. In-situ efficiency determination is essential before taking any decision on implementation of EC. This paper determines the efficiency of IM without
performing no-load test, which is not easily possible for in-service motors, by using evolutionary algorithms. Benefits of Star-delta (Y-Δ) based EC scheme are estimated.

410 Pseudo Open Drain IO Standards Based Energy Efficient Solar Charge Sensor Design on 20nm FPGA

K. Kalia, B. Pandey, K. Nanda, S. Malhotra, A. Kaur and D. M. A. Hussain
Department of Electronics and Communication Engineering, Chitkara University, Chandigarh, India
Department of Energy Technology, Aalborg University, Denmark

Abstract- In this paper an approach is made to design Pseudo open drain IO standards Based Energy efficient solar charge sensor design on 20nm and 28nm technology. We have used LVCMOS18, POD10, POD10_DCI and POD12 I/O standard. In this design, we have taken two main parameters for analysis that are frequencies (GHz) and AIRFLOW. We have taken one value for LFM i.e. 250 and Medium as a default profile for heat sink and constant environment. For the simulation of the logic, Xilinx is used with Verilog as hardware description language. We have done our analysis for different frequency values for POD based solar charge inverter. We also observed maximum total power reduction in LVCMOS18 (Artix-7 FPGA) as compared to other I/O standards at 10 GHz. Also there is maximum total power reduction in POD12 (Ultra Scale Kintex) as compared to other I/O standards at 2 GHz. There is also a significant change in device static, I/O power and Clock Power.

456 Neuro-fuzzy State Space Controller for Drive with Elastic Joint

Marcin Kaminski and Krzysztof Szabat
Faculty of Electrical Engineering, Wrocław University of Technology, Wrocław, Poland

Abstract- This paper presents adaptive control structure applied for electrical drive with elastic coupling between motor and load machine. The main speed controller is based on neuro-fuzzy model. Proposed control structure works using all state variables of the two-mass system. Feedbacks coefficients have been calculated analytically. Information about state variables is given by the Luenberger observer. For better dynamics of estimation and noises reduction, implemented algorithm is modified by introduction of neural network. Concluding, on-line adaptation is applied inside of controller and observer. Simulations are confirmed using dSPACE1103 card.
modules due to change in power dissipation. This paper presents a novel control method, which achieves a reduction of temperature swing during low load conditions by increasing the conduction losses of the switching devices. A temperature controller increases the motor current without affecting the mechanical output power of the supplied motor. This is possible, as a specific motor torque and power can be achieved with different current values as long as certain lower and upper current limits are observed which are defined by system parameters and operation conditions.

74 Development of an inverter using Hybrid SIC power module for EV/HEV applications
Jun Liu, Wei Su Xiang Tai, Wei Sun, Lingyun Gu
Institute of Electrical Engineering, Chinese Academy of Sciences, China
Key Laboratory of Power Electronics and Electric Drive, institute of Electrical Engineering, Chinese Academy of Sciences;
Beijing Engineering Laboratory of Electrical, Drive System & Power Electronic Device packaging Technology

Abstract- Reducing switch loss and increasing heat-sinking capability were very important research topic in the high power density inverter for EV/HEV applications. In this paper, an inverter with a new development power module was built. The power module was packed using a hybrid SIC power device to reduce the switching loss and direct cooling technology to decrease the thermal resistance. The double pulse experiment results show that compared to SI power module the hybrid SIC power module can reduce the turning on loss of IGBT and reverse recovery loss of diodes. Finally, the inverter performance was tested in the platform of 100kw three-phase PM motors. The inverter power density was 14.8KW/L and the power-to-weight ratio reached to 10.5kw/kg.

297 The Effects of Thermal Cycling on Aging of Neodymium-Iron-Boron Magnets
Daniel Huger and Dieter Gerling
Institute for Electrical Drives and Actuators University of the Armed Forces Munich, Germany

Abstract- In this paper, the effects of temperature cycling on Neodymium-Iron-Boron (NdFeB) magnet aging are investigated. An accelerated lifetime test is parameterized and performed. In order to separate the aging mechanism, the temperature limits given by the manufacturer are not exceeded and the thermal aftereffects, observed during the first cycles, are separated. 80 magnets with four different temperature indices and coatings are tested. The required heating and cooling half-cycle times are measured. It is proven that no secondary aging mechanisms distorts the results. A Coffin-Manson-type aging well known from other aging mechanisms and a logarithmic drop in remanence and coercive force is shown.

434 Analysis of Operation Modes and Limitations of Dual Active Bridge Phase Shift Converter
Mohammad Jafari, Zahra Malekjamshidi and Jian Guo Zhu
Faculty of Engineering and Information Technology, University of Technology Sydney, Australia

Abstract- Dual active bridge phase shift converters have attracted a lot of research interest due to their excellent capabilities such as simplicity in structure and control and bidirectional power flow ability. They are employed in a wide range of renewable energy systems due to their distinguished features. Although there are lots of research on theoretical analysis and practical operation of these converters, research on limitations and boundaries of operation still requires more attention. This
paper provides a brief review on power transfer range, soft switching operation and converter currents in different operation modes of dual active bridge converter. It provides more detailed information on appropriate range of converter parameters such as voltage transfer ratio, duty ratio and phase shift angle and their effect on power transfer range via numerical simulations.

436 Simulation of Electric Vehicle Inductive Charging Systems

Shuo Wang and David Dorrell
School of Engineering, University of Technology, Sydney, Australia

Abstract- With the development of the electric vehicle, the demand for fast, reliable, safe and fully automated charging is increasing. Inductive charging is regarded an alternative to plugin charging. One problem with inductive charging is that the system is high frequency but only operates around the resonance frequency, at which point the voltage coupling and current coupling are relatively high. However the power factor is still low. The series-series compensation circuit is analyzed. This paper proposed a cascaded multilevel inverter for an inductive charging system which could reduce the voltage and current requirement for individual converter components. Simulation results will be shown for the proposed transfer system.

Session DGSG-II: Distributed Generation and Smart-Grid II

Date/Time: Thursday, 11 June 2015/09:00 – 10:30 hrs
Venue: Room 2 @ Level 4
Session Chair: Geoffrey Walker, Queensland University of Technology, Australia

225 Impact of Electric Energy Storage Scheduling on Reliability of Distribution System

A. Narimani, G. Pourbakhsh, G.F. Ledwich and G.R. Walker
School of Electrical Engineering and Computer Science, Science and Engineering Faculty, Queensland University of Technology, Brisbane, Australia

Abstract- The development of Electric Energy Storage (EES) integrated with Renewable Energy Resources (RER) has increased use of optimum scheduling strategy in distribution systems. Optimum scheduling of EES can reduce cost of purchased energy by retailers while improve the reliability of customers in distribution system. This paper proposes an optimum scheduling strategy for EES and the evaluation of its impact on reliability of distribution system. Case study shows the impact of the proposed strategy on reliability indices of a distribution system.

342 Development of an Effective Control Scheme for a DC Microgrid with Energy Storage System

Chul-Sang Hwang, Minwon Park, and In-Keun Yu
Department of Electrical Engineering, Changwon National University, Republic of Korea

Abstract- Power control is important in the operation of dc microgrid, particularly for the power sharing between different types of power sources including PV, wind power generation systems. In this paper, an effective control scheme for dc microgrid with energy storage system (ESS) is proposed. The power sharing scheme using two ESSs in a dc microgrid for stable operation is proposed. Detailed effective control scheme of voltage and power control is described. To verify the performances of the proposed effective control scheme, the simulation analysis using PSCAD/EMTDC is conducted. The results demonstrate the effectiveness of the control scheme that can improve power balancing and sharing in connection with ESSs for stable operation of dc microgrid under various generation and load conditions.
435  Modeling of Magnetic Flux in Multi-Winding Toroidal Core High Frequency Transformers Using 3D Reluctance Network Model
Mohammad Jafari, Zahra Malekjashidi, Md. Rabiul Islam and Jianguo Zhu
Faculty of Engineering and Information Technology, University of Technology Sydney, Australia

Abstract- Multi-winding transformers as main part of multi-port phase shift converters play an important role in integration of renewable energy sources, storage device and loads. The range of power transfer in multi-port phase shift converters particularly depends on the leakage inductance of multi-winding transformer. Numerical analysis such as 2D and 3D finite element methods have been widely used in analysis of magnetic structures and estimation of leakage inductance although their computation time is the main issue especially in online and iterative design processes. In this paper, a 3D reluctance network is introduced for modelling of magnetic flux distribution and estimation of self and leakage inductances of multi-winding toroidal core high frequency transformer. The proposed network is formed in cylindrical coordination, according to the geometrical shape of toroidal core. The effective factors on accuracy of model and computation time are studied and the results are compared with experimentally measured parameters to verify the accuracy of model.

439  Grid Emulator Requirements for a Multi-Megawatt Wind Turbine Test-Bench
Nurhan Rizgy Averous, Marco Stieneker and Rik W.De Doncker
Institute for Power Generation and Storage Systems, E.ON Energy Research Center, RWTH Aachen University, Aachen, Germany

Abstract- Full-scale nacelle test-benches accelerate the development process of new multi-megawatt wind turbines. The device-under-test (DUT) is connected to an artificial grid that is emulated by a power-electronic converter system. Since the desired sinusoidal wave form of the voltage can only be approximated, filters have to be applied to suppress voltage harmonics sufficiently. But still, the output voltage is not purely sinusoidal due to a remaining share of harmonics. For the verification of the total harmonic distortion (THD) caused by the DUT, the influence of the grid emulator on the measurements of voltage and current has to be known. Otherwise the source of the harmonics cannot be identified clearly and the DUT might be characterized incorrectly. Within this work the requirements for grid emulators to allow the sufficiently high measurement of the THD caused by the DUT are derived analytically and validated with simulation models. Furthermore, the dynamic of voltage dips that have to be emulated to test the low-voltage ride-through (LVRT) capability of the DUT has to fulfil the established standards (IEC61400-21) for emulating a faulty grid realistically. The consequently derived requirements for the power electronic converters are presented within this paper.

445  A Microcontroller Based SHE Inverter for Maximum Power Point Operation
Srradhanjoli Bhadra and Hirak Patangia
University of Arkansas at Little Rock

Abstract- MPP (Maximum Power Point) integrated inverters are essential to reduce cost and improve efficiency of PV system. It removes the need of two separate power electronic devices: dc/dc converter for MPP; and dc/ac inverter for grid connectivity or driving ac loads. To popularize roof top PV power, micro inverters are commonly used and the system cost can be further reduced if maximum power point tracking is integrated into the inverter. The paper focuses on a new breed
of MPP integrated inverter that will produce high quality power with reduced THD while operating
the inverter at a point to extract maximum power from the PV panel. The work will be centered on
new research results that employ microcontroller based selective harmonic elimination with digital
control of the fundamental amplitude. This has been implemented by the authors to eliminate
harmonics up to 7th followed by low-pass filtering. The fundamental amplitude will be controlled
digitally with a feedback from the load voltage to arrive at the MPP. No such approach has been
investigated in the current literature. The current work in this area employs a one cycle controller in
conjunction with the H-ridge to adjust the output current supplied to the grid as a function of PV
voltage to extract the maximum power.

Session PSPC-II: Power Semiconductors, Power integrated circuits and Passive Components II
Date/Time: Thursday, 11 June 2015/09:00 – 10:30 hrs
Venue: Room 3 @ Level 4
Session Chair: Yen Kheng Tan, Singapore University of Technology and Design, Singapore

39 Dual-Path Frequency Compensation for Current-Mode Buck Converters
Pang-Jung Liu, Shang-Ru Hsu and Tzu-Hsuan Chen
Department of Electrical Engineering, National Taipei University of Technology, Taiwan

Abstract- This paper proposes a dual-path frequency compensation (DPFC) for implementing on-
chip error amplifier (EA). The DPFC uses two operation amplifiers to simultaneously charge and
discharge a compensation capacitor. As a result, the equivalent capacitance is significantly
multiplied with small additional power and silicon area. Since the slew rate of the EA is increased
owing to the small compensation capacitance, the transient response of the buck converter is also
enhanced dramatically. A laboratory converter with the DPFC is implemented with 0.35-µm CMOS
process. Simulation results demonstrate the converter stability and transient response. The transient
recovery time is less than 4 µs for load current changing from 500 mA to 50 mA. With the DPFC,
the compensation capacitor is shrunk significantly and no compensation resistor is needed.

203 Design and Fabrication of Low Voltage Silicon Trench MOS Barrier Schottky Rectifier for High Temperature Applications
Mohd Rofei Mat Hussin(1,2), Muhamad Amri Ismail(1), Sharaifah Kamariah Wan Sabli(1),
Nuraflizah Saidin(1), H.Y. Wong(2), Mukter Zaman(2)
(1)MIMOS Berhad, TPM Bukit Jalil, Malaysia
(2)Faculty of Engineering (FOE), Multimedia University, Malaysia

Abstract- This paper presents the design, fabrication, and characterization of 60V and 100V silicon
Trench MOS Barrier Schottky (TMBS) rectifier. The devices were designed for switching power
supplies operated in high temperature environment. Design considerations of silicon TMBS
rectifiers are discussed in this paper. Trench structure design and trench oxide were improved to
produce low reverse leakage current and high device performance. As a result, TMBS rectifiers
with blocking voltage of up to 60V and 100V were successfully fabricated. The tradeoff between
reverse leakage current and forward voltage drop are well controlled at high operating temperature
(>75°C).

347 A Flexible Test Bench for Power Semiconductor Switching Loss Measurements
Jan Gottschlich, Murat Kaymak, Martin Christoph and Rik W. De Doncker
Institute for Power Electronics and Electrical Drives – RWTH Aachen University Germany
Abstract- In this paper a flexible double pulse test bench for switching loss characterization of power semiconductors is presented. It allows the characterization of switching losses for conventional power semiconductors such as IGBTs and power MOSFETs, but also for modern fast switching wide bandgap devices. Contrary to alternative test bench topologies, test voltage and current can be adjusted independently and without any changes to the test setup from zero to up to 1 kV and 1 kA, respectively. A modular design simplifies the adaption to different test scenarios and enables the usage of widely available off-the-shelf active and passive components. The topology features low energy stored in the dc link inductor and the high voltage capacitor, thus improving safety in case of a device failure.

402 Active EMI-Filter using the Gate-Drivers Power Supply
Matthias Biskoping, Martin Rosekeit and Rik W. De Doncker
Institute for Power Electronics and Electrical Drives, RWTH Aachen University, Aachen, Germany

Abstract- All Power Electronic circuits suffer under the presence of Electromagnetic Interference (EMI) which are caused by the rapid switching of the power switches, which are used to modulate an average voltage over a switching period. The common strategy to reduce the effects onto connected circuits or the utility grid is to use EMI filters. Advanced strategies use active EMI filters which compensate the EMI influence onto the circuitry by inducing the opposed EMI creating current into the circuit, which ideally results in cancellation. This paper presents a new approach which directly uses the gate control signals to generate these opposed commands. Additionally this approach uses the low voltage driver supply for these commands to reduce the component cost, the needed isolation and complexity of the overall circuitry. The described concepts are underlined with measurements on a downscaled full bridge inverter.

431 A Programmable Gate Driver for Power Semiconductor Switching Loss Characterization
Jan Gottschlich and Rik W. De Doncker
Institute for Power Electronics and Electrical Drives – RWTH Aachen University, Germany

Abstract- This paper presents a programmable gate driver unit for power semiconductors such as IGBTs and MOSFETs which allows to adjust the gate voltage and gate resistance for turn-on and turn-off of the power semiconductor independently. As properties of the gate driver have a major influence on the switching behaviour of power semiconductors and thus on switching losses and EMI, it is highly desirable to characterize the influence of gate driver parameters on the switching behavior of power semiconductors experimentally. Contrary to other approaches, the presented circuit is optimized for device characterization in double pulse or similar experiments. The gate voltage range covers most gate-voltage controlled power semiconductors, including GaN and SiC MOSFETs. An internal connection of multiple output stages allows to vary the effective gate resistance over a wide range. As the gate driver parameters can be set remotely during operation, an automated characterization of the gate-driver-dependent switching behaviour is enabled.

Session WBGD-1: Wide Bandgap Power Semiconductor Devices and Technologies I
Date/Time: Thursday, 11 June 2015/09:00 – 10:30 hrs
Venue: Room 4 @ Level 4
Session Chair: Graham Town, Macquarie University, Australia
25 Evaluating 4H-SiC Based Commercial MOSFETs Power Modules
Muhammad Nawaz and Nan Chen
ABB Corporate Research, Vasteras, Sweden

Abstract- This work deals with static and dynamic measurements performed for 4H-SiC based commercial MOSFETs power modules with voltage rating of 1200 V and current rating of 120 A. First results from engineering samples from Rohm show overall good confidence level that resulted in an ON-resistance of 20 – 30 mΩ, blocking voltage of 1300 – 1500 V and threshold voltage of 3.0 – 3.5 V. Power modules have been tested up to 150 oC (recommended Tj was 125oC) where a threshold voltage shift (i.e., decreases) and decay in the peak transconductance is observed. Overall, energy losses remain approximately unchanged with variation in the device temperature. Turn on and turn off energy losses at 800 V and 190 A (120 A) of 102 (38) and 22 (12) mJ respectively, have been obtained at 300 K. Contrary to Si, SiC power modules did not show reverse recovery neither at different supply voltages nor at different temperatures. A short circuit withstand capability of over 10 µS is witnessed when tested under hard switch fault condition. A small current sharing unbalance has been observed for two parallel power modules as a result of either DC capacitor derating or quasysymmetrical busbar design when the total current far exceeds the current rating of the power module (i.e., 120 A).

243 Analysis of Capacitive Losses in GaN Devices for an Isolated Full Bridge DC-DC Converter
Rakesh Ramachandran and Morten Nymand
Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Odense, Denmark

Abstract- The paper presents the analysis of capacitive losses in GaN devices for an isolated full bridge dc-dc converter. The output capacitances of GaN device are responsible for a significant part of switching losses in a hard switched converter. Detailed knowledge of output capacitance losses is therefore important in the selection of optimum number of devices for a given power level. The analysis is performed on a 130V to 50V, 1.7 kW full bridge isolated dc-dc GaN converter operating at a switching frequency of 50 kHz. The paper also presents the measured efficiency curve of the GaN converter. The converter has attained a maximum measured efficiency of 98.7%.

300 A Holistic Approach to Optimise the Power Density of a Silicon Carbide (SiC) MOSFET based Three-Phase Inverter
Ian Laird, Xibo Yuan and Neville McNeill
Department of Electrical and Electronic Engineering, University of Bristol, Bristol, U.K.

Abstract- Conventional multi-kW three-phase power converters (e.g. 380 V output) based on silicon (Si) devices (e.g. IGBTs) typically operate at switching frequencies of 50 kHz or less. By contrast, silicon carbide (SiC) MOSFETs are capable of switching at frequencies of up to several hundreds of kHz while still maintaining high efficiency operation. This opens up opportunities for greater system design optimisation, such as determining the smallest possible power converter volume and weight. Of particular interest is how the switching frequency affects the size of the passive components (e.g. heatsink, line filter, dc-link capacitor and EMI filter) which account for around 70-80% of the power converter’s volume and weight. This paper presents a set of models that outline the effect that changing the switching frequency has on the design of a 2-level, 3-phase inverter using silicon carbide (SiC) MOSFETs as the active switches. In particular it will focus on the effect of the switching frequency on the design of the passive components.
106 High Temperature and High CMR Gate Driver Circuit for Wide-Band-Gap Power Semiconductors
N. Langmaack, G. Tareilus and M. Henke
Institute for Electrical Machines, Traction and Drives Technische Universität Braunschweig

Abstract- Wide-band-gap semiconductors continuously keep on pushing the limits of power electronic devices to higher switching speeds and higher operating temperatures. The proposed new gate driver circuit is designed consequently to meet the demands of these power semiconductor devices for high common mode rejection and the capability to work at high ambient temperatures.

127 Gate Driver Optimization to Mitigate Shoot-through in High-speed Switching SiC Half Bridge Module
(1)Rolls-Royce@NTU Corporate Lab, Nanyang Technological University, Singapore
(2)School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore
(3)Advanced Technology Centre, Rolls-Royce Singapore Pte. Ltd, Singapore

Abstract- The high-speed switching of SiC MOSFET allows power converter to operate with higher frequency and lower switching loss. However, it tends to aggravate dv/dt effect due to the impact of parasitic parameters, resulting in shoot-through and high device stress in the half bridge configuration. In this study, a compact and high-speed gate driver is developed and optimized for SiC half bridge module. The impact of various circuit parameters including Miller capacitance, common source inductance, gate resistance and gate inductance is evaluated. The improved gate drivers with additional features are compared and optimized to eliminate shoot-through.

Session APEHIIA-III: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems III

Date/Time: Thursday, 11 June 2015/11:00 – 12:30 hrs
Venue: Room 1 @ Level 4
Session Chair: R.T. Naayagi, Newcastle University, Singapore

301 Enhanced Operating Strategy for a Three-Phase Dual-Active-Bridge Converter Including Frequency Variation
Hauke van Hoek, Keijo Jacobs, Markus Neubert and Rik W. De Doncker
Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, Germany.

Abstract- Recently, it has been shown that the operating modes of a three-phase dual-active-bridge (3ph-DAB) DCto-DC converter can be altered. This can be used in particular to enhance low load efficiency. The different operating modes show significant differences concerning the utilization of the core material and the required filter effort. In this paper, an enhanced operating strategy including a dynamic variation of the switching frequency is investigated to further optimize the performance of the converter. For a specific electric vehicle application, the efficiency of certain operating points is boosted by up to 1%. The proposed concept is highly beneficial as it affects the operating points with the highest losses, which potentially reduces the cooling effort.
Selection of Power Semiconductor Devices for the DAB DC-DC Converter for Aerospace Applications
R. T. Naayagi
Newcastle University, School of Electrical and Electronic Engineering, Singapore

Abstract- This paper presents the guidelines for selecting suitable power semiconductor devices for the dual active bridge (DAB) DC-DC converter targeting aerospace applications. The main power loss in a switching power supply is the loss associated with power semiconductor devices. The high frequency operation of power electronics reduces the size of magnetic components. As a result, a smaller and lighter circuit design is feasible. However, the high switching frequency increases the power device losses. Therefore, the selection of appropriate power devices is essential to design efficient power electronics. This paper clearly presents the guidelines for selecting suitable power devices (IGBTs) for a 20kW, 540V/125V, 20 kHz DAB converter prototype meant for use in an aerospace application.

Analysis of Electric Vehicle Driving Cycles for Inverter Efficiency Improvement at Partial Load
Eva Knischourek and Dieter Gerling
Universitaet der Bundeswehr Muenchen, Neubiberg, Germany

Abstract- This paper presents an approach to reduce inverter losses in electric vehicles at partial load operation. To investigate losses and efficiency for a given driving cycle a vehicle model for drive resistance calculation, an electric machine model and a circuit model of the inverter are proposed. Special focus lies on accurately modelling the transient behavior of IGBTs and diodes in the inverter. As an example driving cycle the New European Driving Cycle is discussed.

A Single-Switch High Voltage Quasi-Resonant DC-DC Converter for a Pulsed Plasma Thruster
Bingyin Kang and Kay-Soon Low
Satellite Research Centre (SaRC) School of Electrical and Electronic Engineering Nanyang Technological University, Singapore

Abstract- In nano-satellites, the pulsed plasma thruster (PPT) is a suitable electronic propulsion system for drag compensation or attitude control. In this paper, a new quasi-resonant converter topology is proposed for the PPT igniter. It consists of a resonant tank, a step-up transformer and a Cockcroft-Walton voltage multiplier circuit. As compared to other resonant converters, the proposed topology uses a single switch. This improves the reliability and eases switching control. The resonant tank is driven to work at quasi-resonant state to obtain zero-current-switching (ZCS). This reduces switching noise and voltage spike. A prototype circuit has been developed to validate the concept. The output voltage is set to 4kV from a 5V power supply, and the preliminary experimental results show that the circuit works as analyzed.

Performance Analysis of Extended Phase-Shift Control of DAB DC-DC Converter for Aerospace Energy Storage System
R. T. Naayagi and A. J. Forsyth, R. Shuttleworth
School of Electrical and Electronic Engineering Newcastle University, Singapore
School of Electrical and Electronic Engineering The University of Manchester, UK
Abstract- This paper presents a steady-state analysis for the bidirectional dual active bridge (DAB) dc-dc converter operating in extended-phase-shift (EPS) control by proposing a new model that produces equations for RMS and average device currents, and RMS and peak inductor-transformer currents. The DAB converter performance is evaluated based on the mathematical model, focusing on zero-voltage switching (ZVS) operating range average power transfer, and efficiency by considering a small dead-time on the transformer primary under light loads. Experimental results are presented to verify the model and validate the converter performance at 1kW, 160/65V, 20 kHz in ZVS boundary operation for an aerospace energy storage system.

Session DGSG-III: Distributed Generation and Smart-Grid III
Date/Time: Thursday, 11 June 2015/11:00 – 12:30 hrs
Venue: Room 2 @ Level 4
Session Chair: Daming Zhang, University of New South Wales, Australia

167 NPC Photovoltaic Grid-Connected Inverter with Ride-Through Capability under Grid Faults
Hossein Dehghani Tafti(1), Ali I. Maswood(2), Ziyou Lim(3), Gabriel H. P. Ooi(4) and Pinkymol Harikrishna Raj(5)
(1, 2, 4, 5)School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore
(3)Interdisciplinary Graduate School, Nanyang Technological University, Singapore

Abstract- Fault ride through (FRT) capability is one of the challenges faced in the medium to high voltage grid-tied large-scale photovoltaic (PV) power plants. This paper proposes a novel control strategy to enhance the FRT capability of a two-stage multi-string PV plant which consists of DC/DC converters and NPC inverter. The proposed control is implemented to the DC/DC converter to maintain the DC-link voltage under any grid fault conditions by adjusting the extracted PV power to the inverter output power. This is achieved by changing the PV string reference voltage from its maximum power point voltage to a new voltage point with less power. On top of that, a novel voltage-oriented control (VOC) control structure using proportional-resonant (PR) controller is proposed for the NPC inverter. Additionally, the DC-link capacitor voltages are remained balanced at all times due to the adaptive space vector modulation (ASVM) scheme. The evaluation results have verified the feasibility and the FRT capability of a 14kW PV plant using the proposed control scheme under different grid fault conditions.

205 Analysis Of Locomotives And Grid Resonance And Harmonic Transfer Mechanism
Jie Zhang and Yun Li
CSR Zhuzhou Institute Co., Ltd., Hunan Province, P.R.China

Abstract- The locomotives and grid resonance accidents usually occur with the wide application of electrified railway, but the resonance mechanism has not been mastered totally. This not only affects the safety and normal operating of the locomotive, but also severely restricts the rapid development of the electrified railway. This paper summarizes some basic conclusions and laws by theoretical analysis and simulation research on locomotives and grid resonance and harmonic transfer mechanism. Finally, the actual locomotives and grid resonance accident is reproduced and analyzed, which provides an important reference and theoretical foundation for fully mastering the resonance mechanism and taking appropriate suppression measures.
A New Method for Operating Microgrid with the Capability of Coping with Switch-in and Switch-off of Large Percentage of Real and Reactive Power

Daming Zhang and MY Liao
University of New South Wales, Sydney, Australia

Abstract- This paper presents a new method for operating microgrid, which is formed by one droop controlled and other two PQ controlled distributed generators (DGs). The reference power of droop-controlled DG is adjusted by a multiplying factor, which is produced from the voltage variation. By doing so, the dynamic balance of the system can be reached swiftly. The inverter topology is voltage source inverter with LCL filter, which is controlled by proportional resonant controller. Due to the good property of proportional resonant controller and the introduction of the multiplying factor, the system can ride through the disturbance caused by the switch-in and switch-off of large load. There is also no need to change the set point of reference power with respect to the load change.

Intelligent Power Allocation and Load Management of More Electric Aircraft

*Alireza Barzegar, Rong Su, Changyun Wen, Leila Rajabpour, Yicheng Zhang
**Amit Gupta, Chadnana Gajanayake, Meng Yeong Lee
*School of Electrical and Electronic Engineering Nanyang Technological University, Singapore
**Rolls-Royce Corporate, Singapore

Abstract- Intelligent power allocation and load management systems have been playing an increasingly important role in aircrafts whose electrical network systems are getting more and more complex. Load shedding used to be the main means of aircraft power management. But the increasing number of electrical components and the emphasis of safety and human comfort call for more resilient power management. In this paper we present a novel power allocation and scheduling formulation which aims for minimum load shedding and optimal generator operational profiles. The problem is formulated as a mixed integer quadratic programming (MIQP) problem and solved by CPLEX optimization tool.

Analyze and Reduce the Impact of Sampling Delay on LCL Converter with Capacitor Current Feedback Active Damping

Zhiqiang Wan, Jian Xiong, Ji Lei, Chen Chen
State Key Laboratory of Advanced Electromagnetic Engineering and Technology, Huazhong University of Science and Technology, Wuhan, Hubei, China

Abstract- The capacitor current feedback active damping is widely used in LCL converter. However, digital processor needs some time to calculate the output in digital control system which will result in sampling delay. The sampling delay will leads to system instability and unacceptable damping performance, especially in low switching frequency. This paper overcomes this issue by shifting the sampling instant close to the PWM updating instant. This approach can strengthen system stability and achieve sufficient active damping. Moreover, smaller sampling delay corresponds to larger damping ratio. The theoretical conclusions presented in this paper are verified by simulation and experiment.

Session PEET-II: Power Electronic Emerging Technologies II

Date/Time: Thursday, 11 June 2015/11:00 – 12:30 hrs
Venue: Room 3 @ Level 4
Session Chair: Yen Kheng Tan, Singapore University of Technology and Design, Singapore
210 Study on A Boost Motor Driver with Low-Capacitance Charge-Pump Circuit

H. Matsumoto and Y. Nebra
Fukuoka University

Abstract-This paper proposes a boost-voltage motor driver with a low-capacitance charge-pump circuit. To deal with considerably changing boost-voltage, a voltage control method based on the space vector modulation technique is proposed. The experiments under repetitive acceleration and deceleration drive operation confirm that the driver can perform well. Furthermore; the proposed driver is verified to have higher drive efficiencies than the conventional driver.

353 A Constant-on-Time Based Buck Controller with Active PFC for Universal Input LED System

Hongjia Wu (1), Yongliang Zhang (2), Menglian Zhao (1), Hongfeng Shen (1) and Xiaobo Wu (1)
(1)Institute of VLSI Design, Zhejiang University Hangzhou, China
(2)Changzhou TOPIC semiconductor Technology Co. Ltd., China

Abstract- A constant-on-time (COT) based buck controller for driving LED lamp is presented in this paper. The chip integrates active power factor correction (PFC) and is suitable for universal input application. The buck converter is working in critical conduction mode (CRM). With COT control strategy, the input current of the buck converter could well follow the input voltage, thus high power factor (PF) can be attained. Also, the implementation of floating ground architecture helps to simplify the design of the control circuits. Furthermore, since the buck converter operates under CRM, the dynamic loss is also reduced. The chip is designed in CSMC 1.0 μm 40V process. Simulation results show that a power factor of 0.98 is achieved; the deviation of output average driving current is within ±3%, and the power efficiency at full load with 220Vrms input is 96%.

412 Control Integrated Finite State Machine Design for Photovoltaic Module Integrated Converter

Wei Jiang (1), Shiqi Kan (1), Nailu Li (1), Zhengyu Lin (2), Barry W. Williams (3), Seiji Hashimoto (4)
(1)Yangzhou University, China
(2)Aston University, UK
(3)University of Strathclyde, UK
(4)Gunma University, Japan

Abstract- The operation state of photovoltaic Module Integrated Converter (MIC) is subjected to change due to different source and load conditions, while state-swap is usually implemented with flow chart based sequential controller in the past research. In this paper, the signatures for different operational states are evaluated and investigated, which lead to an effective control integrated finite state machine (CIFSM), providing real-time state-swap as fast as the local control loop. The proposed CIFSM is implemented digitally for a boost type MIC prototype and tested under a variety of load and source conditions. The test results prove the effectiveness of the proposed CIFSM design.

414 Wireless Power Charger for Light Electric Vehicles

Wei Jiang (1), Song Xu (1), Nailu Li (1), Zhengyu Lin (2), Barry W. Williams (3)
(1)Yangzhou University, China
Abstract- Wireless power transmission technology is gaining more and more attentions in city transportation applications due to its commensurate power level and efficiency with conductive power transfer means. In this paper, an inductively coupled wireless charging system for 48V light electric vehicle is proposed. The power stages of the system is evaluated and designed, including the high frequency inverter, the resonant network, full bridge rectifier, and the load matching converter. Small signal modeling and linear control technology is applied to the load matching converter for input voltage control, which effectively controls the wireless power flow. The prototype is built with a dsPIC digital signal controller; the experiments are carried out, and the results reveal nature performances of a series-series resonant inductive power charger in terms of frequency, air-gap length, power flow control, and efficiency issues.

Lan Lan and Yen Kheng Tan
Energy Research Institute of Singapore, Singapore
Singapore University of Technology and Design (SUTD), Singapore

Abstract- Building energy monitoring to individual occupant’s personal climate level has vast advantages added on to the present building management system. With Internet of Things (IoT) as part of energy systems, it opens up a gateway of opportunities ahead to personalize energy monitoring. Distributed wireless sensor network (WSN) to integrate with the EnergyPlus model has created an advanced building energy monitoring platform. The proposed building energy monitoring platform has the mean to estimate and predict the energy consumption of an individual in a space within the building (kWh per m²) and the type of building services like air-conditioning, lighting systems, etc. being utilized. Building-wide deployment of a low-cost WSN system to measure these building services’ equivalent parameters, such as temperature, humidity, air pressure and illumination, are integrated into an EnergyPlus model being developed. This results in a more accurate estimation and prediction of the energy consumption within each individual space on top of the building energy measured by existing building management system. In addition, the sensor information helps building owner and tenants to better understand the well-being of the building, as well as, its indoor environmental quality and comfort level in a real-time format.

Session WBGD-II: Wide Bandgap Power Semiconductor Devices and Technologies II
Date/Time: Thursday, 11 June 2015/11:00 – 12:30 hrs
Venue: Room 4 @ Level 4
Session Chair: King-Jet Tseng, Nanyang Technological University, Singapore

155 Temperature-Dependent Electrical Performance of AlGaN/GaN MOS-HEMT with Ultrasonic Spray Pyrolysis Deposited Al₂O₃
Han-Yin Liu(5), Wei-Chou Hsu(1, 2), Bo-Yi Chou(1), Ching-Sung Lee(3), Wen-Ching Sun(4), Sung-Yen Wei(4), and Sheng-Min Yu(4)
(1)Institute of Microelectronics, Department of Electrical Engineering, National Cheng Kung University, Taiwan
(2)Advanced Optoelectronics Technology Center, National Cheng Kung University, Taiwan
(3)Department of Electronic Engineering, Feng Chia University, Taiwan
(4)Material and Chemical Research Laboratories, Industrial Technology Research Institute, Taiwan
Abstract- This work investigates an AlGaN/GaN metal-oxide-semiconductor high electron mobility transistor (MOS-HEMT) with ultrasonic spray pyrolysis (USP) deposited Al2O3. The temperature-dependent electrical characteristics like IGD-VGD, IDS-VDS, and IDS-VGS are measured from 300 K to 480 K. The MOS-HEMT shows lower IGD and higher IDS and higher gm,max. Furthermore, the MOS-HEMT has better thermal stability in electrical performances. The thermal models of electron mobility of the Al2O3/AlGaN/GaN MOS-HEMT and the AlGaN/GaN Schottky-gate HEMT with Al2O3 passivation are analyzed. The superior high-temperature electrical performances of the MOS-HEMT are very promising for high-power and high-temperature electronics applications.

158 AlGaN/GaN MOS-HEMTs with TiO2 Gate Dielectric by Using Non-Vacuum Ultrasonic Spray Pyrolysis Deposition
H. Y. Liu(1), C. S. Lee(1), W. C. Hsu(2), T. T. Wu(1), H. S. Huang(1), S. F. Chen(1), Y. C. Yang(1), B. C. Chiang(1), and H. C. Chang(1)
(1)Department of Electronic Engineering, Feng Chia University, Taiwan, R.O.C.
(2)Institute of Microelectronics, Department of Electrical Engineering, National Cheng-Kung University, Taiwan, R.O.C.

Abstract- AlGaN/GaN metal-oxide-semiconductor high electron mobility transistors (MOS-HEMTs), grown on the Si substrate, with high-k TiO2 gate dielectric (k = 53.6) formed by using non-vacuum ultrasonic spray pyrolysis deposition (USPD) method has been investigated. Pulse I-V and low-frequency noise spectra (1/f) are conducted to characterize the interface property. Enhanced device performances have been accomplished for the devised MOS-HEMT (Schottky-gate HEMT) for the gate dimensions of 1 × 100 µm², including drain-source current density (IDS) at VGS = 0 V (IDSIO) of 384 (342) mA/mm, maximum IDS (IDS,max) of 650 (511) mA/mm, maximum extrinsic transconductance (gm, max) of 107 (110) mS/mm, two-terminal gate-drain breakdown voltage (BVGD) of -155 (-105) V, turn-on voltage (Von) of 3.8 (1.8) V, on-state breakdown (BVDS) of 139 (94) V, gate-voltage swing (GVS) of 2.7 (1.7) V, and on/off current ratio (Ion/Ioff) of 4.5 × 105 (3.5 × 102). Consequently, the present MOS-HEMT design by using the cost-effective USPD method is suitable for high-power RF circuit applications.

54 Two-Dimensional Analysis of Off-State Breakdown Characteristics in Gate and Source Field-Plate AlGaN/GaN HEMTs
H. Onodera, H. Hanawa and K. Horio
Faculty of Systems Engineering, Shibaura Institute of Technology, Japan

Abstract- Two-dimensional analysis of breakdown characteristics of field-plate AlGaN/GaN HEMTs is performed by considering a deep donor and a deep acceptor in a buffer layer. It is shown that the introduction of field plate is effective in improving the breakdown voltage, but it can decrease with the field-plate length, and hence its optimum length should exist. It is also shown that the breakdown voltage of the source field-plate structure is a little lower than that of the gate field-plate structure when the field-plate length is short, because the electric field at the drain edge of the gate becomes higher.

290 High Output Swing Monolithic Inverter with E-D Mode MIS-HEMTs for GaN Power Integrated Circuits
Yun-Hsiang Wang(1,5), Yung C. Liang(1,2), Ganesh S. Samudra(1), Bo-Jhang Huang(3), Ya-Chu Liao(3), Chih-Fang Huang(3), Wei-Hung Kuo(4) and Guo-Qiang Lo(5)
Abstract- AlGaN/GaN power HEMT combined with partial AlGaN barrier recess and multiple CHF3 based fluorine plasma treatments onto ALD deposited Al2O3 gate dielectrics is able to bring a high gate threshold voltage (VTH) for the enhancement mode operations without much degradation on the maximum drain saturation current (IDMAX). This work reports integration of both the enhancement and depletion (E-D) modes AlGaN/GaN MIS-HEMTs to construct a monolithic inverter. Experimental data show that the proposed power inverter provides large noise margin allowances of 4.9V and 3.2V, large output swing of 9.66V and satisfactory propagation switching delay time of 35ns. The configuration is found to be suitable for GaN power integrated circuits.

71 Modeling the Effect of Acceptor-Type Traps on Internal Electric Field of a GaN-pin Device Phenomenon

Shao-Yen Chiu (1), Yu-Teng Tseng (2), Wei-Chen Yang (2), Keh-Yung (Norman) Cheng (2) (1)Episil Technologies Inc., Hsinchu, Taiwan (2) National Tsing Hua University, Republic of China

Abstract-The performance of a pin structure diode fabricated on epitaxial layer on a GaN template using re-growth p-type GaN technology by PAMBE. Experimental results show that relatively forward turn-on voltage and on-resistance are 3.1V and 5mΩ-cm2, respectively. Due to the metal-semiconductor interface has the lower p-ohmic contact. On the contrary, the breakdown voltage of the device operating greater than 800V is observed. Furthermore, the pin structure diode within acceptor-type traps using a two-dimensional simulator as GaN bulk within threading dislocations (about ~108cm-2) was compared to including the electric field different from x and y position. It leads to substantially higher electric field as function of x position between the metal and the p-type GaN when drift layer is not fully depleted.

Session APEHIA-IV: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems IV

Date/Time: Thursday, 11 June 2015/13:30 – 15:00 hrs
Venue: Room 1 @ Level 4
Session Chair: Dylan Lu, University of Sydney, Australia

317 Power Loss Analysis of a Single-Switch Non-isolated DC/DC Converter
Le An and Dylan Dah-Chuan Lu
School of Electrical and Information Engineering, The University of Sydney, Australia

Abstract- A power loss model of a single-switch non-isolated dc/dc converter is developed in this paper. The converter is formed by combining a buck converter with a buck-boost converter. It can be used in a stand-alone photovoltaic (PV)-battery powered pump system. With only a single transistor, the converter is able to efficiently perform three tasks simultaneously, namely, maximum power point tracking (MPPT), battery charging and driving the pump at constant flow rate. The
conduction and switching losses of each individual components of the converter and the inductor core loss are calculated and analyzed when the two inductors operate in different modes. The analysis shows that the output stage inductor and power diode are the major contributors to the total power loss. A 14W laboratory prototype converter is built and the experimental results are compared with the model analysis.

368 Current-Source ZCS High-Frequency Resonant Inverter based on Time-Sharing Frequency Doubler Principle and Induction Heating Applications

Tomokazu Mishima, Kyohei Konishi (1), Mutsuo Nakaoaka (2)

(1)Graduate Sch. of Maritime Sci., Dept. of Marine Eng., Kobe University
(2)Dept. of Electrical Eng., University of Malaya, Kuala Lumpur, Malaysia

Abstract- A new prototype of a time-sharing operation-based current-source (CS) zero current soft-switching (ZCS) high-frequency resonant (HF-R) inverter suitable for induction heating (IH) and inductive power transfer (IPT) systems is presented in this paper. In order to effectively generate a high-frequency resonant current under a minimized switching loss of power devices, a HF load current which has twice or multiple times as much as the switching frequency can be produced by twoor multi-phase CS inverter under the ZCS condition. The performance of the proposed HF-R inverter is evaluated from experimental results, after which the feasibility is discussed from a practical point of view.

379 Adaptive Slope Compensation for High Bandwidth Digital Current Mode Controller

Fazel Taeed and Morten Nymand
Maersk Mc-Kinney Moller Institute, University of Southern Denmark

Abstract- An adaptive slope compensation method for digital current mode control of dc-dc converters is proposed in this paper. The compensation slope is used for stabilizing the inner current loop in peak current mode control. In this method, the compensation slope is adapted with the variations in converter duty cycle. The adaptive slope compensation provides optimum controller operation in term of bandwidth over wide range of operating points. In this paper operation principle of the controller is discussed. The proposed controller is implemented in an FPGA to control a 100 W buck converter. The experimental results of measured loop-gain at different operating points are presented to validate the theoretical performance of the controller.

459 An Inrush Current Elimination Technique for a Transformer-Coupled Series Voltage Sag Compensator

Syed Sabir Hussain Bukhari (1), Shahid Atiq (1), Thomas A. Lipo (2), and Byung-il Kwon (1)

(1)Department of Electronic Systems Engineering, Hanyang University, Ansan-si, Gyeonggi-do, Korea
(2)Department of Electrical and Computer Engineering, Florida State University, Tallahassee Fl, USA

Abstract- Voltage sags are a major power quality problem in many industries. Such sags often affect manufacturing processes and can cause significant financial loss. To deal with such problems, a voltage sag compensator, based on a transformercoupled series-connected voltage source inverter (VSI) is usually installed to protect sensitive loads. However, an important issue with this system is the generation of inrush transient currents at the starting instant of the sag compensation due to the energization of the transformer. These inrush currents can affect sensitive loads and may trigger the over-current protection of the sag compensator. This paper proposes a technique to eliminate inrush
current for a transformer-coupled series voltage sag compensator (SVSC) using a current-regulated voltage source inverter (CRVSI). Successful operation of the proposed inrush current elimination technique is verified by laboratory test results.

462 Characteristics of Quasi Variable Capacitors for Induction Heating

Sachio Kubota and Masami Fukushima
National Institute of Technology, Toba College

Abstract- In this study, the diesel emission control system using induction heating is proposed as a method of reducing toxic substances included in exhaust gas. When the trapping filter of that system is heated by induction heating, ferromagnetic metals are suitable for that filter. However, they are transmuted to paramagnetic metals at high temperature more than Curie temperature. Therefore, automatic resonance tracking control is required to prevent breakdown of power supply because the equivalent circuit parameters of induction heating are rapidly changed at this temperature. Generally, although resonant frequency is tracked by PFM (Pulse Frequency Modulation), it is desirable to operate at constant frequency because the heating piece is changed in accordance with an operating frequency. Accordingly, we have proposed the quasi variable capacitor to maintain a resonance. This paper presents a comparison of the behavior of the proposed quasi variable capacitors. An analytical study of the proposed quasi variable capacitor is performed, and the main results are shown. The results derived from this analysis and the feasibility are verified through experimental prototype.

Session APEPSG-I: Applications of Power Electronics in Power System and Generation/FACTS I

Date/Time: Thursday, 11 June 2015/13:30 – 15:00 hrs
Venue: Room 2 @ Level 4
Session Chair: Shantha Gamini Jayasinghe, University of Tasmania, Australia

162 The Doubly Fed Permanent Magnet Synchronous Machine as a Highly Efficient Drive System for Constant Speed Applications

Alexander Stock, Johannes Teigelkötter, Stefan Staudt, and Thomas Kowalski
University of Applied Sciences Aschaffenburg, Germany

Abstract-In this paper, a highly efficient drive system for applications with a constant rotational speed will be presented. For this a doubly fed permanent magnet synchronous machine (DFPMSM) will be used as motor / generator. Since permanent magnet synchronous machines (PMSM) don’t work stable at the electrical grid without the usage of additional components such as damper windings or a damping mechanical load, they are typically controlled by an inverter. These additive arrangements cause losses. However, the alternative usage of an inverter in the power class of the PMSM results in switching and conduction losses as well. For these reasons, the aim is to reduce those losses to a minimum without impairing the stability of the drive system. Respecting that it is restricted to constant speed applications only the DFPMSM is such an optimized drive concept. The stator of the DFPMSM is fed by two energy sources: first by the electrica grid and second by a low power inverter, compared with the power class of the electrical machine. In this contribution, the focus is on the serious connected DFPMSM (SC-DFPMSM).

293 A New Method for Grid-Tie Inverters Synchronization Based on RDFT with Linear Approximation

Ali Al-Omari, M. Z. Ahmed, Darren T. Bearne
Abstract- A new method based on linear approximation of RDFT is presented in this paper which will provide a computation reduction as well as high accuracy in tracking the fundamental in distorted grid during synchronization. Due to recent developments combined with the increasing of power demand by single phase nonlinear loads, voltage spikes, harmonics and DC component had affected on the electric grid quality. These effects make Synchronization a challenge where filters or DSP analysers are required to acquire the fundamental component as a consequence to the waveform deformation.

Applying DFT “Discrete Fourier Transform” using DSP processors can be one of the best solutions to find the waveform parameters. However DFT is combined with high mathematical computations and required using advanced microprocessors to be applied in real-time.

441 Analysis of Direct Matrix Converter Operation under Various Switching Patterns
Zahra Malekjamshidi*, Mohammad Jafari*, Dan Xiao** and Jianguo Zhu*
* Faculty of Engineering and Information Technology, University of Technology Sydney
** Electrical Engineering and Telecommunications, University of New South Wales

Abstract- This paper provides a comparison between two switching patterns of space vector modulation in direct matrix converter. These patterns are compared considering theoretical and performance aspects such as total harmonic distortion, switching numbers and spectrum analysis of input and output parameters. A simple model is proposed to represent the power circuit, including the input filter and a three-phase Y-connected RL load. Input and output parameters of direct matrix converter are presented in simulations using PSIM software for both switching strategies. The power semiconductors are modelled as ideal bidirectional switches and the MC is controlled using direct space vector modulation approach.

442 Analysis and Comparison of Direct Matrix Converters Controlled by Space Vector and Venturini Modulations
Zahra Malekjamshidi, Mohammad Jafari and Jianguo Zhu
Faculty of Engineering and Information Technology, University of Technology Sydney, Australia

Abstract- This paper provides a brief comparison between two different modulation methods for direct matrix converter (DMC). The power semiconductors are modelled as ideal bidirectional switches and the DMC is controlled using Venturini method, optimized Venturini and space vector modulation respectively. These methods are compared and analysed in some aspects such as total harmonic distortion and harmonic spectrum analysis of output voltage and input current.
A simple model of DMC is proposed to represent the power circuit, including the input filter and a three-phase Y-connected RL load. Simulated input and output parameters of DMC are presented using PSIM software for both modulation strategies.

59 Multirate Strong Tracking Extended Kalman Filter and Its Implementation on Lithium Iron Phosphate (LiFePO4) Battery System
J. Jia (1), P. Lin (1,3), C.S. Chin (2), W.D. Toh (1), Z. Gao (1), H. Lyu (1,3), Y.T. Cham (1),
and E. Mesbahi (2)
(1) School of Engineering, Temasek Polytechnic, Singapore
(2) School of Marine Science and Technology, Newcastle University, Singapore
(3) School of Electrical Engineering, Southwest Jiaotong University, China
Abstract- Lithium Iron phosphate (LiFePO4) battery has obtained extensive attention of researchers for its high energy density, little contamination and ready availability. In this paper, different numbers of RC branches in the equivalent Thevenin circuit model are explored by comparing accuracy of curve fitting with in-house experimental data. Besides, battery system with 6 cells of second order equivalent circuit is modeled using Matlab/Simscape. A multirate strong tracking extended filter (MRSTEKF) is proposed by introducing the multirate control strategy and lifting technology into strong tracking extended Kalman filter (STEKF) to improve tracking stability and estimation precision of state of charge (SOC). Root mean square error (RMSE) is exploited to evaluate the performance of the algorithms of extended Kalman filter (EKF), STEKF and MRSTEKF. Simulation results demonstrate that the proposed MRSTEKF is faster than EKF and STEKF by 55.34% and 49.51%, and is more precise by 52.66% and 33.88%.

Session MDMC-I: Motion Drives and Motion Control I

Date/Time: Thursday, 11 June 2015/13:30 – 15:00 hrs
Venue: Room 3 @ Level 4
Session Chair: Wolfgang Gruber, Johannes Kepler Universität Linz, Austria

69 On the self-sensing technique based on the interlink voltage of two serially connected phase coils
Wolfgang Gruber, Markus Stöckler
Institute for Electrical Drives and Power Electronics Johannes, Kepler University, Austria

Abstract-Self-sensing magnetic bearings have been investigated for several years. A lot of different methods have been introduced and evaluated. In this work a unique method is considered for implementation in a bearingless slice motor. This self-sensing technique relies on the rotor position dependent interlink voltage of two phase coils which are connected in series and which are energized by a standard switching voltage amplifier. The proposed method is modelled and mathematically described. It has only limited need of additional hardware and is, therefore, relatively easy to implement and integrate in the digital signal processor of the bearingless motor control scheme. To show its practical functionality, the proposed method is implemented in the bearingless flux-switching motor. First measurements show encouraging results.

91 Extremely Precise Position Estimation in Sensorless Control of Permanent Magnet Synchronous Motors Using All-pass Filter
Ken-ichiro Tanaka, Masaru Hasegawa and Atsushi Matsumoto
Dept. of Electrical Chubu University, Japan

Abstract- For the stator flux linkage estimation to realize permanent magined synchronous motor sensorless control, a quasi-integrator is often substituted instead of a pure-integrator, resulting the position estimation error in a low speed region. This paper presents a new position estimation for sensorless control of PMSM using all-path filters, which realize extremely precise estimation under transient condition as well as steady state.

97 FPGA Based Controller Drive of BLDC Motor Using Digital PWM Technique
A. Tashakori, M. Hassanudeen and M. Ektesabi
Swinburne University of Technology, Australia
Permanent magnet Brushless DC (BLDC) motors have been used extensively in industrial, automotive and aerospace applications in the last decade. This paper presents a Field Programmable Gate Array (FPGA) based control drive for BLDC motors using digital pulse width modulation (PWM) speed controller. Presented BLDC motor commutation technique is based on three inbuilt Hall Effect sensors. A novel algorithm is proposed to implement a closed loop PWM speed controller using FPGA for BLDC motors. Motor speed is controlled through a predefined value or manually by the user. The proposed method is modeled by Xilinx Integrated Software Environment (ISE) Simulator and MATLAB/Simulink. Performance of the proposed FPGA based control drive of BLDC motor is also investigated through experimental test setup. Simulation results and effectiveness of the proposed method are proved and validated by experimental data.

112 Adaptive Nonlinear Speed Control of IPMSM with Increased Linear Modulation Range for Natural Sampling
Garin Schoonhoven and M. Nasir Uddin
Lakehead University, Thunder Bay, ON, Canada

Abstract- This paper presents a robust nonlinear control method for interior permanent magnet synchronous motors (IPMSM) based on maximum torque per ampere (MTPA) with harmonic injection. Third harmonic injection is employed for increased utilization of supply potential and reduced motor current harmonic distortion. Global asymptotic stability of the drive is demonstrated through Lyapunov stability criterion and Barbalat's lemma. Control expressions are derived through adaptive back-stepping technique, with estimation of dynamic load and mechanical coefficient ensuring dynamic operational consistency. The proposed system has been implemented in a co-simulation environment, with control system and machine model implemented in Matlab/Simulink and PSIM, respectively. Simulation results have demonstrated excellent drive performance, harmonic distortion reduction and an increase in the linear modulation range.

281 An electromagnet model comprehending eddy current and end effects
Sebastian Fizek (1,2), Martin Reisingery (2), Siegfried Silbery (2) and Wolfgang Amrhein(3)
(1)JKU HOERBIGER Research Institute for Smart Actuators, Johannes Kepler University, Austria
(2)Linz Center of Mechatronics (LCM), Austria
(3)Institute for Electrical Drives and Power Electronics, Johannes Kepler University, Austria

Abstract- In modern injection systems and pneumatic valves,solenoid valves are widely spreaded for a volume flow control. The recent literature covers the influence of eddy current on the dynamic response for solenoid valves in depth. Basically pot core assemblies were taken into account and small air gap scenarios were investigated. The large scale actuators like high force lifting magnets are regarded in the present work and the proposed model is not limited to pot cores, because end effects are considered. The inverter operation opens opportunities for different excitation voltages and a high precision model including nonlinearities is required for the loss reduction of the total actuator. It is shown that the proposed model exhibits a promising coherence with the measurements. The proposed model utilizes magnetic equivalent circuits and quasi-static finite elements methods.
310 **Temperature measurements of GaN FETs by means of average gate current sensing**
(1)Philipp Marc Roschatt, Richard A. McMahon, (2) Stephen Pickering
(1)Department of Engineering University of Cambridge
(2)Jaguar LandRover Ltd Whitley, Coventry

Abstract- Gallium Nitride is a promising technology to increase power density in future DC-DC converter. However, the size and volume of heat sinks and cooling equipment needed will limit the maximum achievable power density. Reducing the cooling effort for volume reduction of the heat sink is an option to increase the power density but requires good knowledge of the junction temperature to avoid overheating. The temperature dependent gate leakage of GaN FETs can be used to estimate the junction temperature during operation. This can be measured by observing the current supplied to the gate drive. The methodology shows how the average current supplied to the gate drive unit follows the device temperature.

357 **A Novel Implant Masking Processes for Double Self-Aligned 4H-SiC DMOSFETs**
Jheng-Yi Jiang, Ting-Fu Chang and Chih-Fang Huang
Institute of Electronic Engineering, National Tsing Hua University, Taiwan, R.O.C

Abstract- This paper reports the design and fabrication of a 4H-SiC double implant MOSFET with a novel ion implantation masking process, which eliminates the metal masks in previous approaches. Furthermore, a double self-aligned process and the cell pitch is shrunk by a self-aligned oxidation process and the cell pitch is reduced by an ohmic contact metal self-aligned process. By reducing the cell pitch, the best measured specific on resistance is $85 \text{ m}\Omega \cdot \text{cm}^2$ for a 30 µm drift region device. A single zone JTE is used around the device to enhance the breakdown voltage. In this study, the best measured breakdown voltage is 2240V.

362 **Threshold Voltage Instability in AlGaN/GaN HEMTs**
Ting-Fu Chang (1), Tsung-Chieh Hsiao (1), Szu-Han Huang (1), Chih-Fang Huang (1), Yun-Hsiang Wang (2), Ganesh S. Samudra (2), and Yung C. Liang (2)
(1)Institute of Electronics Engineering, National Tsing Hua University, Hsinchu, Taiwan, R. O. C.
(2)Department of Electrical and Computer Engineering, National University of Singapore, Singapore

Abstract- In this study, the threshold voltage instability of the Schottky gate HEMT, the p-GaN gate HEMT, and the recessed MIS gate HEMT is investigated. The annealed p-GaN gate HEMT and Schottky gate HEMT are relatively stable. The threshold voltage shift of the recessed MIS gate HEMT, which is attributed to the trapping of electrons in the gate dielectric, can be as large as 2.5 V depending on the stress conditions. The activation energies of the trapping and de-trapping are extracted from the time constant spectra for the recessed MIS gate HEMT.

382 **Control of Transconductance in High Performance AlGaN/GaN FinFETs**
Young-Woo Jo, Dong-Hyeok Son, Chul-Ho Won, V. Sindhuri, Ji-Hyun Kim, Jae Hwa Seo, In Man Kang, and Jung-Hee Lee
School of Electronics Engineering, Kyungpook National University, Korea
Abstract- AlGaN/GaN-based fin-shaped field-effect transistors (FinFETs) with very steep sidewall and various fin-widths ($W_{\text{fin}}$) have been fabricated by utilizing electron-beam lithography and additional anisotropic sidewall wet etch in TMAH solution. The device with $W_{\text{fin}}$ of 150 nm exhibits normally-on performance with threshold voltage of -2.5 V, suppression of current collapse phenomenon, low gate leakage current ($10^{11}$ A), low subthreshold swing (SS) of 68 mV/decade, and high linearity characteristic with extremely broad transconductance ($g_m$). On the other hand, devices with $W_{\text{fin}} = 50$ and 70 nm exhibit normally-off performance with positive threshold voltage of 3.0 and 1.5 V, respectively, and less broad $g_m$ characteristics.

Session APEHIA-V: Applications of Power Electronics in Home Appliance, Industry, Aerospace & Automotive Systems V
Date/Time: Thursday, 11 June 2015/15:30 – 17:00 hrs
Venue: Room 1 @ Level 4
Session Chair: R.T. Naayagi, Newcastle University, Singapore

130 Integration of Bi-Directional DC-DC Converter and Highly Efficient Boost Converter for Electric Vehicles Applications
Md. Mizanur Rahman*, M. Nasir Uddin*and Md. Khurshedul Islam**
*Department of Electrical Engineering Lakehead University, Canada
**Department of Electrical & Electronic Engineering International Islamic University Chittagong (IIUC) Chittagong, Bangladesh

Abstract- This paper presents a highly efficient electrical circuit for battery fed electric vehicles (BFEVs) which is an amalgamation of a PI controlled bi-directional DC-DC converter and a boost converter. The PI controlled isolated DC-DC bi-directional converter is designed to provide the desired battery voltage for dc motor control and to run the flow of power under both steady-state and ephemeral conditions. For the period of the boost operation high voltage side is controlled by PI controller and low voltage side acts as a rectifier and vice versa. A boost converter is also designed by paralleling one IGBT with one MOSFET switches in order to condense the conduction loss and to guarantee a high output voltage. These both devices are used to control three modes of BFEVs namely steady state, acceleration and regenerative modes. An equivalent MATLAB/Simulink simulation model of the proposed system is developed to investigate the performance of the proposed converter circuits at different operating conditions. The proposed converter exhibits higher efficiency as compared to the conventional converter circuits.

413 Application of an Integrated Transformerless Buck-boost Converter in Photovoltaic MPPT Systems
Xiaobin He, Xinghao Zhang, Huiying Liu and Huahui Zhang
Shanghai Institute of Space Power-Sources, Shanghai, China

Abstract- A new photovoltaic MPPT system has been developed using an integrated transformerless Buck-boost power converter to improve the efficiency. The paper describes the analysis, modeling and control of the Buck-boost power inverter. The transformerless Buck-boost power inverter includes a superboost converter and a buck converter though a variable mode controller to optimize the PV energy extraction. Finally, experiment research is proceeded to the MPPT system with battery chargers and DC load. Experiment results show that output power increases obviously under different solar radiation.
421 Comparison of Push-Pull and Half-bridge Resonant Inverters for Cold Cathode Fluorescent Lamps
Yueh-Ru Yang
Ming Chi University of Technology, New Taipei City, Taiwan

Abstract- This paper compares a push-pull resonant inverter with a half-bridge resonant inverter for cold cathode fluorescent lamps. The push-pull resonant inverter is fabricated with an input inductor, a center-tapped transformer, a parallel resonant capacitor and two bipolar junction transistors, whereas the half-bridge resonant inverter comprises a series resonant capacitor, a transformer and two metal-oxide-semiconductor field-effect transistors. Nevertheless, both inverters behave zero-voltage-switching and current-output characteristics. This paper depicts the features and compares the efficiency of the inverters with experiments. The experimental results show the voltage-fed half-bridge resonant inverter exhibits a better efficiency than the current-fed push-pull resonant inverter.

284 Characterization of Contactless Power Transfer System and Investigation of Core Shape for AGV Application
(1)Takahiro Kojima, Hayato Tanabe, Akihiro Imakiire, Kiyotaka Fuji, Masahiro Kozako, Masayuki Hikita, (2)Yutaka Imoto, Keiichi Honda
(1)Department of Electrical Engineering, Kyushu Institute of Technology, Kitakyushu, Fukuoka, Japan
(2)HEADS Co., Ltd., Fukuoka, Japan HICS Department

Abstract- In recent years, the introduction of contactless power transfer (CPT) system is required to automated guided vehicle (AGV) used in a factory. This paper deals with development of prototype contactless power transfer system for applying to AGV using both experiment and simulation. It is found that the developed prototype contactless power transfer system allows 1 kW power transfer in more than 68% of power transfer efficiency at 20 mm gap. Furthermore, an attempt is made to optimize the CPT by changing the core shape of the coils. As a result, combination of T-T shape cores made of ferrite core allows transmission of more power than T-E combination cores. These results suggest that the T-T shape cores contribute to further miniaturization of CPT system and larger capacity than previous CPT system using T-E combination cores.

419 Comparison Performance of Si-IGBT and SiC-MOSFET Used for High Efficiency Inverter of Contactless Power Transfer System
Hayato Tanabe, Takahiro Kojima, Akihiro Imakiire, Kiyotaka Fuji, Masahiro Kozako, Masayuki Hikita
Department of Electrical and Electronics Engineering, Kyushu Institute of Technology, Fukuoka, Japan

Abstract- This paper deals with investigation on electrical characteristics of both conventional Si-IGBT and next generation power semiconductor device SiC-MOSFET for high efficiency inverter of contactless power transfer system. This system has an issue that the power conversion efficiency is lower than that of conventional charging system using a plug. Since a prototype type contactless power transfer system that we evaluated before adopted Si-IGBT, higher power conversion efficiency has been required. Thus, an attempt is made to improve the inverter efficiency using SiC-MOSFET. The performance of Si-IGBT and SiC-MOSFET are evaluated by conducting a switching test and experiment of static characteristics. Furthermore, inverter loss is calculated and discussed using experimental results of Si-IGBT and SiC-MOSFET. As a result, the inverter efficiency is found to increase by 0.48% using SiC-MOSFET. Additionally, it is suggested that
ringing of the voltage and current should be suppressed when SiC-MOSFET is applied to an inverter for high frequency application like a contactless power transfer system.

### Session APEPSG-II: Applications of Power Electronics in Power System and Generation/FACTS II

**Date/Time:** Thursday, 11 June 2015/15:30 – 17:00 hrs  
**Venue:** Room 2 @ Level 4  
**Session Chair:** Shantha Gamini Jayasinghe, University of Tasmania, Australia/Yen Kheng Tan, Singapore University of Technology and Design, Singapore

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<td>142</td>
<td>Ultra-Low Power Boost DC-DC Converter with Integrated MEMS Resonator</td>
<td>Yuan-Ta Hsieh, Sheng-Hsiang Tseng, Chiao-Li Fang, Jian-Fu Wu, Hann-Huei Tsai, and Ying-Zong Juang</td>
<td>National Chip Implementation Center, Taiwan</td>
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Abstract-Complementary metal-oxide-semiconductor micro-electromechanical system (CMOS MEMS) resonators provide considerable advantages in size, cost, and power consumption over their crystal-based counterparts. However, the need for external high bias-voltage to drive the MEMS structure has limited the application of CMOS MEMS in portable electronic applications. This paper proposes an ultra-low power boost DC-DC converter with integrated MEMS resonator. The proposed DC-DC converter and MEMS resonator are integrated into a single chip, and the high bias-voltage required for the MEMS resonator is self-provided. The substantial reduction in the size of the resulting device as well as its low power requirements make it ideal for portable applications. A working prototype of the device was fabricated using a UMC 0.18-μm 60-V bipolar-CMOS-DMOS with a MEMS post-process. Measurement results show that the power dissipation of the boost DC-DC converter is less than 15 µW under various input voltages. Comparisons of high bias-voltage from an external supply with an internal DC-DC converter demonstrate the performance of the design. A preserved reset signal at a different clock frequency also verifies the resistance of the proposed design to process variation.

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<td>149</td>
<td>Suggestion of a Novel PHILS Method for Operation Analysis of a Thyristor Controlled Series Capacitor</td>
<td>Minh-Chau Dinh, Sang-Min Park, Sung-Kyu Kim, Minwon Park, and In-Keun Yu</td>
<td>Department of Electrical Engineering, Changwon National University, Korea</td>
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Abstract- A study on practical characteristics analysis of Thyristor Controlled Series Capacitor (TCSC) is needed before applying it to a practical grid. Generally, simulation tools are utilized to investigate the operating characteristics of TCSC with respect to steady-state, temporary and dynamic performance. In this paper, we introduce Real Time Digital Simulator (RTDS)-based power hardware in the loop simulation (PHILS) to examine the operation of TCSC. A laboratory scale TCSC which has the same reactance characteristic as a practical 345 kV TCSC is designed and fabricated. It is incorporated with a 345 kV model power system in RTDS through the interface card. RTDS-based PHILS of TCSC is conducted to verify the power control function of TCSC. Simulation results demonstrate the ability of the proposed method in verifying the design, control strategies and proper functionality of the TCSC and real-time performance of TCSC as well.

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<td>268</td>
<td>Investigation on Active Method for Stabilization of LC Input Filter and DC/DC Buck Converter under Voltage Mode Control</td>
<td>Mingfei Wu and Dylan D.C. Lu</td>
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Abstract- The switching mode power electronic converter with feedback loop control functions as a constant power load (CPL). CPLs have negative input impedance which may cause system instability. Both passive and active stabilization methods can solve this problem. However, active stabilization methods are more power efficient. Several active stabilization methods have been proposed for DC/AC inverter based CPLs. However, active stabilization methods for DC/DC converter based CPLs under voltage mode control have received little attention. In this paper, an active method is proposed for stabilization of DC/DC converter in voltage mode control. A systematic investigation on this active method is carried out. In the active method, a feedforward loop is designed and fed to the voltage control loop of the DC/DC converter. This feedforward loop is a combination of a bandpass filter and a proportional gain. This feedforward loop can create a virtual resistor and a virtual capacitor in parallel with the CPL. And this virtual circuit can modify the negative input impedance of the CPL to satisfy the impedance criterion. Experimental results are reported to verify the analysis and the effectiveness of the active method.

433 A Comprehensive Power Analysis of Induction Heating Power Supply System Using Multilevel Neutral Point Clamped Inverter With Optimum Control Algorithm
Bashar Mohammed Flayyih, Mohammed Zaki Ahmed, Stuart Mac Veigh
Mathematical and Computer Science, Plymouth University, Plymouth, UK

Abstract- A novel super frequency induction heating power supply using multilevel neutral point clamped inverter with optimum control algorithm using high performance STM32F4DISCOVERY board is introduced. The control strategy is to keep phase shift angle between voltage and current approximately zero at all load conditions to ensure maximum power transfer.

518 Hybrid Cascaded Multilevel Inverter with Supercapacitor Energy Storage for Grid Integration of Renewable Energy Systems
S. D. G. Jayasinghe and D. M. Vilathgamuwa
Australian Maritime College, University of Tasmania, Launceston, Australia
Queensland University of Technology, Brisbane, Australia

Abstract- Short-term power exchange using supercapacitors is actively pursued in the renewable energy sector. The most common approach taken in integrating supercapacitors into the power conversion system is the connection to the dc-link of the grid connecting inverter through an interfacing dc-dc converter which introduces additional power losses. Therefore, this paper proposes to use the grid-side inverter itself as the interface for supercapacitors and thereby eliminate the need of an additional converter. The inverter used in this study is the well-known hybrid cascaded multilevel inverter which consists of a two-level inverter and three series-connected H-bridge modules. In the proposed system three supercapacitor banks are directly connected to dc-links of H-bridge modules. The supercapacitor charging/discharging method used in the proposed system, corresponding control strategies and the supercapacitor sizing method used to estimate the required capacity are presented in this paper. Simulation results and a power loss analysis are also presented to show the efficacy of the proposed system.
A Modified Hysteresis-based DTC Strategy for Synchronous Reluctance Motors in High Speed Range
Xiang Shuguang, Zhang Xinan and Gilbert Foo Hock Beng,
School of Electrical and Electronic Engineering, Nanyang Technological University

Abstract: This paper presents a modified hysteresis-based direct torque control (DTC) for synchronous reluctance machines. The proposed method is utilized to achieve high torque capability in flux weakening region. It will be shown that hysteresis-based DTC is established by two hysteresis comparators. A higher torque capability is fulfilled by switching only the optimized voltage vector during torque dynamic condition, instead of alternating between two vectors. The selection of optimized voltage vector can be implemented by modifying the flux error status generated by the stator flux comparator before it is fed to the switching table. The main benefit of the proposed method is its simplicity because it requires only a minor modification to conventional hysteresis-based DTC and does not require a space vector block. The effectiveness is verified by simulation.

Loss Minimization for Dynamic Load Trajectories on Induction Machine Drives without Torque Performance Degradation
Yuying Shi, Yukai Wang, Robert D. Lorenz
WEMPEC, University of Wisconsin-Madison, USA

Abstract: This work is to provide a systematic loss minimizing solution for general dynamic load profiles on induction machines, without compromising desired torque dynamics. The drives use deadbeat-direct torque and flux control (DB-DTFC), in which torque production and stator flux linkage are fully decoupled and the Volt-sec (incremental stator flux linkage) vectors are the manipulated inputs. Stator flux linkage, as a separate degree-of-freedom, can be controlled dynamically to minimize machine losses at the same time that torque follows the commanded trajectory. With properly formed loss models and accurately captured machine dynamics, dynamic programming is adopted to generate loss minimizing stator flux trajectories for given load trajectories. A sinusoidal approximation for cyclic loading profiles and typical servo velocity profiles with large torque steps, are used to evaluate the proposed solution. Two filter-based methods which have been developed specifically for cyclical loading and servo velocity trajectories, respectively, are compared with the proposed method with respect to energy saving capability. Compared to the existing filter-based solutions, both simulation and experimental results demonstrate the proposed approach achieves better energy savings during the standard industrial trajectories examined here.

Influence of an FPGA-based Switching Angle Dithering on Acoustics in Single-Pulse Controlled Switched Reluctance Machines
Daniel Scharfenstein, Bernhard Burkhart and Rik W. De Doncker
Institute for Power Electronics and Electrical Drives, RWTH Aachen University, Germany

Abstract: Switched Reluctance Machines (SRM) are considered as a competitive alternative to conventional rotating field machines, especially in terms of production costs and robustness. Single-pulse operation is often employed to control the SRM above base speed, as it yields a beneficial high efficiency. A serious drawback of SRMs is their unpleasant acoustic behavior, which is hard to control in single-pulse operation. Thus, optimization of SRMs’ acoustics is an important subject. This work proposes and examines dithered switching angles in order to improve the acoustic
behavior of SRMs in single-pulse operation. Different strategies to randomly change the switching angles are evaluated in simulation. The influence on the acoustic behavior is characterized by means of surface normal velocity and the psychoacoustic indicators loudness and sharpness. The results are verified in measurements for a 20kW Switched Reluctance Generator (SRG) using an FPGA-based controller. The results of the proposed strategy yield slightly better acoustic behavior. The sharpness of the SRG’s noise is reduced whereas the mean-square surface normal velocity is nearly kept constant. This is due to the intended cover up effect of the dominant peaks in the frequency spectrum when dithered switching angles are employed.

324 Average Torque Control with Current-Peak Regulation in Switched Reluctance Motors
Niwantha Fernand, Mike Barnes
School of Electrical and Computer Engineering, RMIT University, Melbourne, Australia
School of Electrical and Electronic Engineering, The University of Manchester, UK

Abstract- Switched Reluctance (SR) Motors are favoured in applications that require torque control over a wide speed range. The control of torque in the low speed range with current chopped mode is well known. However, strategies to control average torque in single pulse mode and dynamic transition between these two modes remain to be fully developed. This paper proposes a current-peak regulation method to control the torque in the above two modes of operation of SR motors. The proposed current-peak control method allows seamless transition between the two modes. The proposed control technique is evaluated with finite element model based results and is validated with experimental results.

367 Reduced Torque Ripple and Switching Frequency using Optimal DTC Switching Strategy for Open-End Winding of Induction Machines
Power Electronics and Drives Research Group, CeRIA/FKE, Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, Durian Tunggal, Malacca, Malaysia

Abstract- This paper presents an optimal switching strategy to minimize torque ripple and switching frequency for Direct Torque Control of induction machines. In this proposed method, two inverters are connected to the terminals of open-end windings of an induction machine. By doing so, number of voltage vectors is greater same as available in three-level multilevel inverters. The most optimal voltage vectors will be used to improve DTC performances, i.e. reduced torque ripple and switching frequency. The identification of the vectors are based on operating conditions, specifically by examining the behaviors of torque error and switching frequency of error status produced from the hysteresis controllers. It can be shown that, the proposed optimal switching vectors according to the operating conditions can reduce the rate of change of torque and hence minimize torque ripple and switching frequency. The improvements offered in the proposed method were verified through experimental results.
Abstract- In a high altitude wind power (HAWP) generating system, the generation of wind power is carried out at high altitude above the earth surface and control of power generation is accomplished at the ground based station. Three phase medium voltage permanent magnet synchronous generator (PMSG) is used as the source of power generation in the air-born unit. The ground based power electronic converters (PECs) are used for maximum power-point tracking (MPPT) of the air-born wind turbine (AWT). Optimal torque/vector control of the PMSG is best suited for MPPT of HAWP application. The proposed method does not use mechanical sensor in the air-born system to measure the rotor position. The phase-lock-loop (PLL) is employed to estimate the rotor position, which is used for calculation of MPPT torque/current reference. The AWT is controlled using ground based power conversion system comprising of three-level neutral point clamped (NPC) rectifier for generation side MPPT control. The proposed MPPT control algorithm of the PMSG is validated using MATLAB/Simulink. A 1 kW PMSG generation system prototype is designed in the laboratory and used for experimental validation of the proposed MPPT method.

341 MOSFET Loss Evaluation for a Low-Power Stand-Alone Photovoltaic-LED System

Maria C. Mira, Arnold Knott, Michael A. E. Andersen
Dept. Electrical Engineering Technical University of Denmark Oersteds Plads, 349. Kongens Lyngby, Denmark

Abstract- This paper presents a performance evaluation and comparison of state-of-the-art low voltage Si MOSFETs for a stand-alone photovoltaic-LED Light to Light (LtL) system. The complete system is formed by two cascaded converters that will be optimized for a determined solar irradiation and LED illumination profiles. The comparison is performed based on dynamic characterization and evaluation of the devices energy loss at different current levels.

350 Interleaved DC-DC Converter with Lead-acid Storage Batteries for Power Regulation of Gridconnected Variable-speed Wind Turbine

Tarek Ahmed, Katsumi Nishida, Mutsuo Nakaoka
E & E Dept., Assiut University, Assiut, Egypt
Ube National College of Technology, Ube City, Yamaguchi, Japan
Kyungnam University, Masan, Kyungnam, South Korea

Abstract- This paper presents a small-scale grid-connected wind power conversion system (WECS). The fluctuating output power of the WECS is regulated and kept constant using an interleaved dc-dc converter with 8 lead acid storage batteries connected in series. The control of the battery management system is designed to optimize the use of the 12V, 99Ah advanced Thin Plate Pure Lead (TPPL) lead acid battery, and to prolong the life of the battery with maintaining the integrated wind power delivered to the grid constant. Maximum power point tracking (MPPT) is incorporated into the battery management system, to maximize the output power of the wind turbine driven 1.5 kW interior permanent magnet synchronous generator(PMSG). Instead of using the two-level voltage source inverter, the three-level one is designed and constructed for the grid-integration of the variable-speed wind turbine to highly reduce the switching frequency without increasing the ripple components in the grid-side current of the LCL filter. The experimental results confirm that the proposed control of lead acid storage battery makes the overall system more reliable and cost effective.
426  A New MPPT Technique for the Maximization of Overall System Output in Solar Generation
Huaqian Wang, Lokesh Vinayagam, Hao Jiang, ZhiQiang Cai, Qiang Ni and Hongqun Li
EEE School, Singapore Polytechnic, Singapore
Singapore PowerGrid, Singapore

Abstract- Various maximum power point tracking (MPPT) methods used in solar generation systems have one common point, that is, they all select the output of the solar array as their control target and try to make it maximum. However, a typical solar generation system consists of a solar array and a DC/DC converter. Making the output of the solar array maximum does not certainly result in the maximum DC/DC converter output because the efficiency of the DC/DC converter is dependent upon its input voltage and current and will affect the overall output of the system. This paper describes a new MPPT technique which considers the solar array and the DC/DC converter as one system and maximizes the overall system output. The experiment results verified the validity of the method and some discussions on the new method are made.

519  Dual Inverter System with Integrated Energy Storage for Grid Connected Photovoltaic Systems
S. D. G. Jayasinghe and D. M. Vilathgamuwa
Australian Maritime College, University of Tasmania, Launceston, Australia
Queensland University of Technology, Brisbane, Australia

Abstract- Smooth and fluctuation free power dispatch is strongly encouraged by grid operators and therefore energy storage is becoming an indispensable part in modern large scale grid connected photovoltaic (PV) systems. As a result, associated power converter topologies and energy storage interfacing technologies are currently receiving unprecedented attention. The most common energy storage interfacing technique used in grid connected PV systems is the use of an additional power electronic converter between the energy storage system and the grid connecting inverter. Taking the disadvantages of this implementation into account this paper proposes a dual inverter based battery direct integration scheme for grid connected PV systems. In this approach, the generation of proper multilevel voltage waveforms is a complicated process, particularly when the battery is charging. A modified space vector modulation method and switching strategy are proposed in this paper to address this issue. Simulation results are presented to prove the efficacy of the proposed topology and the modulation technique.

Session ADEM-I: Analysis & Design of Electrical Machines I
Date/Time: Friday, 12 June 2015/09:00 – 10:30 hrs
Venue: Room 1 @ Level 4
Session Chair: King-Jet Tseng, Nanyang Technological University, Singapore

73  Proposal of Pancake Axial-Air-Gap-Type Self-Excited Wound-Field Synchronous Motor
Masahiro Aoyama and Toshihiko Noguchi
Department of Environment and Energy System, Shizuoka University, Japan
Department of Electrical and Electronics Engineering, Japan

Abstract- This paper proposes a pancake type synchronous motor where the space harmonics power is effectively utilized for the field magnetization instead of the permanent magnets. The pancake
axial-gap structure, i.e., a single stator with double rotor configuration, can take great advantage to improve the mutual inductance which is indispensable for self-excitation of the magnet field. The advantages of the proposed motor in terms of the torque density is clarified with the FEM based simulation results. In addition, preliminary experimental test result is demonstrated from the viewpoint of the principle of self-excitation.

109  Development of a compact and low cost axial flux machine using soft magnetic composite and hard ferrite

R. Kobler*, D. Andessner, G. Weidenholzer* and W. Amrhein†
*Linz Center of Mechatronics GmbH, Austria
†Institute for Electrical Drives and Power Electronics, Johannes Kepler University, Austria

Abstract- Especially for automotive applications, the request for small, lightweight, powerful and cheap electrical machines is tremendous - not only for the drivetrain in electrical vehicles but also for ancillary components like air conditioning compressors, starters/generators or pumps. In terms of small size and high power to weight ratio, the use of permanent magnets, especially rare earth magnets is essential. However, rare earth permanent magnets (PM’s) have several concerns caused by a very concentrated resource market, which has already caused unpredictable price increase or export restrictions. Therefore, it is the goal to avoid rare earth magnets on the one hand but, on the other hand, keep the characteristics of a machine for the automotive industry. The combination of hard-ferrite magnets and soft magnetic composites, combined in an axial flux motor topology is a promising approach to fulfill the requirements of a high power density, low-cost and rare earth magnet-free machine. The designed motor structure with ferrite PMs replacing the rare earth PMs and the results of three-dimensional finite element analyses are introduced in detail in this paper. Moreover, a prototype with 600W nominal output power was produced and tested.

198  Influence of Magnet Arrangement on Torque Characteristics of Dual-Rotor PMSMs

Shunsuke Fujiwara, Shigeo Morimoto, Masayuki Sanada, and Yukinori Inoue
Graduate School of Engineering Osaka Prefecture University, Japan

Abstract- Permanent magnet synchronous motors (PMSMs) are increasingly been used in home electric appliances and electric vehicles/hybrid electric vehicles for high performance and high efficiency. Among the different rotor structures in PMSMs, it is expected that the dual-rotor structure can achieve a higher torque than the conventional single-rotor structure. In this paper, various types of dual-rotor PMSMs with different magnet arrangements are examined to investigate the influence of different magnet arrangements on the torque characteristics of the dual-rotor PMSM. In addition, we describe a magnet arrangement suitable for high torque production in the inner and outer rotors.

355  The Closed-Loop Design of Inverse Class-E Power Amplifier for Wireless Energy Transmission System

Hongfeng Shen (1), Wenxiao Gu (1), Yongliang Zhang (2), Menglian Zhao (1), Hongjia Wu (1), and Xiaobo Wu (1)
(1) Institute of VLSI Design, Zhejiang University, Hangzhou, China
(2) Changzhou TOPIC Semiconductor Technology Co. Ltd. Changzhou, China

Abstract- This paper presents an optimal design methodology and a closed-loop control strategy for inverse Class-E power amplifier. An inverse Class-E power amplifier being utilized as the wireless energy transmitter makes the system more miniature and efficient. The load impedance is
considered as a variable, and the inverse Class-E amplifier keeps operating in the optimal state when the load network changes by adjusting the duty cycle and frequency of the switching voltage. Corresponding closed-loop control circuits are designed with the process of SMIC 0.18 μm 3.3V. Simulation results verify the closed-loop design and show that with a 20% tolerance range of the output load network, the inverse Class-E amplifier can keep working in the optimal state.

A preliminary Study of the Effect of Saturation and Cross-Magnetization on the Inductances of a Fractional-Slot Concentrated-Wound Interior PM Synchronous Machine

A. Pouramin, R. Dutta, M. F. Rahman, J. E. Fletcher and D. Xiao
School of Electrical Engineering and Telecommunications, The University of New South Wales

Abstract- Accurate determination of the variation of inductances with respect to increase in current is necessary to characterize the behavior of a Permanent Magnet Synchronous Machine (PMSM) under saturation. This is even more crucial in the Fractional Slot Concentrated Wound Interior PM synchronous machine (FSCW IPMSM) because of increased spatial harmonics in the magnetomotive force (MMF) waveform. This paper attempts to determine the variation of inductances of a prototype FSCW IPMSM due to saturation and cross-magnetization effects. The variation of incremental and apparent inductances and their effect on voltage equations are investigated. The flux-linkage calculation method was used to calculate the incremental and apparent inductances for a wide range of operating points including constant torque and flux-weakening regions. The results of a Finite Element (FE) model which agree well with the experimental results were used to further investigate the inductance characteristics.

Session HSSS-I: Hard-Switching and Soft-Switching Static Power Converters and UPS I

Date/Time: Friday, 12 June 2015/09:00 – 10:30 hrs
Venue: Room 2 @ Level 4
Session Chair: Mohan Lal Kolhe, University of Agder, Norway

Design of A Cascade High Gain Soft-Switching Boost Converter

Yuang-Shung Lee, Wei-Chiao Lin and Ling-Chia Yu
Department of Electrical Engineering Fu Jen Catholic University, Taiwan

Abstract- This paper proposed a high voltage conversion ratio cascade boost converter topology composed two stages of converters. First stage boosts the input source voltage twice larger by using the double-mode switched-capacitor cells converter (SCC). Second stage provides a high voltage conversion ratio boost converter with a couple inductor and diode-capacitor (DC) snubber. For achieving higher efficiency, soft-switching technique is used to design the proposed converter. The converter topology analysis and design are described in detail. Results of simulation and experimental measurements are carried out to verify the performances of the proposed high voltage conversion ratio cascade boost converter under continuous conduction modes.

Smooth Filtering DC Link Type Soft-Switching Two-Stage Power Conditioner

Srawouth Chandhaket, Koki Ogura and Mutsuo Nakaoka
Department of Electrical Engineering Walailak University
Kawasaki Heavy Industry Kobe, Japan
Department of Electrical Engineering University of Malaya, Malaysia
Abstract- This paper introduces a power conditioner with two stages of power conversions. The first stage is the DC boost chopper with the passive auxiliary resonant snubber-assisted soft-switching circuit. The second stage is the sinewave PWM inverter with the active auxiliary resonant snubber-assisted soft-switching circuit. The inverter part is made of half-bridged configuration to limit the number of the circuit elements and to be connected to a normal resistant load. Finally, it is shown that all power switches are operated on the basis of soft-switching and the results are verified by both computer simulations and experiments.

385 New Conceptual High Efficiency Sinewave PV Power Conditioner with Partially-Tracked Dual Mode Step-up DC-DC Converter

Koki Ogura, Srawouth Chandhakhet, Saad Mekhilef and Mutsuo Nakaoka
Kawasaki Heavy Industries, Ltd., Japan
Walailak University, Thailand
University of Malaya, Malaysia

Abstract- This paper presents a novel circuit topology of a high efficiency single-phase sinewave PV power conditioner. This power conditioner is composed of time-sharing sinewave absolute pulse width modulated boost chopper with a bypass diode in the first power processing stage and time-sharing sinewave pulse width modulated full-bridge inverter in the second power processing stage operated by time-sharing dual mode pulse pattern control scheme. Its unique operating principle of two power processing stage with time-sharing dual mode sinewave modulation scheme is described with a design example. This paper also proposes a sinewave tracking voltage controlled soft switching PWM boost chopper with a passive auxiliary edge-resonant snubber. The new conceptual operating principle of this novel single-phase sinewave power conditioner related to solar photovoltaic generation system is presented and discussed through the experimental results.

415 ZCS Interleaved Boost Converter with Saturable Inductors for Reverse-Recovery Reduction

Wilmar Martinez, Jun Imaoka and Masayoshi Yamamoto
Shimane University

Abstract- Conventional DC-DC step-up converters present problems of low efficiency and low power density because of: 1. High power losses caused by hard-switching and reverse-recovery phenomenon. 2. High conduction losses produced by large peak currents when the converter has to operate at a high duty cycle. 3. Bulky and heavy cooling systems needed to dissipate the semiconductors losses. And, 4. Big and heavy capacitors and inductors required for smoothing and decoupling. Therefore, a novel Zero-Current-Switching two-phase interleaved boost converter with saturable inductors for reverse-recovery reduction is proposed. This converter can reduce the switching losses in the semiconductors due to the effect of the saturable inductors. Moreover, downsizing of the inductors and the output capacitor can be achieved due to the interleaving technique and the use of saturable inductors. In addition, high step-up operation can be achieved due to the presence of tapped-inductors. In this paper, the circuit configuration and the operation principle of the proposed converter and the reverse-recovery reduction behavior are presented. Finally, the effectiveness of the proposed converter is experimentally validated with a 600W prototype where a recovery-reduction of 58% was achieved.
107 Multiple-Pole Multilevel Diode Clamped Inverter for Permanent Magnet Synchronous Motor Drive
Pinkymol Harikrishna Raj, Ali I. Maswood, Gabriel H. P. Ooi and Hossein Dehghani Tafti
School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore

Abstract- A five-level reduced device multilevel inverter is proposed for driving permanent magnet synchronous motor. The proposed multilevel inverter drive consists of lesser number of clamping diodes compared to the conventional five-level diode clamped inverter. An active balancing circuit is used to provide balanced voltages across the four dc-link capacitors to ensure five-level voltage waveform in all operating conditions. The field oriented control of a permanent magnet synchronous motor using space vector modulation technique is implemented to investigate the performance of the proposed inverter drive and results are presented based on simulation done in Matlab/Simulink® and PSIM environment.

137 Stator reference frame approach for DC injection-based stator resistance estimation in electric drives
Giovanni Zanuso, Luca Peretti, Paul Sandulescu
ABB Corporate Research, Department of Electrical Systems, Sweden

Abstract- This work discusses an online stator resistance estimation method for synchronous machines. Multiple improvements are provided with respect to a similar method already been used for induction machines. The method is based on the temporary injection of a DC voltage in the machine phases during normal operation. The stator resistance estimation is obtained by means of the Ohm’s law. The proposed scheme works entirely in the stator fixed reference frame, without the need of any machine parameter.

The selection of the DC injection level is discussed, as well as the countermeasures for reducing the spurious harmonics appearing in the currents and the torque when the machine is speed and current-regulated. In particular, minimum electric loss and minimum torque ripple due to the injection is achieved. Moreover, as an alternative to conventional low-pass filtering of the measured signals, it is shown that the resistance estimation can be obtained by averaging the signals over few electric periods. Experims prove the validity of the proposed approach.

278 Rapid Demodulation of Rotor Position for High Frequency Voltage Injection Based IPM Machine Sensorless Control
Tianhao Wang, John Xu
University of Nottingham Ningbo, China

Abstract- A rapid demodulation process of position sensorless control was investigated for Interior Permanent Magnet Synchronous Machine (IPMSM) drive system. In this method, the rotor position is derived with the demodulation of stator current based on high frequency rotating voltage injection. Fundamental component of rotor position signal is isolated from high frequency components containing useless information by synchronization with the angle of high frequency rotating voltage vector. With the comparison between the synchronizing angle deriving from the command voltage and the directly measured voltage value, the estimation performance is studied with respect to the effects introduced by inverter non-linearity. With instantaneous voltage measurement, the proposed method is superior in easiness of implementation, rapid estimation process and insensitivity to the effects on estimation accuracy arisen from the non-ideal behaviors of pulse width modulation and the voltage source inverter.
322 Necessary Calculations of Ultra-Light Overhead Conveyor Systems for In-House Transportation
Batim Latif Aylak (1), Cyril Alias (1), Hermias C.N. Hendrikse (2), Bernd Noche (1)
(1) Department of Transport Systems and Logistics, University of Duisburg-Essen, Duisburg, Germany
(2) ESTEQ Engineering (Pty) Ltd, Pretoria, South Africa

Abstract- Due to the ever-increasing level of global competition, logistics companies face difficult challenges on a daily basis. In order to survive this competition, they need to develop new technologies. The term ultra-light overhead conveyor system is relatively novel to the logistics industry. It is a rope-based conveying system in which the vehicles can move automatically on the rope using a specific mechanism which drives the vehicle. The concept and design of an ultra-light overhead conveyor system are explained by using Computer-Aided Design (CAD) software. The operating time of the vehicles and recharge time of batteries are calculated, a number of assumptions as well as some rope sag calculations are made according to different scenarios. A discrete event simulation model is built using Tecnomatix Plant Simulation in order to test the impact of certain variables on the performance of the system.

339 Reduction of DC Link Capacitor Stress for Double Three-phase Drive Unit through Shifted Control and Phase Displacement
Bruno Basler, Thomas Greiner and Peter Heidrich
Pforzheim University Pforzheim, Germany

Abstract- In automotive industry space is extremely limited. The efficient and fast control of electric motors is a key technology to save energy and space. This paper shows strategies to improve energy consumption of a redundant Voltage Source Inverter (VSI) and an associated double three-phase Permanent Magnet Synchronous Motor (PMSM). Focus is to significantly reduce the DC link power dissipation of the power electronics to extend life time or to reduce the capacity and thus the size required to install the capacitors. In particular, shifted control technique and in addition phase displacement are developed and implemented on a drive unit used in automotive application to control the multi-phase system. Analytical calculations show that these strategies reduce the DC link capacitor effective current value. The conventional three-phase PMSM is compared with the double three-phase PMSM run with the new control strategies.

Session RET-II: Renewable Energy Technologies II
Date/Time: Friday, 12 June 2015/09:00 – 10:30 hrs
Venue: Room 4 @ Level 4
Session Chair: Dylan Lu, University of Sydney, Australia

68 The Impact of Traveling Waves on HVDC Protection
Oliver Cwikowski, Mike Barnes, Roger Shuttleworth
The University of Manchester

Abstract- The development of High Voltage Direct Current (HVDC) protection technology is a necessary step in the development of high power Voltage Source Converter (VSC transmission grids. Presently, only a few industry prototypes have been developed for VSC HVDC grid applications[1-3] However, before any piece of equipment can be installed, it must be subject to testing to prove it is capable of working. These tests are based upon operational experience and/or
theoretical analysis of the system it is to be placed in. To date, no VSC HVDC circuit breaker is in commercial operation. Developing knowledge around the testing of the circuit breaker is an important step on the road to HVDC grids. This paper discusses the impact of traveling wave phenomena on the testing of HVDC circuit breakers for VSC applications, derives theoretical calculations to describe the phenomena and compares this to PSCAD simulations of a VSC under DC side pole-to-pole faults.

102 A LIN Inspired Optical Bus for Signal Isolation in Multilevel or Modular Power Electronic Converters
Mark A. H. Broadmeadow and Geoffrey R. Walker
School of Electrical Engineering and Computer Science
Queensland University of Technology Brisbane, Australia

Abstract- Proposed in this paper is a low-cost, half-duplex optical communication bus for control signal isolation in modular or multilevel power electronic converters. The concept is inspired by the Local Interconnect Network (LIN) serial network protocol as used in the automotive industry. The proposed communications bus utilises readily available optical transceivers and is suitable for use with low-cost microcontrollers for distributed control of multilevel converters. As a signal isolation concept, the proposed optical bus enables very high cell count modular multilevel cascaded converters (MMCCs) for high-bandwidth, high-voltage and high-power applications. Prototype hardware is developed and the optical bus concept is validated experimentally in a 33-level MMCC converter operating at 120 Vrms and 60Hz.

346 Three-phase Four-leg Type PCS with Individual Phase Control Algorithm for Compensating Unbalance Loads using ESS
Chang-Soon Kim (1), Minwon Park (1), In-Keun Yu (1), Gyeong-Hun Kim (2), and Chul-Sang Hwang (2)
(1) Changwon National University
(2) Korea Electrotechnology Research Institute

Abstract- The power systems have encountered with a problem such as unbalance current due to loads unbalance. Particularly, the problem rises in the small scale grid such as a microgrid that is installed in remote country and island which are difficult to reach existing power grid. To solve the unbalance current of the grid, we usually use compensators for balancing the current of the grid. In this paper, the authors propose a power conditioning system (PCS) using energy storage system which has not only normal operation functions but also a compensation function of the unbalance current of the grid without special compensators. The proposed PCS is modeled and simulated using PSCAD/EMTDC to demonstrate the effectiveness of the system.

453 On Modular Multilevel Converters-based Batteries Energy Storage Systems
A. Lachichi
ABB Corporate Research Centre, Sweden

Abstract- This paper presents the analysis of the modular multilevel converter with integrated batteries energy storage and highlights the influence of the active power injected to the grid from the batteries in order to compensate for ac voltage grid asymmetries. The control objective of the converter is to maintain a balance between the phase-leg of the converter and between the arms of each phase. The development of such algorithm relies on the injection of a common ac voltage that oscillates at the fundamental frequency. By redefining the circulating current in order to rebalance
the ac grid voltage asymmetries, it is shown through simulation results that the current injected by the batteries is capable of maintaining the cells well balanced.

Session ADEMGII: Analysis & Design of Electrical Machines II
Date/Time: Friday, 12 June 2015/11:00 – 12:30 hrs
Venue: Room 1 @ Level 4
Session Chair: King-Jet Tseng, Nanyang Technological University, Singapore

183 DSP-based 3D Printed Resolver-to-Digital Conversion System
Chung-Chuan Hou and Han-Wei Lin
Chung Hua University, Taiwan, R.O.C.

Abstract- This study compares a 3D printed resolver with a conventional resolver. The advantages of the 3D printed resolver are cheap, easy manufacture and modification. The equivalent circuit, transfer function, and Bode diagram of the resolver are presented and discussed. Furthermore, a digital signal processor (DSP)-based resolver-to-digital conversion system for 3D printed resolver and conventional resolver is built to validate the performances of the proposed scheme.

193 Design and Optimization of a Special Magnetic Levitated Drive with Unbalance Robustness
Andreas J. Pröll, Gerald Jungmayr, Edmund Marth and Wolfgang Amrhein
Institute for Electrical Drives and Power Electronics, Johannes Kepler University, Austria

Abstract- This paper deals with the design of a passively damped magnetic bearing system in a special construction form powered by a BLDC Motor. Special attention was given to the optimization of the mechanical system in order to minimize oscillation amplitudes due to unbalanced excitation and decay times. In addition, the main components of the presented drive, the magnetic bearings and the BLDC-motor, were optimized for the determined construction space. The internal rotor is stabilized with passive magnetic bearings in radial and tilt directions and by an active magnetic bearing in axial direction. For the damping of the system, the stator is supported by elastomer rings. These damping elements lead to a significant reduction of rotor vibration, because the passive magnetic bearings show negligible damping. Rotor-dynamic effects were examined at the built magnetic bearing system and the theoretical models were verified.

197 Investigations on Permanent Magnetic Materials to be used in Explosion-protected Permanent Magnet Synchronous Machines
Nijan Yogal (1), Christian Lehrmann (1) and Markus Henke (2)
(1)Explosion-protected Electrical Drive Systems, Physikalisch-Technische Bundesanstalt, Germany
(2)Institute for Electrical Machines, Traction and Drives, Technische Universität Braunschweig, Germany

Abstract- Due to the high energy-saving potential (or energy efficiency) during full or in the partial-load range, the manufacturers desire to use a permanent magnet synchronous machine also in potentially explosive atmospheres. The safe operation of a permanent magnet synchronous machine (PMSM) in potentially explosive atmospheric environments requires a better understating of temperature build-up on the the permanent magnet rotor and the effect of temperature on the surface or interior of the permanent magnet. The magnetic properties of neodymium iron boron (NdFeB) magnets need to be considered properly while designing, manufacturing and operating the machines.
The long-term effect of NdFeB-based magnets at high temperatures and their corrosion behavior have to be studied due to the irreversible loss of magnetic properties.

311 Characterisation and Modelling of Automotive Lundell Alternators
Dimitrios Sarafianos, Richard A. McMahon, Timothy J. Flack(1), Stephen Pickering(2)
(1)Department of Engineering, University of Cambridge, Cambridge, United Kingdom
(2)Jaguar Land Rover Ltd, Coventry, United Kingdom

Abstract- This paper presents an electromechanical model of the Lundell alternator which can easily be defined from a set of electrical tests. The means of inferring the model parameters are discussed in the following sections. Steady-state results from the simulation are compared against the experimental measurements for a Lundell alternator using a test-rig. The model captures the main features of the alternator achieving a good match with the experimental results.

408 An Improved Dynamic Model for a Single-Phase Generator based on Three-Phase Cage Rotor Induction Machine
Diana Liyanage and Sumedha Rajakaruna
Department of Electrical and Computer Engineering, Curtin University Perth, Australia

Abstract- An improved dynamic model for recently introduced single-phase induction generator based on a three-phase cage rotor induction machine is presented in this paper. In this generator topology one of the three windings of three-phase induction generator is used as the excitation control winding and remaining two windings connected in series are used as the output winding. The dynamic model of this single-phase generator system presented in some papers is based on a few assumptions which are not adequately represented the machine. In improved mathematical model, the non linear behavior of magnetizing reactance in the saturated region and the effect of core resistance have been taken into account. The comparison of experimental and simulation results confirms that the improved dynamic model is much more accurate than the existing model.
under the zero-voltage-switching (ZVS) condition, leading to a high circuit efficiency. A prototype circuit designed for a 20Ω load is built and tested to verify the theoretical predictions. The measured maximum energy conversion efficiency of the proposed novel single-switch series resonant converter topology reaches up to 95.1%. The experimental results reveal satisfactory performance.

236 Phase Accumulated Carrier Pulse Width Modulation
Geoffrey R. Walker, Mark A. H. Broadmeadow, and Gerard F. Ledwich
School of Electrical Engineering and Computer Science, Queensland University of Technology, Brisbane, Australia

Abstract- An alternative approach to digital PWM generation uses an accumulator rather than a counter to generate the carrier. This offers several advantages. The resolution and gain of the pulse width modulator remain constant regardless of the module clock frequency and PWM output frequency. The PWM resolution also becomes fixed at the register width. Even at high PWM frequencies, the resolution remains high when averaged over a number of PWM cycles. An inherent dithering of the PWM waveform introduced over successive cycles blurs the switching spectra without distorting the modulating waveform. The technique also lends itself to easily generating several phase shifted PWM waveforms suitable for multilevel converter modulation. Several example waveforms generated using both simulation and FPGA hardware are presented.

250 Comparison and Evaluation of Sub-Module Configurations in Modular Multilevel Converters
Georgios Konstantinou (1), Jiaqi Zhang (1), Salvador Ceballos (2), Josep Pou (1), (3) and Vassilios G. Agelidis (1)
(1) UNSW Australia, Sydney, NSW, Australia
(2) Tecnalia Innovation and Research, Spain,
(3) Technical University of Catalonia, Catalonia, Spain,

Abstract- The application and research interest over modular multilevel converters (MMCs) has grown significantly over the last couple of years. The term MMC has been expanded to include all converters built on the series connection of sub-modules (SMs) as a basic building block forming converter arms and phaselegs. A review of the current literature reveals an abundance of SM configurations ranging from SMs derived from the well-known multilevel converter topologies to novel configurations targeted to niche MMC applications. This paper provides a comprehensive review of the current SM configuration state and a comparative evaluation based on complexity of configuration, voltage balancing and component count. It also provides an evaluation of switching and conduction losses for the devices within each SM, identifying those SMs that are more suitable to general MMC applications.

334 Highly Efficient ZCS Boost Converter Used in Rechargeable Batteries
Ying-Chun Chuang, Hung-Shiang Chuang, Chun-Hsiang Yang and Jung-Fang Chou
Department of Electrical Engineering, Kun Shan University, Taiwan, R.O.C
Department of Electrical Engineering, Kao Yuan University, Taiwan, R.O.C
Mechanical and System Research Laboratories, Industrial Technology Research Institute, Taiwan, R.O.C

Abstract- This work develops a highly efficient zero-current-switching (ZCS) boost converter used in rechargeable batteries. An auxiliary power switch in series with the resonant tank enables the
semiconductor devices in the charger circuit are to be turned on and off by soft switching. The
developed charger topology practically eliminates the charging current ripple in the battery,
maximizing battery life without increasing the volume of the converter. Therefore, a battery charger
with the proposed ZCS boost converter can be operated with low switching power losses. No
additional voltage or current stresses are caused on the auxiliary switch or auxiliary diode.
Additionally, the proposed ZCS boost converter for rechargeable batteries has a simple structure,
low cost, light weight, ease of control, and high efficiency. The operating principles and design
procedure are analyzed and discussed in detail. The optimal values of the pertinent properties of the
resonant components are determined from the characteristic curve and the electric functions that are
obtained from the circuit configuration. Simulation results and experimental results obtained using a
laboratory prototype demonstrates the feasibility of the proposed topology. Finally, a prototype
circuit that is designed for a 24V-50Ah lead-acid battery bank is built and tested to confirm the
theoretical predictions. The maximum charging efficiency of the proposed topology throughout the
overall charging period is 95.8%. Experimental results reveal the satisfactory performance of the
proposed topology, which is especially suitable for battery charging applications.

369 Switching Period Randomisation for Multilevel Converter Modulation
Geoffrey R. Walker and Gerard F. Ledwich
School of Electrical Engineering and Computer Science Queensland University of
Technology, Brisbane, Australia

Abstract- The spectral energy associated with the carrier and sidebands of naturally sampled carrier
based PWM can be spread by randomising the carrier (switch) half-period \( T_c = 1/2f_c \). So long as the
switch duty cycle each period still correctly reflects the value of the modulating fundamental
waveform as sampled during that switch period, then the fundamental component will remain
undistorted. Natural sampling will ensure this occurs. Carrier based PWM can be extended to \((m+1)\)
level multilevel converter waveform generation by creating \( m \) triangular carriers, each with an equal
\( 2 \pi /m \) phase displacement. Alternatively the carrier disposition strategy calls for \( m \) amplitude
displaced triangular carriers, each of amplitude \( 1/m \) and frequency \( m f_c \). Randomising these carrier
sub-periods \( T_0 = 1/2m f_c \) is shown to generate \((m+1)\) level PWM waveforms where the first \((m-1)\)
carrier groups are cancelled, while the remaining carrier and sidebands at multiples of \( m f_c \) are
spectrally spread. Numerous five level simulation and experimentally gathered randomised PWM
waveforms are presented, showing the effects of the variation of the degree of randomisation,
modulation depth and pulse number.

Session MDMC-IV: Motion Drives and Motion Control IV
Date/Time: Friday, 12 June 2015/11:00 – 12:30 hrs
Venue: Room 3 @ Level 4
Session Chair: Wolfgang Gruber, Johannes Kepler Universität Linz, Austria

18 An Open-Loop Operation Strategy for Induction Motors Considering Iron Losses and
Saturation Effects in Automotive Applications
Oliver Wallscheid (1), Michael Meyer (2), Joachim Böcker (1)
(1)Power Electronics and Electrical Drives, University of Paderborn, Germany
(2)Volkswagen AG, Baunatal, Germany

Abstract- Induction motors (IM) are suitable traction drives for electric vehicles (EV). In
comparison to permanent magnet synchronous motors (PMSM) the lack of power and torque
density can be compensated by inferior production costs and a greater level of robustness. However,
IM have to be operated at maximum efficiency since the amount of stored energy is still very
limited in automotive applications and the driving energy demand is directly related to costs. To generate a certain torque with minimum losses a precise motor model considering the impact of saturation effects as well as iron losses is required. To consider these nonlinear effects a lookup table (LUT) based open-loop operation strategy (OS) in the rotor flux-oriented coordinate system is proposed. The presented approach allows a smooth transition between the constant torque and the flux weakening area as well as a high level of voltage utilisation above base speed. The LUTs can be generated offline using a maximum efficiency (ME) strategy based on finite element analysis or measured motor data. Efficiency enhancements in the range of 0.1-0.2% for a 60 kW IM in contrast to the classical minimal copper losses (MCL) strategy can be achieved.

151 Drive system loss minimizing trajectories using constrained non-linear optimization
Frederic Blank, Tobias Röser, Jörg Roth-Stielow
Institute of Power Electronics and Electrical Drives, University of Stuttgart, Germany

Abstract- In various industry applications position controlled electrical drive systems fulfill rest-to-rest motions. The control systems reference position is given by trajectories. As the trajectories have an influence on the energy losses of the components, an optimized trajectory leads to a loss minimization of the system. Therefore, by using the loss models of the mechanical components, the electrical motor and power electronics developed before, a new trajectory is calculated. It is implemented with a constrained non-linear optimization algorithm. The approach is applied for a linear drive system under various conditions and the results are validated in measurements. It is shown that this minimizes the total losses of the system which can save around 5% of energy, compared to other trajectories.

204 A Computationally Efficient FS-PTC for IM with Minimum Voltage Vectors
Md. Habibullah (1), Dylan Dah-Chuan Lu (1), Dan Xiao and (2) M.F. Rahman (2)
(1) School of Electrical and Information Engineering, The University of Sydney, Sydney, NSW, Australia
(2) School of Electrical Engineering and Telecommunications, The University of New South Wales, Sydney, NSW, Australia

Abstract—In finite-state predictive torque control (FS-PTC) scheme, torque and stator flux of induction motor (IM) are predicted for all admissible voltage vectors of a voltage source inverter (VSI). Then the predicted torque and flux are evaluated by a predefined cost function. The voltage vector which produces minimum torque and flux ripples is selected for the next control period. Most of the time of the control period is spent on prediction and actuation, and longer execution time of a control algorithm limits the sampling frequency. This is one of the main causes of degradation in torque and flux performance in FSPTC. The prediction and actuation time is greatly increased with the number of admissible switching states of the inverter. This paper proposes reduced number of switching states for prediction and actuation using stator flux position and sign of the torque deviation between reference torque and actual torque. Experimental results show that the performances of the proposed and the conventional control schemes are similar, while the execution time of the proposed control algorithm is reduced.

399 Real Time Maximum Power Conversion Tracking and Resonant Frequency Modification for High Power Piezoelectric Ultrasound Transducer
Negareh Ghasemi, Geoffrey R. Walker and Mark A. H. Broadmeadow
School of Electrical Engineering and Computer Science Queensland University of Technology Brisbane, Australia
Abstract—Piezoelectric ultrasound transducers are commonly used to convert mechanical energy to electrical energy and vice versa. The transducer performance is highly affected by the frequency at which it is excited. If excitation frequency and main resonant frequency match, transducers can deliver maximum power. However, the problem is that main resonant frequency changes in real-time operation resulting in low power conversion. To achieve the maximum possible power conversion, the transducer should be excited at its resonant frequency estimated in real time. This paper proposes a method to first estimate the resonant frequency of the transducer and then tunes the excitation frequency accordingly in real time. The measurement showed a significant difference between the offline and real-time resonant frequencies. Also, it was shown that the maximum power was achieved at the resonant frequency estimated in real-time compared to the one measured offline.

443 A Simple Potential Balancing Strategy for Neutral-Point-Clamped Inverter Fed Direct Torque Control Induction Machines
N. Faehz Alias, Auzani Jidin, Huzainirah Ismail, R.N. Firdaus, M. Khairi Rahim, Atikah Razi, Wahidah Abd. Halim
Power Electronics and Drives Research Group, CeRI/FKE Universiti Teknikal Malaysia Melaka, Malaysia

Abstract—This paper presents a simple and robust potential balancing strategy for Direct Torque Control (DTC) of induction machines. In the proposed method, a two-level hysteresis comparator is used to restrict the error voltage, i.e., difference of upper and lower capacitors voltage, within the hysteresis band. The comparator will produce suitable digitized output status to be indexed into a look-up table for selecting appropriate switching states to compensate the mismatch voltages. In doing so, the variation of two capacitors voltages can be controlled, consistently, as compared to that of using the common SVM approaches where the variation (or error of ripple) is not strictly maintained. Some experimental results are presented to highlight the improvements of DTC performances as well as the robustness of control balancing strategy for steady-state and dynamic conditions.

Session PQHSGI: Power Quality Issues, Harmonic Problems and Solutions I
Date/Time: Friday, 12 June 2015/11:00 – 12:30 hrs
Venue: Room 4 @ Level 4
Session Chair: Don Mahinda Vilathgamuwa, Queensland University of Technology, Australia

212 A Novel Control Strategy for Multi-modular Shunt Active Power Filter System
Qunwei Xu and Guozhu Chen
College of Electrical Engineering, Zhejiang University, Hangzhou, China

Abstract—In order to solve the problem of large capacity of harmonic compensation, this paper proposes a novel structure for multi-modular Shunt Active Power Filter (SAPF) system, which consists of N unified double DSP-controlled SAPFs and a monitoring unit. An average current control strategy is put forward to improve the system reliability and achieve the redundancy operation. Inside each module, a compound control strategy in abc frame combing PI control with repetitive control is adopted to ensure both the steady-state and dynamic performance. Finally, the proposed control scheme is applied to a prototype, which consists of three modular 50 kVA SAPF, and the results have validated its feasibility and validity.
An Analytical Inductor Design Procedure for Three-phase PWM Converters in Power Factor Correction Applications
Alireza Kouchaki, Farideh Javidi, N. Frerk Haase, Morten Nymand
Maersk Mc-Kinney Moller Institute, University of Southern Denmark

Abstract-This paper presents an analytical method for designing the inductor of three-phase power factor correction converters (PFCs). The complex behavior of the inductor current complicates the inductor design procedure as well as the core loss and copper loss calculations. Therefore, this paper analyzes the inductor voltage/current for sinusoidal pulse width modulation technique. Accordingly, the maximum current ripple as a function of the dc link voltage is derived and the minimum required inductance value is calculated. To explain the copper and the core losses in the inductor, the single-phase equivalent circuit is used to provide the inductor current harmonic spectrum. Therefore, using the harmonic spectrum, the low and high frequency copper losses are calculated. The high frequency minor B-H loops in one switching cycle are also analyzed. Then, the loss map provided by the measurement setup is used to calculate the core loss in the PFC application. To investigate the impact of the dc link voltage level, two inductors for different dc voltage levels are designed and the results are compared.

A Comparison between Boundary and Continuous Conduction Modes in Single Phase PFC Using 600V Range Devices
Juan C. Hernandez, Lars P. Petersen, Michael A. E. Andersen
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Abstract-This paper presents an analysis and comparison of boundary conduction mode (BCM) and continuous conduction mode (CCM) in single phase power factor correction (PFC) applications. The comparison is based on double pulse tester (DPT) characterization results of state-of-the-art superjunction devices in the 600V range. The measured switching energy is used to evaluate the devices performance in a conventional PFC. This data is used together with a mathematical model for prediction of the conducted electromagnetic interference (EMI). This allows comparing the different devices in BCM and CCM operation modes and evaluating the performance as a function of the PFC power density and efficiency.

Electromagnetic and Thermal Characterisation of PCB Planar Transformer
Lew Andrew R. Tria, Daming Zhang, John E. Fletcher
School of Electrical Engineering and Telecommunications, University of New South Wales, Australia

Abstract- A comparison of existing design guidelines for printed circuit board (PCB) planar transformers with 3D finite element analysis simulations is presented. The IPC-2152 standard for determining current carrying capacity of tracks on PCBs was compared with FEA simulated results of the transformer winding temperature rise. Core temperature rise was with manufacturer supplied thermal characteristics for planar E cores. Simulations showed large deviation from the IPC-2152 standard but a good agreement with manufacturer supplied data. Through the simulations the non-uniform distribution of temperature and hotspots in the transformer were observed which cannot be predicted by the well-known design standard for PCB tracks or design guidelines for planar transformer cores.
Implementation of Sector Change Detection Schemes for Current Error Space Phasor Hysteresis Controller Based Shunt Active Power Filters

P. N. Tekwani and Siddharthsingh K. Chauhan
Department of Electrical Engineering, Institute of Technology, Nirma University, Sarkhej-Gandhinagar Highway, Ahmedabad, Gujarat, India.
Department of Electrical Engineering, Marwadi Education Foundation’s Group of Institutions, India.

Abstract: Current harmonics injected in the utility by non-linear loads tend to deteriorate the power quality at the mains. These harmonics are compensated by Shunt Active Power Filters (SAPF). Current error space phasor based hysteresis controller for SAPF is presented in this paper, which allows precise compensation of harmonic currents produced by non-linear loads. Because of proper sector change detection logics, the proposed controller is self-adaptive in nature and does not require any particular calculation of voltage vector at the Point of Common Coupling (PCC). The controller operation is studied for two different self-adaptive logics for detection of sector changes – one with outer hysteresis band, and the other without using outer hysteresis band. The proposed controller based SAPF using outer hysteresis band compensates harmonics in supply current effectively. Distortion in supply current is further reduced by avoiding the outer hysteresis band and generating the SAPF compensating currents by synchronizing the sector change with supply frequency. The controller keeps the current error space phasor within the hexagonal boundary (fixed band) by applying SAPF voltage vectors which are adjacent to the reference voltage vector (voltage vector at the PCC). This leads to the switching of optimal voltage vector unlike the random selection of the voltage vectors in conventional hysteresis controller based schemes. Performance of the proposed controller based SAPF is analyzed for dc-link voltage regulation scheme of reference compensating current generation. The performance of controller is tested for balanced as well as unbalanced mains voltage and is found satisfactory. Experimental validations of the proposed controller based SAPF for sector change detection with and without using outer hysteresis band are presented. Detailed theoretical analysis, modelling, simulation and experimental studies are carried out and the claimed performance of the proposed controller is evident from the results presented in the paper.
Abstract- Fractional slot-concentrated wound interior permanent magnet synchronous machines (FSCW-IPMSM) display high power density and high efficiency due to the short stator end windings and absence of rotor windings. The purpose of this paper is to analyze the efficiency of a 42-pole/54-slot FSCWIPMSM under three commonly used current reference trajectory control algorithms namely zero direct axis current control ($i_d = 0$), maximum torque per ampere (MTPA) control and loss minimization (LM) control. Analysis of the experimentally measured efficiency shows that loss minimization control is not as effective as it is in the distributed winding IPM machines. A possible reason for this is that additional rotor losses that are caused by the harmonics of the magneto motive force (MMF) of the FSCW stator are not accounted in the LM control technique. It considers stator core loss due to the fundamental flux only. LM control shows an improvement of efficiency in partial load of FSCW-IPMSM. The analysis of the paper is based on test results conducted on a 4kW prototype FSCW IPMSM.

374 A New Version of Phase-Variable Modeling of an Induction Motor Using PSIM
Ming-Fa Tsai, Chung-Shi Tseng, Yu-Yuan Chen*, and Wen-Yang Peng*
Department of Electrical Engineering, Minghsin University of Science and Technology, Taiwan, ROC
*Industrial Technology Research Institute of Taiwan, ROC

Abstract- This paper presents the construction of the phase-variable model of a three-phase ac induction motor in PSIM simulation tool. The modeling can be divided into an electromagnetic part, an electromechanical part, and a mechanical part. There are two features of the constructed model block. One feature is that the three-phase inputs are circuit-based, so it can be directly connected to the inverter for integrated system simulation. The other feature is that the load torque input is equation-based, so the load torque can be more easily given by a mathematical function. The constructed model block has been compared with the available build-in model block in PSIM and MATLAB/Simulink, respectively. Simulation results show that the correctness of the constructed model in steady-state and transient responses.

395 Acoustics of a 6-Phase Transversal Flux Outer-Rotor Switched Reluctance Drive
Martin Harries, Andreas Hofmann, Rik W. De Doncker
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Abstract- Switched reluctance machines are appealing to the automotive industry due to their cost-efficiency. However, switched reluctance traction drives are likely to be unacceptably noisy. The aim of this paper is to prove that transversal-flux switched reluctance drives exhibit great vibro-acoustic benefits compared to conventional radial-flux reluctance machines. The principle of modal superposition is used to simulate run-up spectrograms for both a transversal-flux machine and a radial-flux benchmark. Modal transfer functions are determined by structural finite-element simulation. The modal excitations stem from the simulated magnetic forces during the run-ups. The comparison of the two machine types highlights the acoustic benefits of the transversal-flux machine. These advantages make it a cost-efficient and at the same time acoustically acceptable alternative to the customary permanent-magnet or induction machines in today’s electric-vehicle market.

450 Methods of reducing the computational complexity of predictive controller with induction motors
K. Wróbel, P. Serkies and K. Szabat  
Department of Electrical Machines, Drives and Measurements Wroclaw University of Technology Wroclaw, Poland

Abstract- The article presents a comparison of methods of reducing the computational complexity of predictive controller drives with induction motors, including a method for reducing the number of regions and a method of using a binary search tree. The mathematical model of the drive in question, the control strategy and the results of experimental studies are presented.

Session MDMC-V: Motion Drives and Motion Control V

87 Simulation Based Improved Analysis of BLDC Motor by Coupling FEM Motor Model with Various Switching Patterns  
Yosub Sim, Noboru Niguchi and Katsuhiro Hirata  
Department of Adaptive Machine Systems, Graduate School of Engineering, Osaka University

Abstract- Simulation based research have been widely used for analyzing characteristics of motors. In this research, a Finite Elements Method (FEM) model of an 8 pole 12 slot Brushless DC (BLDC) motor and a 3 phase BLDC motor controller are coupled together so that we can simultaneously determine the mechanical and electrical characteristics of the BLDC motor and achieve more reliable analysis results. At the analysis, various switching patterns of the high-side, half-going and both-end switching methods were simulated under 0.5 Nm load to determine and compare their effect on the BLDC motors, and determined that the 3rd switching pattern which has switching at both high and low sides before and after the high-side switching period is the most effective.

122 Integrated high-speed PMSM Drive with IMS PCB-Technology for Mobile Applications  
M.Sc. Florian Ludwig, Dr. Ing. Tobias Heidrich, PD Dr. Ing. habil. Andreas M"ockel  
Technische Universit"at Ilmenau Institute for Electric Power and Control Engineering  
Ilmenau, Germany

Abstract- The design of a permanent magnet synchronous machine with an integrated control and power circuit for sensed field oriented controlled (FOC) operation at a high power density is presented in this paper. To cool down the switching power transistors inside the machine, a single sided insulated metal substrate (IMS) PCB is used for thermal coupling of the power components with the housing of the PMSM by mounting them onto the motor end shield. The most common application field for IMS PCB-technology is the lighting industry with their power LEDs [1]. The utilization in a compact PMSM drive system is a novelty. For the angle and current measuring, the FOC-algorithm calculation and the excitation of the power transistors, a piggyback control PCB is also integrated. The system size and the voltage level are based on application standards for handheld power tools. The paper introduces the machine and PCB design of this new compound system and investigates power limitations and curve progressions such as speed, power and efficiency over torque. Also research on thermal distributions of the drive system are considered.

180 Torque Control of IPMSM to Avoid Voltage Saturation
Taketo Sugiyama*, Kazuki Morishita*, Takaharu Takeshita*, Shizunori Hamada†
*Department of Computer Science and Engineering Nagoya Institute of Technology, Japan
†MEIDENSHA CORPORATION Research & Development Group, Japan

Abstract- This paper presents the current control for the vibration torque reference of an Interior Permanent Magnetic Synchronous Motor (IPMSM) to avoid output voltage saturation of the inverter under the reduction of copper losses. The current control point for the constant component of the torque reference is determined from the references of the speed and constant torque to avoid the voltage saturation. The current reference during the period of the torque vibration is derived on the control point. The effectiveness of the proposed method has been verified by experiments.

482 A Novel Design of Rotor Position Estimator for Sensorless Control of SPMSM Operating at Medium and High Speeds
Zhao-Qin Guo and Sanjib Kumar Panda
Department of Electrical and Computer Engineering National University of Singapore Singapore

Abstract- This paper presents a novel design of rotor position estimator for sensorless control of surface-mounted permanent magnet synchronous motor (SPMSM) operating at medium and high speeds. Model reference adaptive scheme (MRAS) is employed to estimate the machine backemf signals, from which the rotor position information can be extracted. To avoid the main drawback of the conventional MRAS based estimator design which is lengthy parameter tuning, a new reference model and new estimation laws are proposed. Compared with the conventional design, the advantages of the proposed new estimator design lie in the following aspects: (1) the reference model is simpler in computing; (2) there is only one estimator parameter to be determined and can be chosen systematically according to motor operating speed; (3) the position estimation accuracy is improved by introducing a phase compensation term in the estimation algorithm. The effectiveness of the proposed estimator is verified through simulations and experimental testings.

Session PQIS-II: Power Quality Issues, Harmonic Problems and Solutions II
Date/Time: Friday, 12 June 2015/13:30 – 15:00 hrs
Venue: Room 4 @ Level 4
Session Chair: Geoffrey Walker, Queensland University of Technology, Australia

21 Application of Power Electronics in Improving Power Quality and Supply Efficiency of AC Traction Networks
Igor Perin, Peter F Nussey, Dr Umberto M Cella, Truc V Tran and Prof. Geoffrey R Walker
Aurizon, Brisbane, Australia
Queensland University of Technology, Brisbane, Australia

Abstract- Major advances in power electronics during recent years have prompted considerable interest within the traction community. The capability of new technologies to reduce the AC railway networks’ effect on power quality and improve their supply efficiency is expected to significantly decrease the cost of electric rail supply systems. Of particular interest are Static Frequency Converter (SFC), Rail Power Conditioner (RPC), High Voltage Direct Current (HVDC) and Energy Storage Systems (ESS) solutions. Substantial impacts on future feasibility of railway electrification are anticipated. Aurizon, Australia’s largest heavy haul railway operator has recently commissioned the world’s first 50Hz/50Hz SFC installation and is currently investigating SFC, RPC, HVDC and ESS solutions. This paper presents a summary of current and emerging technologies with a particular focus on the potential techno-economic benefits.
289 Comparing Total Harmonic Distortion for Cascade HBridge Multilevel Active front-end Converters with Low Carrier Ratio
Chung-Chuan Hou and Chih-Hsiang Yang
Chung Hua University, Hsinchu, Taiwan, R.O.C.

Abstract- This study compares the total harmonic distortion for cascade H-bridge multilevel (CHBML) active front-end converter with low carrier ratio. The low carrier ratio is utilized to reduce the switching loss of active front-end converters. Furthermore, the low carrier ratio is discussed with 9th, 15th and 21st carrier ratio and difference modulation index. The performances of the CHBML active front-end converter with low carrier ratio are validated by simulation results.

393 Common-mode Noise Analysis, Modeling and Filter Design for a Phase-shifted Full-bridge Forward Converter
Ishtiyaq Ahmed Makda and Morten Nymand
Maersk Mc-Kinney Moller Institute University of Southern Denmark

Abstract- This paper presents the common-mode noise analysis and modeling of a phase-shifted full-bridge forward converter. The common-mode noise source due to a transformer inter-winding capacitance is considered for the case of study. The generated common-mode noise voltage-source in a converter is analytically determined, which then leads to a common-mode noise modeling of a phase-shifted converter. Using a proposed model, common-mode noise-current harmonics are calculated and a fully analytical filter design procedure is presented to comply with the CISPR-11 standard. Finally, a prototype phase-shifted forward converter is built to verify the theoretical analysis. This study shows that the primary-to-secondary transformer winding capacitance creates a very significant amount of common-mode noise current in a phase-shifted forward converter.

400 A Control Strategy for Dynamic Voltage Restorer
Dinh Thanh Viet, Nguyen Huu Hieu, Nguyen Le Hoa and Ngo Minh Khoa
University of Science and Technology – The University of Danang, Vietnam
Quynhon University, Vietnam

Abstract- This paper presents a configuration and a control strategy for dynamic voltage restorer (DVR). In order to compensate the voltage of each phase separately, a closed-loop PI control law in the d-q reference frame is proposed. The proposed method provides a fast response and effective sag compensation capabilities. In addition, in order to detect voltage sag, a linear Kalman filter is employed to estimate three-phase voltages. By using Kalman filter, the voltage sag can be detected faster than other conventional methods. Therefore DVR can compensate voltage sag quickly and accurately. The obtained results that are simulated in Matlab/ Simulink indicate that the proposed method can mitigate the balanced and unbalanced voltage sag types efficiently in the distribution networks.

316 Case Study: Simulation of a Thin Controllable Network Transformer on the Eastern Australian Transmission Network
Hayden Wittig and John Fletcher
School of EE&T, UNSW Australia, Sydney, Australia

Abstract- FACTS devices have the capability to improve utilisation on highly reliable meshed electricity networks, however they have experienced poor adoption due to their cost, size, and
impact on reliability. Thin controllable network transformers (CNTs) can provide power flow control without many of the disadvantages of existing FACTS devices, however their capabilities in real networks are largely unexplored. This paper describes a series of simulations conducted in Matlab Simulink that applies a thin CNT to the New South Wales transmission network. The technology’s capability to resolve power flow issues in real networks is assessed, focussing on imbalanced parallel feeder loading. The simulations were conducted using three topologies and under different loading scenarios, demonstrating significant power flow control improvements of interest to utilities, with an increased capacity of up to 100MVA.

Session MSPEGI: Modelling & Simulation in Power Electronics I
Date/Time: Friday, 12 June 2015/15:30 – 17:00 hrs
Venue: Room 1 @ Level 4
Session Chair: Dilip Battul, Singapore Polytechnic, Singapore

72 Fatigue Life Prediction of IGBT Module for Metro Vehicle Traction Converter Based on Traction Calculation
Jie DING (1,2), Ping ZHAN(1), Jianghong LI(2)
(1) College of Civil Engineering and Mechanics, Xiangtan University, China;
(2) CSR Research of Electrical Technology & Material Engineering, China

Abstract- Metro vehicles start and stop frequently, which leads to complex fluctuation of IGBT module's junction temperature and induces fatigue that causes the failure of IGBT module. In order to predict the fatigue life of IGBT module, theory and method for calculating train traction, loss, transient temperature and fatigue life were analyzed, and corresponding calculation modules were developed. Line 7 of Beijing Metro was studied for which electrical parameters and loss were calculated under the rapidest traction strategy and AW2 load condition, the curve of heat pipe radiator thermal resistance versus vehicle velocity was obtained by numerical simulation, temperature curves of IGBT junction, IGBT case, diode junction, diode case and heat sink were calculated further, and the fatigue life of chips were obtained accordingly. Finally, the influence of the economic traction strategy, AW3 load condition, and the influence of ambient temperature on average chip temperature and fatigue damage was discussed.

94 High-Current Test-Bench for Thyristor-Based Semiconductors
Johannes Voss, Garrikoitz Sarregui, Fabian Rossbach, Rik W. De Doncker and Ander Ubillos
PGS - Institute for Power Generation and Storage Systems RWTH Aachen University, Germany
University of Mondragon Mondragon, Spain

Abstract- Increasingly thyristor-based converters (e.g. FACTS) are being integrated in the grids, to stabilize the distribution and transmission grids, due to the high power handling-capability of these semiconductor devices. Nevertheless, during faults, these converters need to withstand high circulating currents without failing. To investigate these scenarios, this paper presents a test bench to simulate different failure modes in a controlled environment. This test bench is able to generate symmetrical and asymmetrical sinusoidal currents up to 20 kA with a maximum duration of two seconds. Directly after the high current event, the voltage blocking capability of the thyristor is tested, by measuring the leakage current of the device under test under high voltage conditions (DUT).
345 Performance Analysis of an Analytical Calculation Tool for Dual-Active-Bridge Converters
Hauke van Hoek, Keijo Jacobs and Rik W. De Doncker
Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, Germany

Abstract- The design process of converters usually requires investigations with different abstraction levels. In this paper, an analytical calculation tool for dual-activebridge DC-to-DC converters is introduced. This tool is used during a pre-simulation design stage. Its calculations are based on idealized current shapes. One of the most important advantages is the high calculation speed: the tool is faster by a factor of 105 to 106 compared to the simulation of an ideal sample-based model. It is capable of including loss descriptions of devices to provide an insight into parameter sensitivity with respect to losses and efficiency. Ultimately, the presented approach can save a significant amount of time within the design process and make subsequent simulations more target-oriented.

448 A Clamped Feedback Based Digital Versatile Optimal Bidirectional Battery Charger for HEV/PHEV
Varun Chitransh, Amit Singh and R.K.Singh
Department of Electrical Engineering, Indian Institute of Technology (BHU), U.P. India

Abstract- Due to the increasing awareness and adoption of eco-friendly vehicle technologies, hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV) technologies have become one of the most interesting areas of research because of the reduced use of fuel and green house emission. Battery chargers are one of the most important parts in developing the HEV’s and PHEV’s. The various existing optimal battery charging techniques are constant current (CC)-constant voltage (CV) charging, pulse charging and reflex charging. The major problem with these conventional optimal battery charging techniques are that different circuits are needed for adopting different optimal charging techniques. This paper presents design and implementation of a field programmable gate array (FPGA) based versatile optimal bidirectional digital battery charger for HEV/PHEV. The proposed digital optimal charger is capable of adapting all the existing optimal battery charging techniques i.e., constant current-constant voltage (CC-CV) charging, Pulse charging and Reflex charging in a single circuit. The proposed system uses a bidirectional magnetically coupled inductor topology with a damping network. When the proposed system adapts CC-CV charging technique, it shows automatic and smooth transition from CC to CV mode without using any extra switching circuit and when the proposed system adapts pulse and reflex charging techniques it gives regulated charging and discharging currents. Modeling, analysis, and simulation have been carried out on a 250W prototype to validate the proposed algorithm.

Session MDMC-VI: Motion Drives and Motion Control VI
Date/Time: Friday, 12 June 2015/15:30 – 17:00 hrs
Venue: Room 3 @ Level 4
Session Chair: Sanjib K. Panda, National University of Singapore, Singapore

273 Redundancy of Angular Speed Sensors in a Double Induction Machine Rear Drive for EV
Michael Schubert and Rik W. De Doncker
ISEA – Institute for Power Electronics and Electrical Drives, RWTH Aachen University, Germany
Abstract- This paper focuses on the redundancy of angular speed sensors in an electric vehicle with two independent single wheel drives at the rear axle. Operation of both drives with a single angular speed sensor, e.g. in case of a sensor fault, is investigated. By applying a speed-sensorless control algorithm, operation of the faulty single wheel drive is still possible. Although speed-sensorless control of induction machines is state of the art and has been demonstrated by a variety of publications, stable operation at zero and very low speed is still not reliably possible. In this paper, a stable approach for speed-sensorless control at low and zero speed is proposed, which uses the speed sensor information of the other single wheel drive and the overall vehicle physics. Based on a detailed mechanical drive train model, the influence of the induction machine control strategy and the different road surfaces on the drive dynamics and the resulting torsional vibrations are investigated.

432 Estimation of the Mechanical State Variables of Two-Mass System Using Adaptive Kalman Filter
Marcin Kamiński, Krzysztof Drózdz and Krzysztof Szabat
Faculty of Electrical Engineering Wroclaw University of Technology Wroclaw, Poland

Abstract- In the paper issues related to the application of the adaptive Kalman filter to estimation of the states and parameters of an drive system with an elastic joint are presented. After a short introduction the mathematical model of the drive and used control structure are described. Next the model of the classical and adaptive nonlinear Kalman filter are presented. The performance of the investigated method is tested under a variety of simulation and experimental tests.

451 Performance Evaluation Of Clamping Position Variation On Advanced Bus Clamping Strategies: Experimental Investigation
Meenu D Nair, G Vivek, Mukti Barai
Department of Electrical Engineering, NIT Calicut, India

Abstract- This paper evaluates the performance of conventional and advanced discontinuous space vector pulse width modulation (PWM) with the variation in placement of clamping position (zero vector changing angle). Conventional space vector pulse width modulation (CSVPWM) employs continuous switching sequence, which equally divides the two zero vector in every sub cycle. Bus clamping PWM (BCPWM) techniques uses discontinuous sequence in a sub cycle. Clamping method reduces the inverter switching losses and the line current distortion. This work brings out the performance of BCPWM techniques which employs the different location of the phase clamping. The line current distortion is considered as the main performance index for analysis. The different SVPWM switching strategies are implemented on a 415V, 2hp, 50Hz, 3-phase induction motor drive which is fed from an IGBT based 2 KVA voltage source inverter (VSI) with a DC bus voltage of 400 V. A low cost PIC microcontroller (PIC18F452) is used as the controller platform. The experimental results shown that the clamping position of a phase has significant role in the reduction in line current harmonics at various power factor angles. The comparative results for clamping strategies for variation in zero vector changing angle reveals that the advanced split clamped SVPWM strategy has less total harmonic distortion compared to the other strategies.

458 Damping of Torsional Vibrations of Two-Mass System Using Adaptive Low Computational Cost Fuzzy PID Controller
Piotr Derugo and Krzysztof Szabat
Faculty of Electrical Engineering Wroclaw University of Technology Wroclaw, Poland
Abstract- In the paper an adaptive fuzzy logic control based structure for damping of torsional vibrations is proposed. Firstly, the commonly-used control methodologies for two-mass drive system are presented. Then the mathematical model of the plant is introduced shortly. Next the adaptive control structure with fuzzy PID controller is described in detail. The computational effort of fuzzy controller is reduced by applied the additional Petri-like transition layer. This allows to implement much more complicated fuzzy controller using simple microprocessor. Different aspect of the proposed control structure is investigated: e.g. working under different trajectories, robustness to the parameter changes. The theoretical considerations and simulation study are confirmed by experimental tests.

**Session PQHSGIII: Power Quality Issues, Harmonic Problems and Solutions III**

Date/Time: Friday, 12 June 2015/15:30 – 17:00 hrs  
Venue: Room 4 @ Level 4  
Session Chair: Daming Zhang, University of New South Wales, Australia

### 244 A Universal Controller for Grid-tied DC/AC Converters for Harnessing PV Panel based Solar Energy and PMSG based Wind Energy

_Daming Zhang_ (1) and _Kingjet Tseng_ (2)  
(1)University of New South Wales, Sydney, Australia  
(2)Nanyang Technological University, Singapore

Abstract- This paper proposes a universal converter topology and its controller for harnessing both PV panel based solar energy and permanent magnet synchronous generator (PMSG) based wind energy. Such controller has the function of maximum power point tracking. For the same level of power harnessing, the same controller’s parameters can be used for both wind energy and solar energy harnessing. LCL filter used to contain current THD into grid set by standard has been optimized by zeros-poles cancellation and differential evolution based methods. Overall system works according to the design target.

### 280 Optimized Design of Wide-Area PSS for Damping of Inter-Area Oscillations

(1)National Institute of Technical Teachers’ Training and Research, Bhopal, India  
(2)University of Agder, Faculty of Engineering & Science, Grimstad, Norway  
(3)National Institute of Science and Technology, Berhampur, India  
(4)University Institute of Technology, RGPV, Bhopal, India  
(5)Oriental Institute of Science and Technology, Bhopal, India

Abstract- In this paper a genetic algorithm based wide area power system stabilizer (PSS) in a multi machine power system for damping of low frequency inter-area oscillations has been presented. The wide area PSS is composed of two stages, the input of one stage is a local signal and the input of other is a global signal. Geometric measure of controllability and observability is used to select the most effective stabilizing signals and location of controller. Tie line active power flow deviation is found to be the most effective input signal. Time domain based objective function is minimized, in which the deviation in the oscillatory rotor speed of generator is involved so that the stability performance of the system is improved. In this work, two area - four machine systems are used as a test system.
**422 Integrated Three-Level NPC Based DSTATCOM Topology Using MISCT Control Algorithm for Load Compensation with Non-Stiff Source**

*S. P. Gawande and M. R. Ramteke*

Yeshwantrao Chavan College of Engineering, Nagpur, India
Visvesvaraya National Institute of Technology, Nagpur, India

Abstract- In this paper, a three-level neutral-point-clamped (NPC) inverter based filter capacitor supported integrated distribution static compensator (DSTATCOM) topology is proposed for load compensation using modified control algorithm. A three-phase four wire low voltage distribution system is taken into consideration with non-stiff source. The suggested topology is realized using three-level NPC voltage source inverter (VSI) with series capacitor to reduce dc link voltage and shunt capacitor to eliminate the high frequency switching components. In addition, a positive sequence component extraction based modified instantaneous symmetrical component theory is also suggested for load compensation (MISCT) in non-stiff system. Various DSTATCOM configurations are analyzed based on the filter capacitor combinations using MISCT and compared with conventional instantaneous symmetrical component theory (CISCT) for DSTATCOM applications, using hysteresis pulse width modulation (PWM). The performance analysis carried through an extensive MATLAB simulation shows excellent improvement in load compensation with significantly lower total harmonic distortion (THD) and reduced switching components in the terminal voltage for integrated DSTATCOM structure with series and shunt filter capacitor using MISCT.

**427 Magnetically Levitated Rotor Spinning Drive System with high System Stability**

*Martin Reisinger, Siegfried Silber, Jiri Sloupensky, Milan Moravec, Wolfgang Amrhein and Peter Dirnberger*

Linz Center of Mechatronics GmbH, Austria,
Rieter CZ s.r.o, Czech Republic
Institute of Electrical Drives and Power Electronics Johannes Kepler University Linz, Austria

Abstract- This paper describes a high speed drive system for textile rotor spinning applications with individually driven spinning units. High energy efficiency and lifetime is obtained by utilization of a slotless electronically commutated PM motor and active magnetic bearings for rotor suspension. Compared to traditional, centralized driven machines the proposed configuration allows a rotor design open at both sides. The result is an advanced arrangement of the spinning components and an improvement in the spinning process. Each unit includes its own power and signal electronics. The PM motor, with rotational speeds of up to 150 000 rpm, is supplied by a quasi current source inverter (QCSI) and controlled by means of back EMF based, position sensor - less control. An uninterruptable power supply (UPS) is inevitable for the magnetic bearing section to avoid a fatal rotor crash in case of a power supply interruption. A QCSI in a bidirectional configuration is used to supply the bearing section in this condition by utilizing the stored kinetic energy of the PM motor. An additional external UPS is not necessary for reliable system operation.