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Short Description of the Proceedings PCIM Europe 2010

Keynotes

Energy storage: state-of-the-art and future trends
Dirk Uwe Sauer, RWTH Aachen, Germany
Energy storage systems are a key element in an ever increasing number of technical applications. This includes primary batteries for several electronic devices or mother boards in computers, and secondary rechargeable batteries for applications such as uninterruptible power supply systems for critical loads, server farms or telecommunication equipment, mobile applications such as mobile phones or laptops, and traction application such as electric vehicles or hybrid power trains for various applications. Another major future application for energy storage systems will be the power supply infrastructure for the integration of increasing amounts of fluctuating renewable energies. This presentation will discuss the state of the art of secondary battery technologies and their requirements with regard to charging and management electronics as well as the limitations of the different technologies. Lithium-ion batteries will be in the focus. Special emphasis will be made on a clear differentiation of the different material combinations and their special performance parameters. Beside this an outlook to future technology option for energy storage technologies will be given. For the design of battery systems, optimised management strategies and diagnostic algorithms and hardware are required. This needs to be combined with an optimised thermal management. This gives an outlook to the needs in electronics and power electronics for the energy storage systems

HVDC Light can deliver 1,100MW
Björn Jacobson, ABB Ludvika, Sweden
Our appetite for electric power seems to have no limits and is predicted to double over the next 40 years. This heavy demand for electricity comes at a cost to the environment, both in its generation and in its transmission. An increasing share of new power generation comes from renewable sources, often located in remote areas. Since the mid 1990s, ABB has been developing a new system, called HVDC Light® (high voltage direct current), for electric power transmission, with the aim of providing a new transmission alternative, reducing some of the inherent disadvantages of the existing systems. With HVDC Light systems it is possible to transfer DC power over long distances on land by the use of robust and quick-to-install polymeric cable systems. Similarly, submarine cables can be used for sea crossings. HVDC Light converters enrich the electric transmission network with properties like improved black-start capabilities. This presentation will discuss the development of HVDC Light to 1100 MW and the applications of such transmission links. The present limitations of the technology and some important development drivers will also be discussed.

Virtual prototyping of power electronics system
Jürgen Biela J. W. Kolar, A. Stupar, U. Drofenik, A. Müsing, ETH Zürich, Switzerland
The future development of power electronics is driven by requirements for efficiency and power density besides the continuous demand for cost reduction. These demands can be met by using new topologies/modulation schemes and new wide-band gap semiconductor technology. However, besides that the performance of a system can be improved significantly by assigning optimal values to the design variables in the course of the design process, i.e. by comprehensive multi-objective optimisation. In order to perform such an optimization first a mathematical model, i.e. a Virtual Prototype of the main converter circuit has to be established, including thermal models and the measures for DM and CM EMI filtering. Based on this model, an optimization for multiple objectives, as e.g. efficiency or power density, can be performed. The optimisation makes best use of all degrees of freedom of a design and also allows studying the sensitivity of the system performance on base technologies like Figures of Merit of the power semiconductors or magnetic core materials. Furthermore, different concepts can be easily compared and inherent performance limits identified. In the paper the current status of design tools for electric, magnetic, thermal and EMI, which in combination could serve as basis for realising the Virtual Prototype, are reviewed. In addition an analytical approach for covering the various design domains is discussed which result in a significantly lower computational effort. This concept has been proven successfully by the design and practical implementation of converter systems of exceptional performance like ultra-compact and ultra-efficient single-phase PFC rectifier and telecom DC-DC converters. Furthermore, the linking of the different design domains via e.g. the heat exchange, the parasitic electromagnetic coupling and the geometry and/or shape of components will be discussed. Based on such strongly interlinked multi-domain models, finally a scenario for future automated virtual prototyping and optimization is drafted and key steps for achieving this goal are identified.

Oral Presenations

Application Optimized Switches

650V IGBT4: The optimized device for large current modules with 10 µs short circuit time
Andreas Härtl, Peter Kanschat, Martin Knecht, Infineon Technologies AG, D
This paper presents the new Infineon 650V IGBT4. Designed especially for medium and large current applications, the device offers a better softness during switch-off, and a higher blocking voltage capability. The measures used to realize these features were to increase the chip thickness, to reduce the MOS channel width, and to enhance the back-side emitter efficiency. As a consequence, also the short circuit robustness is significantly improved.

A new IGBT family optimised for high switching speed
Holger Hüsken, Infineon Technologies AG, D; Davide Chiola, Thomas Kimmer, Infineon Technologies Austria, A
In recent years, the discrete IGBTs has diversified in to disparate fields of applications. The application needs differ in part radically, requiring application specific device optimizations. We report on the 3rd generation of HighSpeed devices in 1200V (‘HS3’-product family) designed for high-frequency applications like welding, solar inverters and UPS. The characteristics of the new products are presented and compared to other product families in light of the target application needs.

A New 1200V IGBT module for high switching frequency applications
Taku Takaku, Fuji Electric Corp of America, USA; Shunta Horie, Shogo Ogawa, Fuji Electric Systems Co., Ltd., J
Power supplies for medical apparatus, welding machine, and plasma cutter are used in the high switching frequency range as 20~50kHz. The high-speed IGBT module was developed and this module was optimized for these high frequency applications. Lower switching loss was achieved by reducing density of backside p+ layer, shortening cell pitch and optimizing trade-off of IGBT and FWD chip. A further improvement of efficiency and miniaturization can be achieved by applying this module.

High efficiency and ease-of-use with a new generation of superjunction devices
Winfried Kaindl, Holger Kapels, Infineon Technologies, D; W. Jantscher, U. Kirchner, A. Steiner, F. Stückler, Infineon Technologies Austria, A
Superjunction devices enable fast switching performance and drive applications where efficiency is a key requirement. Up to now, their fast switching transients have been a blocking point for extensive use in commodity applications. The new generation of CoolMOS™ 650V C6 devices combines both, high efficiency and ease-of-use in applications, where fast switching transients are critical. This results in an optimum trade-off between EMI and efficiency requirements.

Special Session
Digital Power and Energy Efficiency

Reducing standby energy consumption of consumer electronic applications to virtually Zero
Carsten Deppe, Georg Sauerländer, Philips Technology GmbH, D
The energy consumption of consumer electronics while in off state is a never ending discussion and leads to always improving and more complex solutions. This paper shows our experiences with a concept completely removing such consumption while maintaining the most important remote control functionality. The concept has been evaluated on the example of a recent flat TV model, but can be adapted to many applications.

0W PC – new opportunities for energy saving
Willi Sterzik, Peter Busch, Fujitsu Technology Solutions GmbH, D
In 2005 the EU commission has published the regulation 2005/32/EC. As a consequence all manufacturers of Energy using Products (EuP) had to cope with a new requirement for future devices. It was obvious, that energy saving will be a future key design criteria in the future. Efficiency in energy conversion, reduction of stand by losses gained importance in any market segment. Also the IT industry is facing this situation. However, reduction of stand by losses was linked in the past very closely to the reduction of “convenience functions”. A very simple method to reduce the stand by losses to 0W, is to have just a mains switch in the power cord. However the user looses any convenience like automated shut down and power on or remote maintenance possibilities. Fujitsu Technology Solutions has developed a technology for IT equipment to overcome these drawbacks and still having 0W in stand by condition.

Zero power platform
Daniel Luthi, EM Microelectronics, CH
A new power supply topology, the „Zero Power Platfrom“, is presented lowering standby power consumption to values below 10 mW while maintaining wakeup capability (IR)

New cost-effective measuring method for bridgeless PFC converter
Wenqi Zhou, Manfred Reddig, UAS Augsburg; Manfred Schlenk, NMB-Minebea, D
Because of the reduced conduction losses, bridgeless PFC converters have drawn more and more attention recently. In this paper, current sensing techniques are discussed. Compared with LEM-transformer, a state of the art current transformer is shown to reduce power losses and cost without any performance degradation. A newly developed current transformer is proposed to further reduce component count and power losses.

IGBT module with integrated current measurement unit using Sigma-Delta conversion for direct digital motor control
Ulrich Schwarzer, Andre Arens, Martin Schulz, Infineon Technologies, D
System integration is one of the market driving issues in power electronics. In this paper the integration of precise shunts and complete A/D-conversion units with isolation interface into IGBT modules is compared to today’s conventional solutions based on Hall effect sensors and additional A/D-converter chip sets for inverter output current measurements.

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High Power Converters

Low inductance – low temp rise DC bus capacitor properties enabling the optimization of high power inverters
Edward Sawyer, SBE Inc., USA
High power density converter design is a fundamental requirement to meet the challenging performance, size, reliability, efficiency, and cost goals. PEM engineers use faster IGBTs that enable designs to meet these goals. Choosing the optimal bus structure is critical and drives the need for connections to minimize inductance and achieve optimal power density. Annular capacitors provide higher current carrying capability and lower temperatures, creating the opportunity to explore new bus options.

A high current pulse-power supply for flash lamps in PV-panel measurement-facilities
Dayana El Hage, Y. Birbaum, Alfred Rufer, EPFL, CH
Winner of the PCIM Europe 2010 Young Engineer Award
The paper presents a new topology for measurement and calibration equipments used for testing photovoltaic cells and panels. These equipments comprise a high power short-time lightning flash lamp. The new concept proposed for the pulse power-supply of the lamp, uses, on one hand, the switching technology that enables much higher energy efficiency, and on the other hand, the capacitive energy storage with variable capacitor voltage, allowing a strong reduction of the amount of capacitors.

High power density three-phase AC-DC 48V power supply
Andrea Romanelli, LARCET; A. Lidozzi, L. D'Errico, L Solero, University of Rome, I
Nominated for the Young Engineers Award
In this paper the prototypal realization of a three-phase ac-dc 48V power electronic converter for telecom system supplying and relative experimental testing are described. The main constraints in the power supply design are the required power density of about 900W per dm3 as well the absence of the neutral wire in the supply grid.

Control of a multilevel modular DC/DC converter for mobile applications
Daniel Montesinos-Miracle, CITCEA-UPC, Oriol Gomis-Bellmunt, Antoni Sudria-Andreu, Catalonia Institute for Energy Research, E; Alfred Rufer, EPFL, CH
This paper compares in terms of weight and volume different cascaded and multilevel topologies for DC/DC converters for regenerative braking using supercapacitors in mobile applications. The paper shows that the multilevel buck derived topology can beneficiate from both reduced voltage across the inductor and increased frequency to reduce the inductance, even if there is a need for an input LC filter to reduce harmonic content in supercapacitors.

Sensorless Drives I

Sensorless motor drives in industrial applications
Jose Mario Pacas, University of Siegen, D
In the last years a lot of efforts in industry and academia were dedicated to the development of sensor-less AC-drives featuring a dynamic behavior comparable or similar to the drives with mechanical sen-sor on the shaft. Some of these developments were adopted in the industry and are available on the market. The present paper discusses the present situation in Europe and the reasons that determine the acceptance or refusal of the different solutions on the side of manufacturers of motor drives.

Sensorless control of PM synchronous machines in the whole speed range using a novel load torque observer and a combined INFORM/EMF-Model
Wolfgang Staffler, Manfred Schrödl, Vienna University of Technology, A
The paper describes an extended mechanical observer structure in combination with an enhanced voltage model for sensorless control of permanent magnet synchronous machines (PMSM) working stable in the whole speed range. Depending on the speed range, two different feedback structures are used. The paper shows the structure and stability analysis in the low speed range. The mechanical observer estimates rotor speed, rotor angular position and load torque. It is stabilized by INFORM measurements. The observer output stabilizes the back EMF model even at standstill and low speed. Hence, a highly dynamic change from low speed range to high speed range is guaranteed. Furthermore, the estimated load torque is considered at the speed controller output as a disturbance compensation. Hence, the speed controller can be implemented as a simple proportional element without steady-state deviation at load.

Specific features of position-sensorless methods on synchronous linear motors
Roberto Leidhold, Peter Mutschler, Darmstadt University of Technology, D
There is an increasing interest in using linear motors for industry applications. By using sensorless methods for position estimation, the same advantages can be taken as in rotative motors. Moreover, as linear position sensors are more complex and expensive than rotative ones, the sensorless methods are more significant for linear motors. However, there are specific features that must be considered in linear machines. The position dependence of the back EMF and the inductance are influenced by end effects, non-constant air gap, and segmented stators. These features are highlighted and analyzed regarding their influence in different position estimation methods.

An analysis of the position measurement by HPI method on the axial flux permanent magnet motor
Janusz Wisniewski,Wlodzimierz Koczara, Piotr Dobron, Warsaw University of Technology, PL
This paper describes phenomena related to a HPI method. The method has been designed and developed to detect a position of the rotor at standstill without mechanical rotor position of the axial flux permanent magnet motor. It is based on saturation of the stator core. The paper shows an analysis of the magnetic circuits of the motor during position identification and measurement. Finally, some laboratory results of the 40 kW axial flux permanent magnet motor are performed.

Special Session:
Power Electronics for Efficient Inverters in Renewable Energy Applications

Comparison of high power semiconductor technologies for renewable energy sources
Björn Backlund, Munaf Rahimo, ABB Switzerland Ltd, CH
High power semiconductors are key components for control of the generation and connection to the net work of renewable energy sources as wind turbines and photo voltaic. For highest efficiency of the energy source it is therefore essential to select the right device for the given conditions. This paper looks at the features for the available high power semiconductors of choice and also takes a look at future devices and their expected impact on efficiency.

High power renewable energy applications, state-of-the-art & new design proposals
Dejan Schreiber, SEMIKRON Elektronik, D
Renewable energy applications are a great challenge today. Efficiency and reliability are the prevailing requirements. The best solution for MW converter design is paralleling of inverters / power blocks. An alternative solution is a medium voltage source and transmission connected to MV grid-side inverter based on low-voltage silicon - power blocks - connected in series. In addition, interleaved PWM reduces the size of the sinusoidal filter and the switching frequency.

(GaN)-based power device technology and its impact on future efficient solar grid connected micro-inverters, power optimizers and string Inverters
Alberto Guerra, Jason Zhang, International Rectifier, USA
GaN-based power device technology is progressing rapidly and expanding its applicability in a wide range of power applications including Solar Inverters. Along with intrinsic scalability in low and high voltage power conversion topologies and coupled with dramatic FOM improvement vs. Si based devices, GaN power products are set to have a direct impact on future efficient grid connected PV micro and string inverters.

New low loss transfer mold IPM for photovoltaic generation
Ming Shang, Hirofumi Oki, Kazuhiro Kuriaki, Toru Iwagami, Toshiya Nakano, Mitsubishi Electric Corporation, J
This paper presents a low loss large-scale Dual In-line Package Intelligent Power Module with rating of 50A developed by Mitsubishi Electric for photovoltaic generation. 50A/600V low loss large-scale DIPIPM$_{TM}$ was achieved by using the DIPIPM$_{TM}$ Ver.4 package with novel heat dissipating insulation sheet, etc. High efficiency is required when DC electricity generated by solar cells is converted to AC electricity. To realize high efficiency, the switching loss of Photovoltaic DIPIPM$_{TM}$ is reduced by using fast 5$_{th}$ generation full gate CSTBT$_{TM}$ and high output current driver IC which leads to a higher switching speed.

Thermal Aspects in Power Systems

Reduction of conductor lead resistance in high current power modules
Samuel Hartmann, Dominik Truessel, Daniel Schneider, Raffael Schnell, ABB Switzerland Ltd., CH
With higher current rating of semiconductor chips the contribution of resistive losses to the power module's losses are getting higher. High currents flowing cause unwanted power dissipation via the power terminals to the connected bus bar and can lead to reliability problems due to the overheating. These issues are addressed by an optimized conductor leads geometry that lowers the electric resistance by 21%.

Thermal characterization of multi-die IC products
Lawrence Durfee, Fairchild Semiconductor Corp, USA
In the development of today's products, the thermal analysis of multi-die IC products is very important in satisfying cost and reliability requirements. The obvious enabler for thermal analysis is in having available the detailed thermal characteristics for that product. Establishing thermal information about a part can be partitioned into two major elements – Data Collection and Data Reduction. This paper discusses that process and the issues involved.

Power electronics module with integral micro-channel heatsink
Ljubisa Stevanovic, Adam Pautsch, Richard Beaupre, Arun Gowda, Juan Sabate, GE Global Research; Stephen Solovitz, Washington State University Vancouver, USA
The paper describes a micro-channel heatsink fabricated directly in the back of ceramic DBC/AMB substrate, thus minimizing junction-to-fluid thermal resistance while maintaining electrical isolation. The substrate is bonded to a baseplate featuring a set of interleaved inlet and outlet manifolds that help reduce the pressure drop and minimize temperature gradient across the heatsink surface. Experimental results show extremely low junction-to-fluid thermal resistivities approaching 0.1 °C*cm2/W.

Compact PCB-packaging and water cooling of a 25-kW inverter
Andreas Munding, E. Mongui, Liebherr-Elektronik GmbH; M. Thoben, T. Hong, Infineon Technologies; M. Nold, M. Kerkhoff, ZF Friedrichshafen; S. Lutz, BMW AG, D
Winner of the PCIM Europe 2010 Young Engineer Award
Typical power electronic applications in transportation are inverters, which require a compact, weight optimized and robust packaging in order to constitute an added value. We present a design approach which features a low pressure loss in liquid cooling, and a printed circuit board assembly which enables effective thermal management and EMC. Thermal simulations and experimental results for the board assembly and for a pin-fin based cooling channel and are presented.

Power Electronics in Energy Generation and Distribution

Modelling and control of a DC/DC-converter system for fuel cell - direct storage - hybrid units
Thilo Bocklisch, Karel Besorna, Martin Paulitschke, Wolfgang Schufft, Steffen Bocklisch, Rene Warsitz, Chemnitz University of Technology, D
A system of two DC/DC-converters for a fuel cell-direct storage hybrid unit is investigated. The non-linear multivariate control plant is modelled employing "state-space averaging". A simulation model is presented, supporting the optimal design of bus voltage and fuel cell current controller. Simulation and experimental results demonstrate excellent controller performance and reveal the benefits of the hybrid system approach, namely reduction of fuel cell stress and increase of total efficiency.

Methodical design of inductive power transmission systems
Daniel Kürschner, Christian Rathge, Axel Hoppe, Ifak Institute for Automation and Communication, D
Nominated for the Best Paper Award
With inductive power transmission you can transfer electrical energy without cables or slip rings. An efficient power transmission needs the adaption and well tuning of both, coil system and power electronics. Therefore, the development effort for new systems is very high. The paper presents a computer-aided design method and investigates special power loss effects of the coil system. As a result, a transmission system in the power range of 500 W is presented which is used in packaging machines.

Inverters as smart grid interface - standardized feeding modes for different distributed generation units and grid requirements
Max Lingemann, E. Ortjohann, W. Sinsikthavorn, S. Jaloudi, A Schmelter, P. Wirasanti, South Westphalia University, D
Technologies for distributed energy generation are available. However, strategies and concepts for the control of their grid connection and the integration into the grid control are still lagging behind. This paper presents a standardized categorization of conventional control modes, and their potential application to power electronic grid interfaces (inverters). Example implementations for different source and load situations are given and test results are shown to prove practicability.

A fuel-cell model emulator, including temperature effects
Valeria Boscaino, G. Capponi, University of Palermo; F. Marino, STMicroelectronics, I
In this paper, a circuit emulating the effective fuel-cell steady-state and dynamic behavior, including temperature effects, is proposed. Saving cost and hydrogen reserves under preliminary downward system test,using a portable circuit even if simulating kilowatt fuel cells, are only some of emulator's strengths. The proposed emulator circuit provides a digital controller, implemented on FPGA, and a power interface for electronic load connection. Simulation and experimental results are compared.

Sensorless Drives II

The dynamics of sensorless BLDC (PMSM) drive operation
Chuck Raskin, Dynetic Systems, USA
The focus of this paper is to cover the dynamics for both Trapezoidal and Sinusoidal Sensorless commutation. In the past, sensorless commutation of any kind was limited to Vector drives and Stepper motors. The processing power required to perform real time, high speed sensorless commutation algorithms was not yet available. Halls & Encoders were used as the main commutation indicators. Trapezoidal and Sinusoidal commutation capability was available, but sinusoidal commutation using an encoder required quite a bit of algorithmic manipulation in order to run a motor at reasonably Hi-Speed with good results. Today, Microprocessor and DSP instruction rates, in excess of 100-Mips (straight line coding), along with Hi-Speed MOSFET's, IGBT's and Intelligent Power modules, have taken the BLDC (PMSM) drive markets to new levels. The application of sensorless commutation algorithms to low inductance, Hi- Speed motors has become a reality. Sensorless commutation using Trapezoidal or Sinusoidal techniques is now as common as one riding a bike. Although Trapezoidal commutation is still the main method in use, Sinusoidal capability is developing at a rate that should soon allow it to become the main commutation methodology.

Sensorless control for PMSM using an 8bit microcontroller and dc-link current measurement
Matthias Förster, G. Berger, J. Petzoldt, Ilmenau University of Technology; A. Rabenstein, Infineon Technologies, D
A sensorless field-oriented control of an induction machine using an 8bit microcontroller is presented. The current measurements take place in the low-side switches of the converter through a shunt. There is no potential separation between the power unit and the controller. The real stator currents are determined in dependency of the space vector modulation pattern and the measurements. The rotor flux determination is realised with a flux model containing a rotation speed dependent feedback.

Integrated implementation of multiple AC motor control and two phase interleaved power factor correction system using single low cost microcontroller for HVAC applications
Bilal Akin, Manish Bhardwaj, Nene Hrishikesh, Brett Larimore, Texas Instruments, USA
The cost sensitive drives like heating ventilating and air conditioning (HVAC) appliances have been utilizing variable speed drives to maximize the efficiency and comfort for the user. Most of these applications employ more than one motor, e.g. ventilation and compression. On the other hand, with various regulations limiting the input current harmonic content, especially with the IEC 61000-3-2 standard that defines the harmonic components that an electronic load may inject into the supply line, a power factor correction stage has become an integral part of most rectifier designs. In this work, two motors are controlled independently using field oriented control (FOC) in order to enhance the over all performance in addition to front-end two-phase interleaved PFC stage. This study shows that using the low-cost 32 bit PiccoloTM microcontroller platform can provide a true single chip solution for multiple motor drives including front end PFC.

Position sensorless MTPA control for high-speed IPMSM drive using simple expression of Q-axis inductance as function of rotor speed
Takashi Kosaka, Shoichiro Tanaka, Nobuyuki Matsui, Nagoya Institute of Technology, J; Ju-Suk Lee, Kyonggi Institute of Technology; Sun-Kyoung Lim, LG Electronics Inc., ROK
This paper reports a simple MTPA control approach for position sensorless high-speed IPMSM drive by introducing a virtual expression of q-axis inductance as a function of rotor speed. The proposed approach makes it possible to simply achieve not only stable position sensorless drive but also MTPA control automatically. The effectiveness of the proposed controller is verified through experiments using 4pole-10kW-10,800r/min IPMSM for an air-conditioning compressor drive.

Module Design

A new 1.7kV CSTBTTM(III) for the next generation power module
Kenji Suzuki, Tetsuo Takahashi, Koichi Tsurusako, Yoshifumi Tomomatsu, Ryoichi Fujii, Mitsubishi Electric Corporation, J
As the next generation IGBT power module, we have already proposed the concept of CSTBTTM(III) in terms of a finer pattern for the trench gate structure and retrograde doping profile in the CS-layer. Based on CSTBTTM(III) concept, we optimized a MOS structure for 1.7kV class. We also adapted a newly developed planarization technique for a surface of an emitter electrode in order to expand a power cycling capability.

New assembly and interconnects beyond sintering methods
Karsten Guth, Frank Hille, Frank Umbach, Dirk Siepe, Jens Görlich, Infineon Technologies AG, D; Holger Torwesten, Roman Roth, Infineon Technologies Austria, A
Increasing power densities form an obstacle for the use of soft soldering in future power modules. Particularly with regard to the chip-to-substrate joint new concepts are needed to meet the reliability demands for power cycling. In this paper we present a new joining technology for 200°C applications with best in class reliability values. This process, which is an adaption of standard soft soldering, stands out due to a high degree of flexibility, short process times and low material costs.

New module generation for higher lifetime
Alexander Ciliox, Frank Hille, Frank Umbach, Jens Görlich, Karsten Guth, Dirk Siepe, Sandra Krasel, Piotr Szczupak, Infineon Technologies AG, D
In this paper we will discuss in detail the first module generation with a real operating temperature of 175°C for 1200V IGBTs and diodes. Infineon provides a new set of mounting technologies which allow the new operation temperature without a drawback in lifetime compared to IGBT4.

Design strategies for stray inductance optimized wire-bond power modules
Ole Mühlfeld, W.-Toke Franke, Friedrich W. Fuchs, Christian-Albrechts-University, D
This paper presents design strategies providing an approach for designing DBC layouts with low stray inductance. Different options of routing the copper tracks on DBC substrate are compared regarding their influence on the modules inductance. The proposed approach intends to show rules for the developer during the design process.

Design of IGBT module packaging for high reliability
Yoshitaka Nishimura, Kazunaga Oonishi, Fumihiko Momose, Tomoaki Goto, Fuji Electric Systems Co. Ltd., J
An IGBT module consists of various materials. At the time of module use, mass heat occur the jointed area of IGBT module structure is destroyed by heat destruction and the CTE mismatch of materials. Therefore the lifetime of an IGBT module varies significantly depending on materials used and structural design. In this time we have investigated thermal designs and joint techniques.

High Power Density Design

New module concepts exclusively built with low temperature joining technique for single- and double-sided cooling
Elisabeth Schulze, Christian Mertens, Volkswagen AG; Andreas Lindemann, Otto-von-Guericke-University, D
The Low Temperature Joining Technique is frequently discussed to be a good alternative solution for automotive qualified power electronic modules. New developments in processing methods made it attractive also from the production point of view. This paper describes theoretical discussions of different concepts for power modules with Low Temperature Joining Technique, the way of experimental evaluation of the new concepts and their individual procedural problems.

Integrated base plate (IBP) power modules using novel metalized ceramic substrates and sputtered thick coating (STC) technology
Youngpyong Kim; Hunchang Im, Dongkeun Jang, LS Industrial Systems; Yongmo Kim, Kabseog Kim, Korea Instrument Co., Ltd., ROK
The increasing demands in terms of the performance and reliability of power modules in automo-tive as well as in advanced industrial applications require new packaging solutions. For high reliability applications, the power modules are needed with a sufficient thermal stack and stability against ther-mal cycling. To meet these demands, the power modules are usually formed with an excellent thermal performance material, such as AlN DBC, and using a stress reducing base plate, such as AlSiC. In this paper, the IBP (Integrated Base Plate) power module using ceramic coating as an insulator on metal substrate and thick copper coating as a conductor by STC (Sputtered Thick Coating) technology is in-troduced and how to increase the thermal performance and reliability of power modules is discussed.

Small size, low thermal resistance and high reliability packaging technologies of IGBT module for wind power applications
Koji Sasaki, M.Hiyoshi, K.Horiuchi, Hitachi, Ltd., J
In order to feature in next generation wind power generation systems, a new 600A-1700V IGBT module has been developed. The module has (1) low thermal resistance, (2) small package size and (3) high reliability. The thermal resistance Rj-w of the IGBT module is reduced by 35% when compared to conventional modules. The developed IGBT module and channel cover jacket are approximately 45% lighter and 45% smaller when compared to conventional modules with the same power capability.

High cell-density, shielded-gate power MOSFET for improved DC-DC converter efficiency
Ritu Sodhi, Fairchild Semiconductor, IND; Ashok Challa, Jon Gladish, Steven Sapp, Chris Rexer, Fairchild Semiconductor, USA
Microprocessor power consumption has continued to increase and the voltage regulator has continually advanced with the ability to deliver increased power densities. This has only been made possible with the recent advancements made in power MOSFETs - both silicon and package. One such innovation will be discussed in this paper

SMT high power density construction of industrial, automotive and lighting electronics
Ivan Josifovic, Jelena Popović-Gerber, J.A. Ferreira, Delft University of Technology, NL; M. Stadler, UAS Ingolstadt, D
Nominated for the Best Paper Award
The paper presents application of new SMT construction method – Power Sandwich for high power density manufacturing of industrial, automotive and lighting electronics. The Power Sandwich manufacturing method employs new x-dim components, having the same height, double sided SMT terminations and enhanced thermal properties.

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High Speed Switching Applications

1200 V 6 A SiC BJTs with very low VCESAT and fast switching
Martin Domeij, C. Zaring, A.O. Konstantinov, J-O. Svedberg, K. Gumaelius, I. Keri, A.Lindgren, H. Grenell, M. Östling, M. Reimark, TranSiC AB, S
The paper presents progress with long-term stable SiC bipolar junction transistors (BJTs) with significantly reduced power losses in the on-state and during switching. System benefits using the improved SiC BJTs will be shown by simulation.

Characteristics of A 1200 V, 550 A SiC DMOSFET dual module
Robert Wood, Army Research Lab; Thomas Salem, U.S. Naval Academy, USA
The enhanced material properties of silicon carbide (SiC) offers improved performance capabilities for power electronic devices compared to traditional, silicon-based components. Recently, a 1200 V, 50 A, SiC DMOSFET has been developed and its use in a 100 A switch has been reported. Based on this work, a 1200 V, 550 A, all SiC dual module has been fabricated. This paper reports on the experimental characterization of this advanced dual power module that incorporates eleven DMOSFETs per switch.

CASCODE LIGHT - normally-on JFET stand alone performance in a normally-off Cascode circuit
Daniel Domes, Xi Zhang, Infineon Technologies AG, D
Using a normally-on high voltage SiC JFET combined with standard low-voltage MOSFETs, a normally-off Cascode circuit appears. This paper analyzes Cascode function in inverter application and explains drawbacks of the classic solution. To get rid of the Cascode problems, a so called Cascode Light approach was realized combining best JFET stand alone performance with the safety of a standard Cascode.

1700 V enhancement-mode SiC VJFET for high voltage auxiliary flyback SMPS
Robin Kelley, Gray Stewart, Vlad Bondarenko, David Sheridan, Andrew Ritenour, SemiSouth Laboratories, USA
The newly developed 1700V enhancement-mode SiC JFET targeted for high voltage auxiliary flyback SMPS is introduced. A comparison of device performance of the new 1700V, 550mOhm, EM SiC JFET to a 1500V MOSFET and ESBT in a commercial aux SMPS evaluation board shows 4.5x less RDS(ON) and 94% less turn-off power loss. The 1700V EM SiC JFET demonstrates sufficient voltage rating for 1000V applications and efficient unipolar switching characteristics making it an ideal for high voltage aux SMPS.

A hard switching VIENNA boost converter for characterization of AlGaN/GaN/AlGaN power DHFETs
Jordi Everts, Pieter Jacqmaer, Ratmir Gelagaev, Johan Driesen, Catholic University Leuven; Jo Das, Marianne Germain, IMEC; Jeroen Van den Keybus, TRIPHASE, B
A high frequency, hard switching boost converter (VIENNA topology) was constructed for characterizing new power AlGaN/GaN/AlGaN Double Heterojunction Field Effect Transistors. This converter enables us to accurately measure the, in power circuit design, most important device parameters (dynamic on-resistance Rdyn, gate charge Qg, Miller charge Qgd, switching times, FOM,…).

Advanced Control in Drives

Sensorless controller for the purpose of wear reduction by active vibration damping for three-phase drives
André Warschofsky, Ulrich Beckert, Freiberg University of Technology, D
The article presents an estimation algorithm for three-phase drives in closed-loop control involving an oscillatory mechanical system. The algorithm estimates the air gap torque and the speed of the motor, the torque of the drive shaft, and the speed and the load torque of the driven machine in dynamic operation. The algorithm can be used as a basis for sensorless state control with the objective of active vibration damping to reduce wear and enhance life span of the mechanical system.

High speed digital direct current controllers – a new class of intelligent controllers for future needs
Jens Baumeister, Ansgar Ackva, Harald Wießmann, UAS Würzburg-Schweinfurt, D
To meet future requirements power electronic control algorithms should be capable to handle non-linear and unknown loads in a very fast way by reduced current ripple and improved robustness. Direct current controllers are well suited for these purposes. But one of their most significant disadvantages is that they are realized with analogous technology. In the presentation a new class of high speed purely digital direct current controllers and their extensive opportunities is presented.

Fast and high precision motor control for high performance servo drives
Christoph Klarenbach, Jens Onno Krah, UAS Cologne, D
Winner of the PCIM Europe 2010 Young Engineer Award
This paper reports a new architecture of a fast current controller with two feedback signals for high performance motion control. Due to parallel processing inside the Field Programmable Gate Array (FPGA), the control algorithm computing time is significantly less than 1 µs. Together with advanced control technologies in combination with a new current observer the bandwidth of fast switching IGBT or MOSFET power stages is not limited by the delay time of high precision (integrating) current measurement any longer. Using that technology high control bandwidth in conjunction with high precision current control is now possible at no trade off. The control strategy relies on a simplified machine model without incurring performance degradations. The presented results have been produced with a high speed Computerized Numerical Controlled (CNC) machine.

Mosolver-Implementation
Donald Labriola, Quicksilver, USA
The Mosolver combines the functions of a motor and a position resolver within a single device utilizing the same magnetic structure. The position sensing coils require only a slight modification to the motor, yet provide absolute - within an electrical cycle - position information, even when the motor is stationary. Due to magnetic coupling between phases of a 2 phase hybrid step motor, the timing of the driving pulses may be optimized to simplify the hardware needed to decode the motor position.

Reliability of Components

Comparison of the power cycling stress between IGBT and BIGT inverters
Daniel Wigger, Hans-Günter Eckel, University of Rostock, D
Bi-Mode Insulated Gate Transistors are a new class of semiconductors, which combine the functionality of an IGBT and a diode in a single chip. One of their advantages is the reduced temperature ripple at low fundamental frequencies, which leads to a reduced power cycling stress. This paper evaluates, how this effect influences the expected lifetime of the modules at different mission profiles and cooling conditions.

Impact of test control strategy on power cycling lifetime
Stefan Schuler, Uwe Scheuermann, SEMIKRON Elektronik, D
Power cycling is an important method to characterize the lifetime of power semiconductor modules. An important condition for the lifetime of a module under repeated temperature swings is the control strategy applied during the test. Power cycling tests with identical start condition but different control strategies have been performed. The results show, that different control strategies deliver lifetime results that vary by a factor of 3.

Power electronics reliability - the materials behaviour is the key
Max H. Poech, Fraunhofer Institute for Silcon Technology (ISIT), D
Life-time of power electronics assemblies is limited, mainly due to thermal cycles. Differences in thermal expansion coefficients (CTE) of materials cause fatigue degradation. To understand load and degradation mechanisms due to thermal cycling, thermal-mechanical models are presented. Models and calculated results will be presented for bond-wire lift-off failures and for crack propagation in large-area solder joints. Reasonable agreement with available experimental data has been achieved.

Study of ageing of the metallization layer of power semiconductor devices
Stéphane Lefebvre, S. Pietranico, SATIE; S. Pommier, LMT-Cachan; Z. Khatir, NRETS-LTN; S. Bontemps, Microsemi PPG; E. Cadel, GPM, UFR Sciences et Techniques, F
In order to accelerate the ageing of the metallization layer, repetitive short circuit operations are applied to COOLMOSTM Transistors. Regularly, metallization is observed in a Scanning Electron Microscope which allows us to observe the process of cracking at the grain boundaries. Different electrical characterizations are also done regularly and evolution of characterization results are linked to the metallization ageing.

Interleaved Converters

98% efficiency interleaved soft-switching half-bridge bus converter
Bogdan Bucheru, Ionel Dan Jitaru, Delta Energy Systems, USA
The paper presents an innovative isolated dc-dc converter for 48 V input and 8 V output, with the peak efficiency exceeding 98 %. The low profile converter design delivers 320 W of power using constant frequency dual interleaved half-bridge topology with high frequency zero voltage switching and zero current switching for primary and secondary switchers. The resulting product delivers “true” 100 % duty cycle and increases the power capability compared with medium and high power bus converters.

Input-series and output-parallel configuration adopted interleaved LLC resonant converter for high current applications
Myungbok Kim, Donghye Cho, Fairchild Semiconductor, ROK
In this paper, an input-series and output-parallel configuration, which guarantees robust load sharing property between master and slave converters, is introduced and analyzed. In order to validate the proposed configuration, the laboratory experiments are executed and discussed with a 480W prototype.

Bridgeless and interleaved PFC stages for high efficiency - comparison in a wide-mains, 300-W application
Joel Turchi, ON Semiconductor, F
Environmental concerns lead to new efficiency requirements when designing modern power supplies. Compactness is another driver for high efficiency in applications that as high-end adapters, require a high power density. These requirements force power-supply designers to work on innovative solutions. This paper will compare the respective merits of two emerging options: bridgeless and interleaved PFC, in a 300-W application

Phase-shift controlled zero current switching high frequency inverter in the MHz frequency range
Hiroyuki Matsuo, Fuji Electric Systems; H. Yonemori, Y.Yasaka, Kobe University, J
This paper deals with the soft-switching inverter topology and its capability of MHz switching to be adopted to the power conversion. There are some problems to be solved, to realize the power supply in the MHz switching. Switching loss and noise increase by the MHz is significant. In order to solve these problems, we propose the phase-shift controlled ZCS inverter. This circuit has soft-switching capability in the MHz switching and can control the output by the phase-shift controlled method.

Energy Storage

Performance improvement of a small car with LiFePO4 batteries
Daniel Chatroux, B. Beranger, S. Fiette, M. Perrin, E. Fernandez, CEA, F
In 2009, a presentation was done in PCIM about the experience feedback on electric vehicles of the French car fleet and the cost of battery use in this application. The replacement of the initial NiCd battery of an AX vehicle by an iron phosphate Lithium battery with 1600 small cells was presented in conclusion. This presentation is focalized on the improvements of the vehicle performance due to the power LiFePO4 battery.

Energy storage on board of railway vehicle
Michael Fröhlich, M. Klohr, J. Rost, Bombardier, D
The on board energy storage system with double layer capacitors for railway vehicles presented in this paper was proven to be a reliable technical solution by outstanding 4 years revenue service on an LRV (Light Rail Vehicle). An enormous energy saving of 30% propulsion energy was measured. The paper describes the new equipment for 19 series LRV's, a world first in this application area. The vehicles have been commissioned in September 2009 and will go into revenue service.

Efficiency evaluation of a novel supercapattery stack with a power electronic interface for energy storage systems
Ponggorn Kulsangcharoen, Christian Klumpner, G. Asher, X. H. Zhou, C. Peng, G. Z. Chen, M. Rashed, Nottingham University, UK
This paper proposes a method to evaluate the round-trip efficiency of a supercapacitor energy storage system (SCESS) consisting of supercapacitors (SCs) and their associated power electronic interface. The experimental results show that when increasing power level and discharging SCs to a low SoC, the demanded current that increases sharply causes overall system efficiency to decrease dramatically.

Investigations on the power cycle lifetime of supercapacitors
Björn Veit, M. Bodach, M. Wittig, UAS of Western Saxony, D
The knowledge of the reliability and expected power cycle lifetime of electrochemical energy storage systems is of fundamental importance. In case of Ultracapacitors, the essential parameters regarding the power cycle lifetime are defined by the capacitance C and the equivalent series resistance RESR, DC...

Inverter Control in Motor Drives

Advanced design features of a dedicated IGBT power stack controller board
Tim Friederich, Edward Hopper, MACCON GmbH, D
This paper presents the special design features of an embedded motor controller for the optimum control of modern IGBT power stacks. This dedicated controller has some outstanding features in a very small volume.

Lifetime oriented control of a three-phase voltage source inverter
Marco Weckert, Jörg Roth-Stielow, University of Stuttgart, D
Increasing the lifetime of power semiconductors demands a reduction of the amplitude of thermal cycles. By an intelligent control of the switching frequency and a shift of the neutral point potential whereby the power losses are reduced and equalized within the power electronic structure could fulfill this demand.

Switched diamond hysteresis control
Harald Wießmann, Ansgar Ackva, Jens Baumeister, UAS Würzburg-Schweinfurt, D
In most of today's power electronics systems the inner and fastest controller stage has to regulate the output current. Direct current control methods can achieve much better performance than the well known "PWM-Schemes" especially with non linear loads. This paper presents an improved controller, called "Switched Diamond Hysteresis Control" which offers all the advantages of a direct current controller and eliminates the important drawbacks of existing controllers.

On-line semiconductor junction temperature estimation for frequency inverters
Jens Onno Krah, Christoph Klarenbach, UAS Cologne, D
The simple I^2T model to estimate the junction temperature is often used because it is easy to calculate. But the I^2T model it is not fitting for all applications. Utilizing a more detailed FPGA based model the estimated junction temperature is fitting much better even with different modulation schemes, switching frequencies, ripple current values and also with non constant dc link voltages.

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Power Electronics in Automotive and Traction

Facing high thermal loads on power modules in hybrid electrical vehicles
Andre Christmann, Krzysztof Mainka, Infineon Technologies, D
Nominated for the Best Paper Award
In automotive industry the IEC standard Q100/101 is often used as a guideline for stress testing and reliability requirements. This paper deals with the questions if the thermal shock test mentioned in the IEC standard is appropriate and if an increasing demand for thermal load can be addressed by simply increasing the required number of cycles (e.g. to 2000).

Test-platform for starter-alternators or high efficiency alternators and first test results and conclusions
Benno Köppl, Dušan Graovac, Ingo Voss, Frank Auer, Michael Scheffer, Infineon Technologies, D
A test platform for starter alternators and high efficiency alternators used to perform application tests will be presented. He will show which criteria were used to select the used semiconductor devices, show different test results and gives an outlook to future solutions for starter alternators and high efficiency alternators

Combined supercapacitor-batteries power converter for Traction Drives
Giuseppe Tomasso, Ciro Attaianese, M. Di Monaco, V. Nardi, University of Cassino, I
The control of a tandem voltage source inverter applied to traction droves is presented in this paper. It allows to manage the power flows from and to two separate energy storage units: batteries and supercapacitors. By means of the proposed control, it is possible to recharge the supercapacitors also during the normal runs of the vehicle, without overloading the batteries.

Connection of a 3 MVAR STATCOM based on AC chopper topology to a 25 kV / 50 Hz railway substation. modelling and simulations of harmonic interactions
Luc Lowinsky, Philippe Ladoux , Yvon Chéron, University of Toulouse; Hervé Caron, SNCF, F
25 kV single phase AC railway systems of the French Railways company (SNCF) must be equipped with reactive power compensation device to reduce the spending for reactive power. This paper focuses on the behavior of a single phase STATCOM based on AC Chopper topology in the SNCF electrical network. Frequency analysis and numerical simulations of the railway system are proposed.

Pole restraining -- a novel control approach for power-electronic systems
C. Heising, M. Oettmeier, V. Staudt, A. Steimel, Ruhr-University Bochum, D
State-of-the-art control approaches often neglect the time-variant characteristics of power-electronic systems in favour of a time-averaged approach. In consequence, the resulting system is partly instable, thus not optimally controlled. A novel control approach is presented, taking the introduced characteristics into account. Due to its main maxim – the restraining of the eigenvalue movement – it is named pole-restraining approach.

High Voltage Components

The next generation 3300V BIGT HiPak modules with current ratings exceeding 2000A
Arnost Kopta, Munaf Rahimo, Ulrich Schlapbach, Raffael Schnell, J. Vobecky, ABB Schweiz, CH
Nominated for the Best Paper Award
In this paper, we continue to report on the progress achieved towards the practical realization of the Bimode Insulated Gate Transistor (BIGT) in ABB`s future product range. The introduction of the BIGT technology in the 3300V HiPak module line-up with current ratings exceeding 2000A will be presented. Static and dynamic results will be provided with the associated relevant parameters outlining the basic performance levels that will be expected from the new technology.

Wide temperature operation of high isolation HV-IGBT
Kenji Hatori, Shuichi Kitamura, Shigeru Hasegawa, Shinichi Iura, Mitsubishi Electric Corporation; Masuo Koga, Fukuryo Semicon Engineering Corporation, J; Eugen Stumpf, Mitsubishi Electric Europe, D
We developed the new high isolation HV-IGBT modules. It is confirmed that the new module can safely operate even at -50°C and 150°C. The new modules have excellent robustness of SOA at TJ=150 °C. And, the rugged SCSOA at TJ=150 °C is achieved by optimized package layout. No snap-back characteristics at TJ=-50 °C is achieved. The operation of the new modules with high isolation package even at -50°C and 150°C is qualified by reliability tests.

Six inch thyristors for UHVDC transmission
Virgiliu Botan, Juerg Waldmeyer, Magnus Kunow, Kranthi Akurati, ABB Semiconductors, CH
Nominated for the Young Engineers Award and the Best Paper Award
With the advent of rapidly growing needs for transmission of high amounts of electric power over large distances, as seen in China's fast developing society, more powerful thyristors have been asked for by the DC transmission industry. For this purpose, ABB has developed a six inch thyristor of 8.5 kV/4000 A capability. We have achieved good blocking properties, high dv/dt capability and yet the required latching sensitivity.

10kV HPT IGCT rated at 3200A, a new milestone in high power semiconductors
Iulian Nistor, Tobias Wikström, Maxi Scheinert, Munaf Rahimo, Sven Klaka, ABB Switzerland Ltd, CH
We present a newly developed 10 kV IGCT chip set having the highest voltage and current ratings available today in the market. This chip set includes an innovation in GCT wafer design which enables a current capability in excess of 3200 A. In addition, a 10kV free wheeling diode has been developed to avoid snappy reverse recovery typical for standard high voltage diodes.

GaN-based lateral and vertical power devices for high voltage switching applications
Umesh Mishra, Srabanti Chowdhury, Brian Swenson, Yuvaraj Dora, Chang Soo Suh, Stacia Keller, University of California, USA
We present a newly developed 10 kV IGCT chip set having the highest voltage and current ratings available today in the market. This chip set includes an innovation in GCT wafer design which enables a current capability in excess of 3200 A. In addition, a 10kV free wheeling diode has been developed to avoid snappy reverse recovery typical for standard high voltage diodes.

Motor Drives

Ultrahigh speed AC motor drive applied in the utilisation of waste and renewables and recovering waste energy
Peter Stumpf, R.K. Jardan, I. Nagy, Budapest University of Technology, H
Nominated for the Young Engineers Award
The paper is concerned with the study of an ultrahigh speed induction machine (USIM) - turbine set applied in the utilisation of renewables and recovering waste energy. The study has three main targets: 1.,Comparing speed control loops for optimizing 2., Analyzing the adverse effect of subharmonics generated by the PWM converter supplying the USIM. 3., Present a novel numerical calculation method for the determination of subharmonics. The results are verified by simulations and laboratory tests.

Hybrid servo control system for highly dynamic axes
Dominik Lindemann, Christian Brecher, Michael Merz, Manfred Zavelberg, Fraunhofer-Institute for Production Technology (IPT), D
Nominated for the Young Engineers Award
The paper presents a combined servo system for mechanically coupled highly-dynamic axes used in production machines. Dynamic movements with a bandwidth of up to 100 Hz and a stroke of several mm are generated by an electro-magnetically driven axis. For highly dynamic movements with a bandwidth of up to 2 kHz a piezo-actuator is used. The control of the dynamic axes bases on an FPGA system enabling position control clocks above 100 kHz and a microprocessor based system for setpoint generation.

Regenerating operation of the Z-source inverter
Moritz von Zimmermann, Lothar Sack, Bernhard Piepenbreier, University of Erlangen, D
Nominated for the Young Engineer Award and the Best Paper Award
Z-Source inverters provide unique boost capability in contrast to conventional inverters. The simple structure needs no additional switching elements and only small step-up chokes. The authors describe how to enhance the new drive topology for regenerating operation in conjunction with a 3-phase supply. Derived from waveforms and characteristics, a simple open-loop control scheme for the rectifier is presented. The suitability for standard drives applications is verified by experimental results.

Multilevel inverter for low inductance permanent magnet synchronous motor
Rudolf Mecke, UAS Harz, D
For ship propulsion a special PMSM with very low stator inductance is constructed. With a two-level PWM inverter large current ripples and harmonic power losses up to 10 % are produced. For this application a NPC three-level inverter is investigated. The harmonic power content can be reduced by 5 %. The three-level inverter can be equipped with 600 V-IGBT with lower conduction and switching losses. The power semiconductor losses can be reduced by 40 % compared to a two-level inverter.

New Components and Cooling

Optimisation of surface protection by super hydrophobic surfaces for medium sized distribution-transformers or inductive components in outdoor areras
Heinz Berger, Tauscher Transformatoren GmbH, D
An essential factor for the electrical performance of inductive components are multi-stress conditions like contamination, moisture and electrical stress during operation. Unfortunately this implies an in-creasement of the ageing speed of insulations and other components. To extend the lifetime of such high voltage insulating systems it is of particular importance to reinforce the surface of materials. They need to be able to deal with contemporary electrical and climatic stress.

Efficient water cooled transformer for high frequency induction heating applications
Alexander Stadler, Christof Gulden, STS GmbH & Co. KG, D
An efficient water cooled transformer with an application to high frequency induction heating is proposed. The secondary side of the transformer is realized by a water cooled copper tube with rectangular cross section. This winding configuration allows the interleaving of the windings with the direct consequence of considerably reduced copper losses and a very low leakage inductance of the transformer. FEM simulations are conducted to investigate different winding arrangements.

Film capacitor with integral water cooling provide efficient heat transfer and system thermal management
Ralph Kerrigan, NWL, USA
This paper demonstrates how the addition of integral water cooling to film and metallized film capacitor which removes heat aids in the capacitor life as well as controlling the watts to be dealt with in system design.

Development of silicon nitride substrates with high thermal conductivity for heat sink applications based on economic technologies
Ina Sichert, ANCeram, D
This investigation illustrates the possibility of assembling a Si3N4- AMB-substrate with a three times higher thermal conductivity as usual for heat-sink applications with the use of low cost shape forming and sintering methods and thus makes it possible to increase the life cycle of electronic assemblies.

New superior assembly technologies for modules with highest power densities
Roland Ott, Marco Bässler, Roman Tschirbs, Dirk Siepe, Infineon Technologies, D
Power module development is striving for higher power densities in existing housings. Main challenges for these kinds of upgrades are to meet the new requirements towards ampacity and heat dissipation. These new requirements enforce adjustments in the utilized packaging technologies to overcome the given package limitations. The current talk investigates the challenges of increased power density in existing housings and how they can be mastered.

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Inverters for Renewable Energy and UPS

Comparison of transformerless topologies for solar application concerning efficiency, leakage current and volume
W.-Toke Franke, Friedrich W. Fuchs, Nils Oestreich, Christian Albrechts University, D
Nominated for the Best Paper Award
An overview of the performance of three phase transformerless topologies as VSI, NPC and ZSI is given. Therefore the topologies are introduced and the working principles are explained. The power losses, the resulting leakage current at the pv array and the volume of the inverter are investigated mathematically, by simulation and experimental measurements. From the efficiency point of view the NPC has the best performance followed by the VSI and ZSI. The leakage current is for all topologies ok.

Evaluation of a Three-Phase Two-HF-Switch PV Inverter with Thyristor-Interface and Active Power Factor Control
Christian Nöding, Benjamin Sahan, Peter Zacharias, University of Kassel, D
PCIM Europe 2010 Best Paper Award Winner
To feed in a high-power alternating current into the medium voltage AC grid several requirements have to be kept. Next to a rugged and interference-insusceptible electronics, attention has to be given to new grid connection guidelines in Germany since 2008. These rules affect the cost of inverters, especially when usual semiconductors are employed. This paper deals with a topology that combines the rugged properties of well known thyristor-circuits with the features of modern inverters.

Utility interactive 3-phase pulse modulated PV inverter embedding neutral point voltage shifting scheme into instantaneous current control implementation
Nobuyuki Hattori, Noriyuki Morotomi, Shuji Miyake, DAIHEN Corporation; Mutsuo Nakaoka, Kyungnam University/Yamaguchi University, J
The newly-proposed control strategy introduced to the utility interactive three-phase PV inverter is based upon a neutral phase voltage shifting reguration algorithms in order to improve the inverter efficiency as well as dynamic power quality characteristics of utility grid connected these phase inverter system.

A study of high efficiency UPS using advanced three-level topology
Makoto Yatsu, Kansuke Fuji, Satoki Takizawa, Yoshihiko Yamakata, Yasuhiro Okuma, Kousuke Komatsu, Haruo Nakazawa, Fuji Electric, J
Because the concern has risen to the energy environmental problems, it is important to make UPS system highly effective. On the other hand, the UPS should supply a steady electric power to the load. Therefore, the demand to use the double conversion UPS is very high. Then, to improve efficiency further than two levels UPS, we developed new UPS that the method of V-connecting wires to use advanced three-level topology. In addition, we develop and are applying advanced three-level module. We call this module Advanced Neutral Point Clamped (ANPC) IGBT module. In this paper, first, it explains the feature of UPS using advanced three-level topology and the module developed. In addition, the evaluation result of the prototype system is referred.

Sensors and Metering

Realization of a (400 A/DC-10 MHz) clamping HOKA current probe
Boris Hudoffsky, Jörg Roth-Stielow, University of Stuttgart, D; Nico Karrer, ETH Zürich, CH
Due to the reduced switching times and maximum currents as well as transients extended to higher values the need for current measurement which can handle this challenge is coming up. The isolating current measurement principle HOKA has many advantages and is presented in a clamping version including new GMR technology for low frequency current capture. A DC-open-loop prototype to measure up to 400 A DC and transients of more than 1 kA per µs is built and measurement results are shown

Compact current transducer for high-voltage, direct current (HVDC) electric power transmission
Wolfram Teppan, Marc Schaerrer, LEM, CH
The working principle, design, and application of a fully integrated current transducer for HVDC systems are explained. The main features are low cost, a relatively high nominal current, a big aperture for the primary conductor (high-voltage bushings with a large diameter need to be inserted), a low DC error even at high AC current levels, a compact package as well as easy maintenance. Results of electronics simulation are compared with measurement results at static and dynamic conditions.

Precise loss measurement for 60 MW railway system intertie
Helmut Weiss, Montan-University Leoben; Hugo Baldauf, OeBB Instrastruktur, A; Pascal Mauron, Ivonne Zickermann, ABB Switzerland, CH
A special loss measurement was carried out at the final acceptance test for the 60 MW Austrian Railways system intertie at Timelkam/Austria. With the 2-block arrangement, single-phase power output of first block was re-entered at second block creating a circular power flow. Total losses equal active power drawn from 50 Hz side. Through special measurement equipment and defined temperature models low error margins can be obtained for a clear decision about meeting guaranteed rated maximum losses.

Innovative design to communicate and supply in high voltage environment
Wolfram Teppan, Marc Schaerrer, LEM, CH
An innovative design to isolate analog signals and power supply in high voltage environments. Main features are high isolation, accuracy and high common rejection. Even though input and output of the transducer are analog, it is an advantage to transmit data digitally across the isolation. In the chosen design, both data stream and power are isolated with double-series-connected-transformers. The performances of a voltage transducer and a shunt isolator that use this design are presented.

Electrical Machines

Torque pulsations reduction for a permanent magnet synchronous steering feedback actuator
Milorad Risticevic, ebmpapst St. Georgen; Dorin Iles, Dr. Dorin Iles, D
Permanent magnet synchronous motors are finding an expanded use in automotive steering systems where torque smoothness is mandatory. An electric drive based on an interior permanent magnet synchronous motor for a steering feedback system will be presented in this paper. A current harmonics injection control method for torque ripple reduction is introduced and implemented in an experimental set up.

On construction of a compact in-wheel transverse flux machine with distributed windings
Salwa Baserrah, Keno Rixen, Bernd Orlik, University of Bremen, D
A novel design of a small outer rotor transverse flux machine for low speed platforms with distributed windings around the stator will be constructed and investigated. The proposed configuration is set in a comparative study via finite element (FE-) program, with a similar machine of the normal layered-three phase construction. The new design showed better torque productivity even if the axial length of the machine is reduced. A prototype is shown and some performances are summarized.

Selecting the best magnetic materials for use in electric machines
Dan Jones, Incremotion Associates, USA
One of the major problems in high performance electric machine design is the selection of the best magnetic materials. While the major elements in electric machine design include the machine geometry, winding configuration and the magnets for permanent magnet machines, the losses in the magnetic soft iron members can reduce machine performance by as much as 25% in higher speed machines. The trend toward more power efficient design of electric motors fostered by the current Green revolution places an emphasis on using the optimum magnetic material. An 86 mm brushless PM motor (PMSM) is selected as the vehicle to examine the process of minimizing magnetic material losses and maximizing motor performance. The selection of the optimum magnetic material is tied to the required motor performance needed by the application. There are two development trends that have been favored in new applications driven by both market needs and political and cultural desires. This need is to improve motor efficiency at speeds below 8000 rpm and to develop other motors that operate efficiently above 20,000 rpm. This paper will focus on a high speed application, establish a baseline performance and then illustrate the importance of magnetic material selection in reaching these performance levels.

High precision identification method for differential dq-inductances of permanent magnet synchronous machines
Josef Reill, Sven L. Kellner, Sebastian Ebersberger, Markus Seilmeier, Bernhard Piepenbreier, University of Erlangen, D
Accurate knowledge of the machine parameters is very important for high precision field oriented control of PSMs and especially for sensorless control with test signals. Sensorless control with test signals is based on the differential inductances. This parameters are measured with high precision by the proposed algorithm.

Poster Presentations

Considerations on switching losses and electromagnetic compatibility (EMC) of innovative semiconductor technologies
Mehmet Kazanbas, Samuel V. Araújo, Peter Zacharias, University of Kassel; Norbert Henze, Jörg Kirchhof, Fraunhofer Institute for Wind Energy and Energy System Technology, D
Nominated for the Young Engineer Award
New switch technologies are capable of performing very fast switching transients with reduced losses what leads to the interesting potential of operating at a higher switching frequency. Though this may allow size reduction of passive elements, significant problems related to EMI may arise due to the high values of dv/dt and di/dt. This paper will firstly focus on the electrical properties of such devices and then analyze the potential and benefit of increasing the switching speed.

Vector control of induction generator with parallel stator resistance and rotor speed estimation
Boris Dumnic, Djura Oros, Dragan Milicevic, Dragan Matic, Veran Vasic, University of Novi Sad, SRB
This paper presents vector control strategy with parallel rotor speed and stator resistance estimation for induction generator used in wind turbine application. Model reference adaptive system is used in order to estimate the rotor speed of induction generator. Since stator resistance of induction generator varies with operating conditions, stable and accurate operation at fully load and low speed region requires an appropriate online identification algorithm for the stator resistance.

Comparison of different concepts of distributed power generation with fuel cells
Yuriy Bessarab, Igor Merfert, Andreas Lindemann, Otto-von-Guericke-University, D
This paper deals with two power supply concepts based on a fuel cell. Both systems operate as power supply to non-linear loads and active power feed into the mains. The fuel cell is used with an additional energy buffer in form of a battery. A DC link connects two DC/DC converters with the inverter in the first case and every DC/DC converter of the fuel cell and of the battery has its own DC link and inverter in the second one. The possibilities of power management will be shown.

Comparison between energy battery and power one for electrical vehicle applications
Julien Dauchy, Daniel Chatroux, CEA, F
In 2009, a presentation was done in PCIM about the experience feedback on electric vehicles of the French car fleet and the replacement of the initial NiCd battery of an AX vehicle by an iron phosphate Lithium battery with 1600 small cells [1]. This cells are power ones. This presentation is a comparison between this power battery and an energy battery in the same format.

Improving efficiency of parallel UPS installations in low-load conditions
Lorenzo Giuntini, GE Consumer & Industrial, CH
Double conversion UPSs are often the preferred choice for protecting critical loads. While providing optimum protection, this topology may not offer the highest efficiency. Additionally, system load in field installations may be significantly far from optimal UPS efficiency (particularly in redundant 2N, 2(N+1) installations). This paper discusses parallel UPS systems, and proposes a method for improving their efficiency in low-load conditions, while maintaining double-conversion protection.

Measurements of mains impedances in the frequency range up to 20 kHz and analysis of harmonics up to 10 kHz in low voltage mains
Eugen Balzer, Holger Borcherding, UAS Ostwestfalen-Lippe; Heyno Garbe, Leibniz University Hanover, D
Limits for conducted emissions for the frequency range from 2 to 9 kHz are in discussion. Because of this mentioned gap in the standards there is an uncertainty how to design filters and disturbance sources like converters. In this paper current investigations on mains impedances and harmonics are presented which were carried out in universities, companies and private houses. The results could be used as a base for finding limits and for designing filters and disturbance sources economically.

Power losses of induction motors in relation to supply voltage quality
Toomas Vinnal, Kuno Janson, Heljut Kalda, Tallinn University of Technology, EST
This paper is focused on active and reactive power consumption and power losses in induction motors depending upon supply voltage quality parameters. Supply voltage level deviations from rated voltage naffect directly power consumption and losses in induction motors. Active and reactive power relation to supply voltage level is characterized by load factors. In the paper a practical method for determining the load factors is described. Measurement results of voltage harmonics in some specific industry cases are shown. Harmonic distortions and asymmetry of supply voltage affect power losses and need more attention and studies to estimate power losses in the consumer low voltage systems.

Optimal control of UPFC for load flow control and voltage flicker elimination and current harmonics elimination
Hedaya Alasooly, Mohammed Redha, University of Bahrain, BRN
Recent advances in the power system handling capabilities of static switches have made the use of the voltage source inverter (VSI) feasible at both transmission and distribution levels. In this paper, comparison between optimal control strategies applied to a system with unified power flow controller, shunt converter and series converter have been demonstrated. The control strategies were tested using a power system distribution mode. It was observed that when the system is with one converter, there will be only two control inputs in the system, which means it is possible to track only two outputs in the system and if the objective is to maintain capacitor voltage constant, it is possible to track one output for the system for the capacitor voltage to be maintained constant. When the system is with two converters, then we will have four control inputs in system, which means it is possible to track only four outputs in the system. The series converter is able to eliminate the voltage flicker, while the shunt converter is able to eliminate the current harmonics. The UPFC can remove both the current harmonics and voltage flicker from the system.

MOSFETs or IGBTs in the modern ERC and SUSTAIN modules of PDPs? An empirical approach for choosing suitable power switches
Giuseppe Consentino, STMicroelectronics; Andrea Perri, Calabria University, I
This paper studies the ERC and sustain modules of the PDPs focusing the attention on the power switches mounting on them. In particular, the analysis implemented is used to evaluate which between MOSFET or IGBT is the best solution to propose either in the ERC or in the sustain modules in terms of power losses, efficiency and reliability, taking into consideration the newest devices technology. The comparison is performed considering either the latest 300V or the previous 200V PDP applications.

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Architectures for hybrid-digital control of switch-mode power supplies
Stefan Schmitt, BLOCK, D
The majority of commercially available switch-mode power supplies still employ purely analog control and pulse width modulation despite the promising advantages of digital control. One reason for this lack of acceptance is the lack of a standard control architecture like it is used for analog control. Here, possible hybrid-digital architectures incorporating digital and analog components are defined using abstract morphological analysis and evaluated for feasibility.

Time-shift control of LLC resonant converters
Claudio Adragna, STMicroelectronics, I
This paper describes a new control technique for resonant converters that outperforms the direct frequency control (DFC) method implemented in all the commercially available control ICs. When applied to LLC resonant converters, the resulting dynamic behavior is that of a first-order system under all operating conditions. Thus closing the control loop to meet stability and dynamic performance specifications becomes a much easier task.

Turn-off active gate control of low voltage automotive power MOSFETs with high current ratings
Björn Wittig, Friedrich W. Fuchs, W.-Toke Franke, Christian-Albrechts-University, D
An analysis of turn-off active gate control circuits for Low Voltage Power MOSFETs with high current ratings in automotive converters is presented. Different gate control circuits are described with focus on the reduction of the undesirable overvoltage at turn-off under the precondition of low increasing the switching losses. They are compared to a simple gate drive circuit. Experimental results are presented and compared for two different types of MOSFETs.

Dynamic performance evaluation of a non-linear digital control technique for multiphase VRMs
Valeria Boscaino, M.Gaeta, G.Capponi, University of Palermo; F.Marino, STMicroelectronics, I
Saving cost, minimizing system size, while lowering power supply voltage values, is mandatory to benefit from modern technology advances. Due to the increasing capabilities of modern processors, higher and higher current slew-rates are required. In this paper, a multiphase buck converter for VRM applications is proposed. A non-linear digital control avoiding limit cycle and minimizing both recovery time and output voltage over- and under-shoots is presented. Experimental results are shown.

Design by optimization of a Boost converter; Integration of the control aspect
Kamal Ejjabraoui, C. Larouci, ESTACA; P. Lefranc, Supelec; C. Marchand, Laboratoire de Génie Electrique de Paris, F
This paper presents an approach by optimization to design a Boost converters which is carried out in tow main steps. The first step consists on determining the most adapted architecture to and the appropriate technologies of the passive and the active components. The second step consists on optimizing the selected architecture under multi-physic constraints. The controller parameters are designed for the optimized architecture.

Capacitive DC-DC Converter for electric vehicle applications
Christopher Pelczar, Oliver Zirn, Clausthal University of Technology, D
This paper deals with the design and implementation of a capacitive DC-DC converter. We examined the phenomena that influence the performance of DC-DC converters. The performance of the DC converter was tested over a range of loads and switching frequencies. The comparison of simulation and measurement results as well as design parameter studies elucidate the simulative design options as well as the achievable power and efficiency.

A DC/DC high voltage power supply
Nikolay Madzharov, Miroslav Stefanov Gardevski, Gabrovo University of Technology, BG
This paper presents a high-frequency transistorized converter used in power supplies of high frequency tube generators for induction and dielectric heating. The high-frequency transistorized converter has two operating modes: zero-current-switching and zero-voltage-switching. After the computer analysis the ZVS was selected. The feature steps are formulated concerning high voltage output transformer and high frequency rectifier.

Eoff and Eon characterisation of SiC diodes
Jose Jordan,V. Esteve, Enrique Dede, E. Sanchis, E. Maset, A. Ferreres, J.B. Ejea, University of Valencia; J. M. Magraner, C. Cases, GH Electrotermia, E
The predominant features in high frequency switching are the turn on (e_{on}) and turn off energy (e_{off}).There is not information about e_{on} and e_{off} in data sheets and we try to obtain information of e_{on} and e_{off} dependence. We have characterized three types of SiC diodes and one diode developed in the National Microelectronics Center of Barcelona. The first characterization determines switching losses according to switching current (I_{FSW}) for two different temperatures (25 °C and 125 °C). Switching parameters are: constant voltage and MOSFET gate resistance constant. The second characterization determines switching losses of SiC according to current switching speed (*di/dt*). The parameters of the switch are: constant voltage and constant current switching. This study of switching losses has been made at two temperatures (25 °C 125 °C). Finally we compare e_{on} and e_{off} for similar Si Diodes

Novel characterization and reliability estimation of 1200V IGBTs for domestic induction heating
Cesare Bocchiola, International Rectifier Corp., I; J.Cerezo, International Rectifier Corp., USA
SEPRCtopology is important in domestic IH.Major drawback is the need for high voltage switches;IGBT above 1200V have higher conduction and switching losses.A reliability estimation of 1200V IR trench IGBTs was carried out, to check if the platform can withstand more than the DC rated voltage in transient conditions. This paper shows that no new failure mechanisms are triggered. A novel transient IGBT's Breakdown Voltage (BVce) characterization is presented.

Influence of the gate drive on the short-circuit type II and type III behaviour of HV-IGBT
Jörg Schumann, Steffen Pierstorf, Hans-Günter Eckel, University of Rostock, D
This paper presents simulation results about the interaction between HV IGBTs and their gate-drive in case of short circuits. It describes the reason for the current overshoot in the so called short-circuit type II and the distribution between IGBT and diode-current in case of a short-circuit type III. The influence of the parasitic inductance in the gate drive is investigated and different measures to improve the short-circuit type II and III behaviour by the gate drive are discussed.

Superjunction MOSFETs utilized in resonant ZVS-inverters for higher frequencies – analysis of the inverse diodes
Klaus F. Hoffmann, W. Mißfeldt, Helmut-Schmidt-University, D
In many power applications resonant ZVS-inverters have been utilized with high switching frequencies. For this, Zero-Voltage-Switching methods have been used combined with power superjunction MOSFETs. The inverse diodes of these MOSFETs have mostly unfavourable turn-off behaviour, but this can be neglected in in the majority of ZVS applications. However, in this paper the influence of these parasitic diodes at higher frequencies above 450kHz will be analysed and discussed in detail.

Power MOSFETs for automotive battery management systems
Marco Pürschel, Infineon Technologies AG, D
Due to fuel economy and CO^2 reduction targets the electrification of the power train in automotive is in the focus. Different kind of hybrid solutions was introduced. One solution to safe fuel is the start stop system, where the combustion engine will be switched off and restart automatically. One challenge is the battery voltage drop during cranking. This paper will focus on the battery management for such start stop applications. Which power MOSFET is ideal and why will be explained.

SP3 boost chopper module with ESBT® switch and SiC boost diode for highest efficiency power converters
Serge Bontemps, Alain Calmels, Microsemi PPGM, F; Hans Oppermann, Powercon, D
New power devices as the ESBT®, (Emitter Switched Bipolar Transistor), allow meeting as good, if not lower, total switching losses as the available fastest IGBT devices but offer dramatically reduced conduction losses. Microsemi has developed an ESBT® Boost chopper module built with SiC chopper diodes that allow comparable converter efficiencies to the use of SiC switching devices at a much more affordable price.

ΔT and over temperature protection of smart power MOSFETs using integrated seebeck difference temperature sensors
Donald Dibra, Matthias Stecher, Christoph Kadow, Infineon Technologies AG; Andreas Lindemann, Otto-von-Guericke-University; Josef Lutz, Chemnitz University of Technology, D
Smart power MOSFETs in automotive power applications are exposed to very high power dissipation when operated in short-circuit or overload conditions. Those devices must also survive repetitive short-circuit and overload operation. Suitable protection methods must prevent device destruction in repetitive operation by minimizing the thermo-mechanical stress on the device. Here we present Delta-T and over-temperature protection circuits of power MOSFETs using integrated Seebeck Delta-T sensors.

Thermal-mechanical analysis of solder layers in power modules under superimposed cycling conditions
Tilo Poller, Marco Feller, Josef Lutz, Chemnitz University of Technology, D
The superimposed cycling test is a new method for the lifetime estimation of power modules. It was already presented on the PCIM 2007. In this test the solder layers are damaged on the borders and edges. This paper wants to explain these damage behavior and will make a comparison to other standard lifetime tests.

Direct liquid cooling of power modules in converters for the wind industry
Klaus Kristen Olesen, Frank Osterwald, Michael Tønnes, Danfoss Silicon Power; Ronald Eisele, UAS Kiel, D; Ryan Drabek, Danfoss Drives, USA
Direct liquid cooling of power modules is offering a more reliable, compact and cost effective solution than traditional cold-plates. The thermal conditions of the cooler and the thermal stack of cold plate and direct cooled solutions are analyzed and modeled. The mission profile from the wind power applications is applied to both solutions. Results are compared. It is demonstrated, that the light weight and cost effective ShowerPower® is ready for use in wind power.

Thermally enhanced 5x6mm powerQFN packaging for MOSFETs
Dennis Lang, Fairchild Semiconductor, USA
This paper will introduce a new package technology developed for power semiconductors. With the increasing power densities of modern electronics design, many engineers are looking for ways to cool power semiconductors, such as MOSFETs, without adding more heat energy to the printed circuit board. This new technology enables the efficient use of a heat sink in the common 5x6mm MLP footprint.

Method and test assembly for power cycling tests at converter conditions
Alexander Hensler, Josef Lutz, Chemnitz University of Technology; J. Zill, emCoSys GmbH; Reinhold Bayerer, Infineon Technologies, D
For reliability test at converter conditions a concept and method was developed. With this test assembly It is possible to record significant parameters of power module at converter operations to detect the degradation of solder layer and bond wire failure.

Active power cycling for end of life tests of heavy wire bond interfaces on power semiconductors
Jens Göhre, M. Schneider-Ramelow, U. Geissler, K.-D. Lang, Fraunhofer Institute for Reliability and Microintegration (IZM), D
In this publication shear test results of heavy Al bond wires on power semiconductors after power cycling with different temperature swings and maximum temperatures are presented. In addition, cross sections and microstructure analyses reveal the exact path of the crack.

Reaching new Limits with high power bipolar devices
Jens Przybilla, Joerg Dorn, Reiner Barthelmess, Ralf Joerke, Uwe Kellner-Werdehausen, Infineon Technologies Bipolar; D
High power bipolar semiconductors are based on mature and well-proven technologies. They have demonstrated their outstanding reliability and performance for many decades in a variety of applications. Further developments of such devices are carried out in close cooperation with customers' system innovations in the relevant applications. Different aspects of the applications can drive the semiconductor device development. An increase of the overall performance of the application can result in the requirement of more powerful semiconductor devices. The reduction of complexity or number of components in a system may require devices with a higher blocking capability. Applications with new or more challenging requirements or system cost reduction targets sometimes lead to an optimization of existing power semiconductors. Examples include the development of devices with higher current capability, adaptation of the blocking voltage measurement and increase of the blocking capability according to application aspects and increased switching ruggedness. This paper describes some of the progress in the field of high power bipolar semiconductor devices, achieving new standards and therefore enabling significant improvements in the relevant applications.

EMI analysis of flyback topology for SMPS
Alfred Hesener, Fairchild Semiconductor, D; Allen Wang, Fairchild Semiconductor, CN
Electromagnetic interference (EMI) is ubiquitous. The desire for a better environment and quality of life has led to increasingly stringent requirements being placed on the electromagnetic compatibility of electrical and electronic products all over the world. Through analyzing the magnetic core, the winding and shielding layers of the transformer in flyback switch mode in power supplies, this article presents methods of conduction mode EMI operating under these conditions.

A novel series of intelligent power modules "V1"with internally paralleled FULL GATE CSTBT and mirror emitter technology for short circuit sensing
Marco Honsberg, Thomas Radke, Mitsubishi Electric Europe BV, D; Nishida Nobuya, Uota Shiori, Yoneyama Rei, Tametani Fumitaka, Orita Shoichi, Mitsubishi Electric Corporation, J
Intelligent Power Modules (IPM) have substantially contributed to miniaturization of drives. Mirror Emitter technology detects a short circuit situation before the IGBT desaturates and can reduce the stress on the IGBT during short circuit. The new V1 series of IPMs provide 2in1 configurations employing state-of-the-art loss performance by FULL GATE CSTBT technology with high reliability and extended protection functions like over temperature (on chip) under voltage (UV) and short circuit (SC).

FPGA-based digital implementation of a hybrid spread-spectrum technique for EMI mitigation in DC-DC converters
Gamal Dousoky, Masahito Shoyama, Kyushu University, J
To effectively spread the conducted-noise frequency spectrum and at the same time attain a satisfactory voltage regulation, two parameters (carrier frequency and pulse position) are randomized, and the third parameter (duty ratio) is controlled by a digital compensator. Moreover, the converter's EMI performance has been experimentally investigated.

New technologies boost performances on photovoltaic applications
Gaetano Belverde, Giuseppe Sorrentino, STMicroelectronics, I
In this paper we will present a full working grid-connected inverter prototype suitable for rooftop applications will be introduced. That prototype has a wide input voltage operation since 200V to 400V, and 3 KW of maximum power output, it is intended for rooftop applications. A stage by stage explanation will be presented, as well as the topologies adopted and a deep analysis will be discussed about the front-end stage of that inverter.

A zero voltage transition isolated cuk current source inverter for photovoltaic module integrated converter applications
Georgios Lempidis, M. Rzeszut, P. Zacharias, University of Kassel, D; N. Polyzos, Technological Educational Institute of Crete, GR
The proposed paper presents a zero voltage transition soft switched current source isolated Cuk inverter. The proposed topology is promising for module integrated converter applications due to the capability to work at high frequencies with low switching losses. The High frequency leads to higher power density and thus lower volume

A new dual buck chopper-assisted PFC converter with minimized ripple output voltage characteristics and its extended circuit topologies
Kazunori Nishimura, Nobuhiro Yokoyama, Hiroshima Institute of Technology; Katsuya Hirachi, Maizuru National College of Technology; Mutsuo Nakaoka, Soon-Kurl Kwon, Kyungnam University/Yamaguchi University, J
This paper presents a novel improved circuit topology for a modified chopper type single phase PFC converter which has high power density reactor size and can minimize the DC output voltage ripple factor with the feedback control. In addition, this active converter can be also suppressed the line current harmonics in Utility AC grid. In this paper the operating principle of proposed AC-DC converter circuit are described, along with its simulation and experimental results and their evaluations.

New current balancing topology for backlight inverters
Robert Weger, NMB-Minebea, D
A purely semiconductor based current balancer is presented which facilitates driving multiple lamps by only one power transformer. The balancing limits and the mechanisms of debalancing are analyzed and circuits for detecting balancing limits and for minimizing the resistive balancing losses are investigated.

Single period sinusoidal pulse generator for efficient drive of Dielectric Barrier Discharges
Michael Meisser, M. Paravia, W. Heering, R. Kling, Karlsruhe Institute of Technology, D
Dielectric barrier discharges (DBD) are mainly capacitive loads that are to be charged and discharged within periods in the microsecond range to obtain high plasma efficiency. Based on a resonant principle, the presented topology generates a single period sinusoidal HF pulse that leads to two lamp ignitions per pulse. A DBD lamp with C_{DBD} = 2.9 nF, that is homogeneously driven with a 500 kHz pulse, reaches an efficacy of 14 lm/W at a light output of 2140 lm. Electrical efficiencies up to 80 % are obtained. Additional component and switching pattern enhancements are presented.

High performance HB-LLC resonant adapter implements advanced synchronous rectification controlling
Alberto Stroppa, Claudio Spini, STMicroelectronics, I
This paper presents the characteristics and performance of a 90 W-19 V AC-DC adapter for notebook PCs tailored to the latest power saving requirements. The power supply is composed of a front-end PFC pre-regulator and an HB-LLC resonant downstream converter. An innovative synchronous rectification control, integrated in the new SRK2000, is the key element in achieving superior efficiency at high load without affecting standby consumption.

Environment-friendly uninterruptible power supply (UPS) systems
Ibrahim Gunes, Bulent Ustuntepe, Mehmet Islek, Nihat Ece, Enel Energy Electronics Company; Ahmet M. Hava, Middle East Technical University, TR
Uninterruptable power supply (UPS) systems are widely used in the public infrastructure (hospitals, security centers, etc.), residential applications (PCs), and industry to supply the critical loads with continuous and high quality energy. Due to the rapid increase in energy prices as well as increasing environmental awareness, UPS systems are becoming more efficient and more compact. Until recently, on-line UPS systems with isolation transformer have been employed to supply critical loads. However, environment-friendly transformerless UPS systems have been rapidly replacing the old technology due to their superior performance, higher efficiency and smaller size attributes. In this paper, the technology (topology, components, control, etc.) of the environment-friendly transformerless UPS systems with the 6-300kVA range will be discussed and their experimental performance, and size/weight information will be provided. Energy savings via the improved efficiency and positive impact on the eco-environment via the material size/weight/manufacturing process reduction will be emphasized.

A new gate control approach for power MOSFET to reduce conductive EMI
Matthias Rose, Dresden University; Jörg Krupar, DMOS GmbH, D
This paper describes a new gate control approach for power MOSFET gate drivers. The approach applies different gate currents during a switching transition. This allows a specific control of the current and voltage commutation in the power section. The digital control algorithm can be integrated in a driver IC. By application of this approach supply line inductances of EMI filters can be reduced. Especially in high current applications this approach reduces power losses and cost of materials.

Oscillation circuit analysis of switching mode power supplies
Vera Höch, M. L. Pham, J. Petzoldt, T. Ellinger, Ilmenau University of Technolgy; Holger Kapels, A. Schlögl, Infineon Technologies; Tobias Reimann, ISLE GmbH, D; G. Deboy, Infineon Technologies Austria, A
Energy savings require the decrease of losses. The resulting devices' switching behavior is stronger dependent on circuit parasitics. Parasitics are critical for the occurrence of oscillations. The need of an optimum trade-off between switching slope shaping and efficiency requirements results in devices that are not operated at their best dynamic behaviour. To break the contradiction between loss and noise reduction, an approach for the analysis of high frequency oscillations is presented.

High-temperature operation stability of SOI single chip inverter IC
Hajime Akiyama, K.Watabe, T.Terashima, Mitsubishi Electric Corporation; J
We announced the SOI Single Chip Inverter IC M81500FP in 2007. This is the rated voltage of 500V and a single chip inverter of the rated current of 1A. An inverter drive of brushless DC motor can be performed in inputting Pulse Width Modulation from the outside. This time, we could recognize some satisfactory results of the preliminary evaluation under the high-temperature environment up to around 200□.

Current sensorless power factor corrector applied to electronic ballast for HID lamps
Victor López, F. Javier Díaz, Francisco Javier Azcondo, University of Cantabria, E
This paper presents new design considerations and a control strategy for a two-stage ballast system; power factor correction (PFC) and resonant inverter (RI), for high intensity discharge (HID) lamps. This type of lamps is very sensitive to voltage supply fluctuations that produce flicker. A correct actuation over the voltage loop of the PFC stage reduces the sensitivity. A novel digital control technique for PFC stage is used.

A dynamic control method for a multiphase DC/AC converter with interleaved pulse width modulation using a decoupling network
Christian Nemec, Jörg Roth-Stielow, University of Stuttgart, D
This article presents a possibility to control a multi-phase inverter with several partial branches forming each output branch. Current controllers for each partial current are used to avoid circulating currents between the branches. In order to release the integrating part of each single controller a decoupling network is used.

High efficiency AC/DC power supply for onboard aircraft gallery equipment
Ghulam Rasool, Bernd Orlik, Timo Christ, University of Bremen; H. Raffel, Bremer Centrum für Mechantronik, D
In most of the future developments it is envisioned that individual system component be self aware and intelligent. A new state of the art 150Watt AC/DC digital power supply system for aircraft gallery equipment is developed which uses interleaved PFC stage at input and front end employs LLC resonant converter.

Simple design techniques for optimizing efficiency and overvoltage spike of synchronous rectification in DC to DC converters
Christian Mößlacher, Lutz Görgens, Infineon Technologies Austria AG, A
Due to continuous increase of the packaging density and the more and more restricted energy guidelines (80PLUS® [1]), the efficiency of switched-mode power supplies (SMPS) has to be successively improved to go above 90 %. One of the main losses are the diode forward losses of the secondary side rectification of an isolated power converter. Thus, reaching high efficiency is only possible with synchronous rectification (SR), using modern power MOSFETs. This measure can be a trade-off between low efficiency at light output loads due to increased switching losses and high voltage overshoots violating the maximum voltage rating of the synchronous MOSFETs versus efficiency gain. This paper proposes simple to implement design techniques for optimizing overall system efficiency and reducing voltage overshoots for speeding up the SMPS design process.

Cost-effective, high-efficiency boost converter for Photovoltaic applications
Giovanni Mangraviti, M. Laudani, STMicroelectronics, I
This paper describes how to design and implement a cost-effective 3 kW boost converter able to reach efficiencies above 99% in the best working conditions and able to stay above 98% under most other conditions. The converter was designed keeping in mind most of the requirements needed in photovoltaic inverters, including the cost which can be estimated in the range of 2.5 $/kW as far as the silicon content is concerned.

Double resonant topology for 72V battery charger used in a hybrid electric locomotive - study and experimental validation
Alexandre De Bernardinis, Stéphane Butterbach, Richard Lallemand, Gérard Coquery, INRETS; Yannick Evain, Alain Jeunesse, SNCF; Philippe Aubin, FAIVELEY Transport France, F
This work deals with the study, adaptation and experimental validation of a 9kW battery charger used to feed the 72VDC bus inside the hybrid electric locomotive demonstrator in the frame of the French research project “PLATHEE”. The topology of the charger is based on a high frequency double resonant series-parallel circuit which allows soft switching, losses minimization, reduction of passive component weight and facilitates system integration. Specific charging and floating modes were applied to the battery. The battery charger has been first validated on a laboratory test-bench using a battery emulator, and then integrated in the locomotive. Simulations have been done, completed with experimental results.

New DC–DC converters circuits with better features and zero commutation of all appliances
Nikola Gradinarov, Nikolai Hinov, George Kraev, Dimitar Arnaudov, Technical University Sofia, BG
New converter circuits with better features and zero commutation of all devices are offered in this work. Authors have received a patent for these circuits [1]. The halfbridged and full-bridged circuit variants are shown on Fig 1 and Fig 2. Main difference compared with known circuits from that type is the fact that maximum values of currents through power devices at switch on of DC–DC converter is strongly limited, as well as in emergencies (shortcut in load). The features of the offered circuits are compared with the well-known circuits of resonant DC–DC converters with zero commutation of all devices. Suggested circuits allow regulation of output voltage value in certain limits, by change of keys control frequency, but at same time also keeping zero commutation of devices. Shown are simulated results and results from practical research work, which confirm and prove important advantages of offered new circuits.

Design considerations for DC-DC converter comprising parasitical parameters of transformer with the air-gap
Saijun Mao, GE Global Research Center, CN
Comparing with a conventional transformer without an air-gap, the voltage boost transformer with a large air-gap between primary and secondary has large leakage inductance and small magnetizing inductance. And the large parasitical capacitance of the secondary windings is also an important factor for the voltage boost transformers. And these parasitical parameters of air-gap transformer will influence the converter operation. In this paper, the fourth order LLCC resonant DC-DC converter topology is designed compatible with the air-gap transformer parasitical parameters to achieve high efficiency and high voltage gain operation. Based on the detailed multi-resonant converter characteristics study and air-gap transformer parameter characterization, a 400V input, 5kV/200mA output converter prototype operating at 500kHz~1MHz switching frequency with 90% efficiency is built in lab with air-gap transformer to investigate the characteristics.

Latest ST MOSFET and IGBT technologies for the best efficiency in solar inverters
Simone Buonomo, L.Abbatelli, R.Scollo, STMicroelectronics; M.Cacciato, Alfio Consoli, V.Crisafulli, University of Catania, I
Key factors in designing UPS and solar inverters are efficiency, reliability, performance and costs. The so-called mixed-frequency topologies such as full-bridge and three-level neutral-point-clamped (NPC) topologies show specific advantages at system level design. ST advanced planar technology allows designers to choose the ideal switch for each specific function

A novel approach to stabilize the automotive energy net using a floating converter
Thomas Hackner, Johannes Pforr, UAS Ingolstadt, D
A novel floating converter system is proposed to stabilize the automotive energy net against undesired over and under voltage spikes and therefore to limit the voltage range for sensitive electrical loads. This low cost topology, which is connected in series to the loads, was analyzed for different operation modes and a prototype was designed for a high power automotive energy net. A control circuit was developed and implemented into the prototype to verify theoretical predictions.

Multilevel DC/DC converter design for mobile applications
Daniel Montesinos-Miracle, CITCEA-UPC, Oriol Gomis-Bellmunt, Antoni Sudria-Andreu,Catalonia Institute for Energy Research, E; Alfred Rufer, EPFL, CH
This paper compares in terms of weight and volume different cascaded and multilevel topologies for DC/DC converters for regenerative braking using supercapacitors in mobile applications. The paper shows that the multilevel buck derived topology can beneficiate from both reduced voltage across the inductor and increased frequency to reduce the inductance, even if there is a need for an input LC filter to reduce harmonic content in supercapacitors.

Fast and accuarte simulation method for switch-mode power supplies
Markus Schmid, Alexander Bucher, Marc Doebroenti, Thomas Duerbaum, University of Erlangen-Nuremberg, D
In order to describe the voltage and current waveforms of a switch-mode power supply (SMPS) accurately by simulation the parasitic output capacitance of the MOSFET cannot be neglected. For this reason the paper describes and compares two different simulation methods which take the capacitance into account without extending the simulation time considerably, so that a fast and accurate simulation of the SMPS is obtained. The first method is an analytical solution with an equivalent linear capacitance; the second method really considers the non-linear dependency of the capacitance on the voltage. The measurement shows, that the second method describes the SMPS very accurately.

Design of a transverse flux machine for small direct driven wind turbines
Markus Rüter, Wolfgang Oberschelp, UAS Gelsenkirchen; Uwe Baader, Ritter Elektronik; Günter Schröder, University of Siegen; D
For decentralized and renewable supply of electricity or also for integration in public power supply structures more and more frequently small wind turbines are used. The development and the construction of a direct drive function according to the transverse flux principle is presented in this paper. The machine is designed for small wind turbines operating according to the H-Darrieus-rotor principle. The complete system is improved by a clear increase of the robustness and efficiency as well.

Diagnosis method for monitoring the electrical frequency of AC-machines on basis of PWM signals
Heiko Zatocil, Sebastian Villwock, Uwe Hensel, Ulrich Strunz, Baumüller Nürnberg GmbH, D
Nominated for the Young Engineers Award and the Best Paper Award
This paper deals with the detection of the electrical frequency of the rotating field in AC machines. The proposed method only utilizes the digital control pulses of the IGBTs. The aim of the project is the development of a diagnosis strategy in order to detect whether the encoder of the drive works properly or not. The proposed method is a part of a condition monitoring function.

Sensorless control of induction motor using an 8bit microcontroller with low cost current measurement
Matthias Förster, G. Berger, J. Petzold, Ilmenau University of Technology; H. Eisenreich, Elektromotorenwerk Grünhain, D
A sensorless field-oriented control of an induction machine using an 8bit microcontroller is presented. The current measurements take place in the low-side switches of the converter through a shunt. There is no potential separation between the power unit and the controller. The real stator currents are determined in dependency of the space vector modulation pattern and the measurements. The rotor flux determination is realised with a flux model containing a rotation speed dependent feedback.

A low-cost energy-saving control technique for induction motor drives
Giacomo Scelba, G. Scarcella, A. Consoli, University of Catania; S. Billé, D. Constanzo, A. Cucuccio, STMicroelectronics, I
The paper proposes a detailed analysis of a practical low-cost, scalar control for induction motor drives, which minimizes the joule losses of the system through the control of the phase shift between the stator voltages and currents. The strong point of the proposed technique is the ability to lead a drastic reduction of the drive losses in a wide operating range, without requiring additional computational resources to the control unit.

Grid-tied PV inverter by using PV-IPM
Cuijiao Ma, Song Gaosheng, Mitsubishi Electric & Electronic; Haitao Xiang, Haijiang Jiang, Shanghai Aero-Sharp Electric Technologies, CN
This paper presents a dual input two stage grid-tied PV inverter by using Mitsubishi PV-IPM of PM50B6LA060. Features of Mitsubishi PV-IPM, circuit topology of developed PV inverter system and applied control approach are introduced. Lastly, a picture of PV inverter prototype based on PM50B6LA060 and efficiency test results are given.

Thermal simulation of smart power devices on PCB with SPICE
Wim Teulings, Freescale Semiconductor, F; Iko Schmadlak, Torsten Hauck, Freescale Halbleiter Deutschland, D
This paper presents a new method for thermal modeling, simulation and design of a multichannel power semiconductor device on Printed Circuit Board (PCB). The innovative aspect of the followed approach is that it allows simultaneous determination with PSPICE of the temperature of the semiconductor junctions and the PCB track underneath the semiconductor device

MOSFET temperature estimation using several variable correlations for CPU multi-phase voltage regulators
Chong-Sheng Wang, Steve Zhou, International Rectifier, USA
MOSFET temperature of CPU multi-phase voltage regulators can be quickly estimated at early design stage using the several variable correlations and correction values. In presented three examples, good agreement was achieved between the estimated values and test data or CFD simulation results.

Self acting PressFIT module
Thilo Stolze, Infineon Technologies, D
To continue the approach for easy connection & mounting technologies, a new module platform based on the high reliable PressFIT technology has been developed. This offers furthermore an extremely robust one step mounting technology. Special focus has been put on avoiding the risk of DCB cracks resulting from hardly controllable forces originating from the module fixture by means of a screw

Novel silver contact paste, lead free solution for die attach
Wolfgang Schmitt, W. C. Heraeus GmbH, D
Heraeus has developed a novel concept for silver sinter pastes. The new concept uses well known micro scale silver particle technology combined with sinter additives. The novel pastes have higher sinter activity than nano-silver pastes and a can be used in low pressure bonding processes or complete with-out pressure. The physical properties such as shear strength at temperature above 200°C, electrical and thermal conductivity are outstanding compared to solder or silver adhesives. The new paste con-cept can reduce the pressure required for “Low Temperature Joining Technology”, is an alternative to nano-scaled silver pastes and can be potential lead free solutions for die attach applications. A large va-riety of applications are possible.

An IGBT gate driver for operation in high pressure hydrostatic environment
Riccardo Pittini, Magnar Hernes, Kjell Ljøkelsøy, Astrid Petterteig, SINTEF Energy Research, N
This paper presents results from an on-going research project on pressure tolerant power electronics in dielectric environment. An existing IGBT gate driver has been modified and tested for operation in high pressurized environment. The intended application is converters for operation down to 3000m ocean depth. Modifications for pressure adaptation of individual driver components and preliminary test results are presented. The results from the preliminary tests are promising.

SKiiP4 system – switching and thermal aspects
Detlev Richter, Ingo Staudt, Gert Kobernik, Stefan Schuler, SEMIKRON Elektronik, D
A new fast switching power semiconductor generation challenges for new driver concepts to control shorter switching times. With the aim to further improve electronics for power sections, a concept will be discussed to minimize switching losses and to reduce EMI.

Power losses analysis in a single switch resonant reset forward converter implemented with a SiC power JFET
G. Lempidis, University of Kassel, D; Nicolaos Polyzos, E. P. Drakakis, K. Siderakis, TEI of Crete; E. C. Tatakis, University of Patras, GR
A study of the power losses observed in a single switch resonant - reset forward converter is performed, aiming to determine the distribution of the losses of the components employed and the influence of the duty cycle to the converter efficiency. In addition the converter is implemented considering the advantages of SiC. The proposed converter is implemented by a normally-on SiC power JFET.

Analysis of zero-voltage-switching conditions in multi-level Inverter with resonant tank
Christian Düerkop, J. Bergmann, K. F. Hoffmann, Helmut-Schmidt-University, D
This paper describes the influence of additional discrete snubber capacitors on theZero-Voltage-Switching Conditions ofMulti-Level inverters with resonant tank. The analytical investigations will be compared with measurement results of a prototype Three-Level inverter.

A new 650V super junction device with rugged body diode for hard and soft switching applications
Giulliano Aloise, Infineon Technologies Austria, A; D. Zipprick, M.-A. Kutschak, H. Kapels, A. Ludsteck-Pechloff, Infineon Technologies, D
With the new CoolMOS™ 650V CFD technology a new benchmark is set for high voltage power MOSFETs with a high performance body diode of the MOSFET. The transistor combines a high blocking voltage of 650V with lowest RDS(on) and low capacitive losses together with an improved body diode ruggedness during reverse recovery especially for hard and soft switching applications.

Admittance representation of an advanced multivariable control for 16.7-Hz railway traction line-side converter
C. Heising, M. Oettmeier, R. Bartelt, V. Staudt, A. Steimel, Ruhr-University Bochum, D
Grid stability is a major concern for the control of a traction vehicle line-side converter. To achieve best dynamic performance, the obligatory resonant circuit has to be considered during the control design process. This paper includes a brief derivation of a multivariable control for the line-side converter fulfilling these requirements. Excellent operation is verified by measurement results. Additionally, the admittance representation of this advanced control is given – essential for railway-traction applications – and compared to the admittance representation of a standard PI-control.

Flux-based multivariable control of a static converter feeding a 16.7-Hz single-phase load under different fault conditions
M. Oettmeier, C. Heising, M. Gorski, V. Staudt, A. Steimel, Ruhr-University Bochum, D
Nominated for the Young Engineers Award
Actually, AC 16.7-Hz railway grids are fed via back-to-back converters from the public grid. A flux-based multivariable control of the three-phase-side converter is presented which takes the obligatory resonant circuit of the DC link into account, leading to excellent stationary and dynamic behaviour. In this paper the dynamic behaviour of the introduced control is analysed under different fault conditions.

Carrier based PWM technique for a novel three-to-five phase matrix converter
Atif Iqbal, Haitham Abu-Rub, Moin Ahmed, Texas A&M University at Qatar, Q; Rizwan Khan, Aligarh Muslim University, IND
This paper proposes a novel configuration of matrix converter with three-phase ac input and five-phase ac output. Multi-phase (more than three-phase) converters are required mainly for feeding variable speed multi-phase drive systems. This paper discusses one such solution by using direct ac-ac converter that can be used to supply a five-phase drive system. Simple Pulse width modulation (PWM) technique is developed for the proposed matrix converter configuration. The developed modulation technique is based on the comparison of high frequency carrier signal with the input voltages, similar to the one used in voltage source inverter. Although carrier-based scheme is widely employed for control of voltage source inverter, it is very recently being used for a three-phase to three-phase matrix converter [1]. The similar concept is extended in this paper for controlling a three-phase to five-phase matrix converter. Two techniques are proposed, one outputs 0.75 of the input magnitude and the output reaches 0.7886 of the input with the other method. This is the maximum value of the output voltage that can be achieved in this configuration of the matrix converter. The viability of the proposed control techniques is proved using analyticala and simulation approach.

New multi-zone soft starters for alternating-voltage machines
Gennadiy Zinoviev, A. V. Udovichenko, Novosibirsk State Technical University, RUS; Helmut Weiss, University of Leoben, A
New approaches to build-up of arrangements of a soft start of the induction machines are considered, allowing to improve quality of a starting current of the motor and to reduce or even to come to naught additional consumption of a reactive power of a network. Both multizone approaches use symbiosis of concepts of discrete peak and continuous phase or pulse-width regulation. Load, energy and control characteristics of regulators are calculated.

Comparison of losses between matrix and indirect matrix converters with an improved modulation
François Gruson, P. Le Moigne, P. Delarue, X. Cimetière, Unviersity of Lille; M. Arpillière, Schneider Toshiba Inverter Europe, F
Matrix and indirect matrix converters are direct three-phase to three-phase compact power converters providing variable frequency and amplitude control of their output voltage. This paper deals with the comparison of silicon losses for both converters used in classical industrial applications with constant RMS current load, similar to a constant motor torque. Results show that the direct solution is best for efficiency criterium

High frequency leakage current to the building structure from PWM inverter-motor system
Masayuki Morimoto, Tokai University, J
A leakage current of PWM inverter driven induction motor system is discussed. In this paper, the mechanism of the leakage current in the integrated grounding systemincrease is discussed.

Analysis of common mode currents in inverter fed drives
Dominic Wode, Rudolf Mecke, UAS Harz; P. Ecklebe, FEST AG, D
The appearance of common mode currents in inverter fed drives and their influence on the whole drive system is presented. Therefore two factors will be discussed. First the influence of shielded cable referred to the length (3m until 100m) and their parasitic effects on the development of high frequency common mode currents. Second, in how far the switching frequency of the semiconductor components (IGBT) takes differences in amplitude and frequency behaviour of those currents.

Investigations on a high performance control structure for accelerator magnet power supplies
Xinhua Ke, Felix Jenni, UAS Northwestern Switzerland; Rene Künzi, Paul Scherrer Institute, CH
Accelerator magnet power supplies with digital control have reached a very high precision. However, their dynamic behavior is relatively poor. This work has the goal of improving both the precision and speed, using a new control structure implemented on the existing power supply and control hardware. The result of the investigation is a sophisticated two loop structure, combining a state space controller for a fast voltage control loop with a PI-controller for the outer current loop.

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Simulation tool for coupled but independently controlled power-electronic systems applied to NPC converters

Carsten Heising, R. Bartelt, M. Oettmeier, V. Staudt, A. Steimel, Ruhr-University Bochum, D

Fast and accurate simulation of complex power-electronic systems with high accuracy is a major concern, e.g. in context of wind-energy parks and their grid coupling. In these decentralised, coupled topologies all power-electronic devices are controlled independently which has to be emulated by an advanced simulation concept. Moreover, the interaction of many energy-storing elements like capacitors and inductors, partly resulting from cables with low damping, may easily cause indesirable resonances. The effect of the switching of power electronic devices on these structures requires a time resolution down to the individual switchings. In this paper the capability of the presented approach to fulfil these requirements is shown by simulation results of a multiterminal system containing two neutral-point-clamped (NPC) three-level inverters sharing one DC link. The two partial DC-link capacitor voltages are independently controlled by two 2- level converters fed via a transformer with a star- and delta-connected windings on the secondary side.

Design and characterization of planar integrated passive component for power converters

Saijun Mao, Yingqi Zhang, Xiaoming Yuan, GE Global Research, CN

The passive components integration technology with the advantage of component amounts reduction, compact volume, better thermal management, and potential cost saving is an enabling platform technology for converter miniaturization. It is introduced to combine inductor (L), capacitor(C) and transformer (T) into a single integrated passive component (L-C-T). The manufacture process is fully compatible with PCB process by using embedded capacitor materials. Innovative structures with magnetic flux decoupling are proposed. Electromagnetic modelling method with higher accuracy has been developed to predict integrated L-C-T component parameters and electromagnetic field distribution. The prototype of integrated L-C-T component has been tested with promising performance.