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RESEARCH TOPICS

- Design, Management and Control of Electric Propulsion Systems
- Universal SiC and GaN based DC-DC Converter for Plug-In Electric Vehicles
- Multi-Objective Optimization of GaN Gate Driver in EV applications
- Charging Infrastructures for e-Mobility
- Modelling, Management and Control of Energy Storage Systems
- Advanced PWMs for Multilevel Neutral-Point-Clamped Converters
- Smart Grids and Microgrids

DESIGN, MANAGEMENT AND CONTROL OF ELECTRIC PROPULSION SYSTEMS

Keywords: Electric vehicles, Energy management, Energy storage systems, Ferrites, High-speed electrical machines, Vector control, Permanent magnet machines, Transmission systems

The research activity regards powertrain optimization at both component and system levels, ranging from novel design and control of high-speed Brushless DC machines coupled to double-stage magnetic gears to optimal electric vehicle energy management.

References

- [1] A. Damiano, A. Floris, G. Fois, I. Marongiu, M. Porru, A. Serpi, "Design of a High-Speed Ferrite-based Brushless DC Machine for Electric Vehicles", *IEEE Trans. Ind. Appl.*, vol. 53, no. 5, Sept.-Oct. 2017, pp. 4279-4287.
- [2] G. Fois, A. Floris, A. Serpi, M. Porru, A. Damiano, "Design Criteria for Ferrite-Based High-Speed Permanent Magnet Synchronous Machines", in Proc. *E/DPC 2017*, Wuerzburg (Germany), Dec. 5-6, 2017, 7 pp.
- [3] A. Serpi, M. Porru, "A Real-Time Energy Management System for Operating Cost Minimization of Fuel Cell/Battery Electric Vehicles", in Proc. *VPPC 2017*, Belfort (France), Dec. 11-14, 2017, 5 pp.
- [4] A. Serpi, G. Fois, M. Porru, A. Damiano, "Flux-Weakening Space Vector Control Algorithm for Permanent Magnet Brushless DC Machines", *VPPC 2018*, Chicago (USA), Aug. 27-30, 2018, accepted for publication.
- [5] A. Floris, A. Serpi, M. Porru, G. Fois, A. Damiano, "Design of a Double-Stage Magnetic Gear for High-Speed Electric Propulsion Systems", *ICEM 2018*, Alexandroupoli (Greece), Sept. 3-6, 2018, accepted for publication.

UNIVERSAL SiC-GAN-BASED DC-DC CONVERTER FOR PLUG-IN ELECTRIC VEHICLES

Keywords: Gallium Nitride, Silicon Carbide, DC-DC Converter, Plug-In Electric Vehicles

The research activity regards the development of a novel configuration of two-phase asymmetric universal bidirectional dc-dc converter for Electric Vehicle applications characterised by the integration of SiC and GaN based topology. The proposed configuration allows the reduction of the complexity of multi-phase converter with high number of paralleled GaN-based phases.

References

- [1] M. Moradpour, G. Gatto, "A New SiC-GaN-Based Two-Phase Interleaved Bidirectional DC-DC Converter for Plug-In Electric Vehicles", *IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM)*, June 2018.



- [2] M. Moradpour, G. Gatto, "Controller Design of a New Universal Two-Phase SiC-GaN-Based DC-DC Converter for Plug-In Electric Vehicles", *IEEE 18th International Conference on Power Electronics and Motion Control (PEMC)*, Aug. 2018.
- [3] M. Moradpour, G. Gatto, "Dead-Time Analysis of a Universal SiC-GaN-Based DC-DC Converter for Plug-In Electric Vehicles", *Submitted to IEEE Industrial Electronics Society (IECON)*, Oct. 2018.

MULTI-OBJECTIVE OPTIMIZATION OF GAN GATE DRIVER IN EV APPLICATIONS

Keywords: Gallium Nitride, Gate driver, Multi-Objective optimization, Electromagnetic Compatibility, Efficiency, Electric Vehicles

The research activity is focused on optimization of GaN Gate Driver in Wide Band Gap (WBG) devices for power switching converters used in Electric Vehicles (EVs). In particular, the criteria for design properly the R_G and L_G in order to mitigate the Electromagnetic Interference (EMI) issues and minimize the switching losses has been proposed.

References

- [1] M. Moradpour, A. Lei, A. Serpi, G. Gatto, "Multi-Objective Optimization of Gate Driver Circuit for GaN HEMT in Electric Vehicles Application", *IEEE Industrial Electronics Society (IECON)*, Nov. 2017.

CHARGING INFRASTRUCTURES FOR E-MOBILITY

Keywords: Charging infrastructures, Design, Electric mobility, Electric vehicles, Planning

The research activity focus on defining novel methods for planning and designing charging infrastructures for electric vehicles.

References

- [1] M. Mureddu, A. Facchini, A. Scala, G. Caldarelli, A. Damiano "A Complex Network Approach for the Estimation of the Energy Demand of Electric Mobility", *Scientific Reports*, Vol. 8, Issue 1, 1 December 2018, Article Number 268.
- [2] M. Porru, M. Mureddu, A. Serpi, A. Damiano, "A Combined Planning and Design Approach of a Public Charging Infrastructure for Electric Vehicles", *VPPC 2018*, Chicago (USA), Aug. 27-30, 2018, accepted for publication.

MODELLING, MANAGEMENT AND CONTROL OF ENERGY STORAGE SYSTEMS

Keywords: Active filters, Batteries, Energy management, Microgrids, Modelling, Optimal control, Power Quality, Smart grids, Supercapacitors

The research activity is focused on optimal power and energy management algorithms and novel highly-integrated configurations of energy storage systems for both smart grids and electric propulsion systems.

References

- [1] M. Porru, A. Serpi, A. Lai, G. Gatto, A. Damiano, "Modeling, Sizing and Control of Hybrid Energy Storage Systems for Electric Vehicles", in Proc. *IECON 2017*, Beijing (China), Oct. 29-Nov. 1, 2017, pp. 5260-5265.
- [2] M. Porru, A. Serpi, A. Salimbeni, A. Damiano, "An Advanced Frequency-based Energy Management of Hybrid Energy Storage Systems for Microgrids", in Proc. *IECON 2017*, Beijing (China), Oct. 29-Nov. 1, 2017, pp. 7617-7622.
- [3] M. Boi, A. Salimbeni, A. Damiano, "A Thévenin Circuit Modelling Approach for Sodium Metal Halides Batteries" in Proc. *IECON 2017*, Beijing (China), Oct. 29-Nov. 1, 2017.
- [4] A. Serpi, M. Porru, A. Damiano, "An Optimal Power and Energy Management by Hybrid Energy Storage Systems in Microgrids", *Energies*, vol. 10, no. 11, 1909, Nov. 20, 2017, pp. 1-21.
- [5] S. Korjani, M. Mureddu, A. Facchini, A. Damiano, "Aging Cost Optimization for Planning and Management of Energy Storage Systems", *Energies*, vol. 10, no. 11, Nov. 2017.
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- [7] A. Salimbeni, A. Serpi, M. Porru, A. Damiano, "Integration of Sodium Metal Halides Batteries in Microgrids for Providing Active Filtering Services", *SPEEDAM 2018*, Amalfi (Italy), June 20-22, 2018, accepted for publication.
- [8] M. Boi, A. Salimbeni, D. Battaglia, A. Damiano, "A Non-Linear Electrical Model for Iron Doped Sodium Metal Halides Batteries", *ECCE 2018*, Portland (USA), Sept. 23-27, 2018, accepted for publication.



ADVANCED PWMs FOR MULTILEVEL NEUTRAL-POINT-CLAMPED CONVERTERS

Keywords: DC-link voltage equalization, DC-link voltage unbalance, Digital scalar PWM, Energy Storage Systems, Multilevel converter, Multilevel space vector PWM

The research activity consists of developing novel and advanced PWM techniques for three-level neutral-point-clamped converters with the aim of enabling suitable grid supply and DC-link voltage and current management simultaneously.

References

- [1] M. Porru, A. Serpi, I. Marongiu, A. Damiano, "Suppression of DC-Link Voltage Unbalance in Three-Level Neutral-Point Clamped Converters", *Journal of the Franklin Institute*, vol. 355, no. 2, pp. 728-752, Jan 2018.
- [2] U. Abronzini, C. Attaianese, A. Damiano, M. Di Monaco, M. Porru, A. Serpi, "A Dual-Source DHB-NPC Power Converter for Grid Connected Split Battery Energy Storage System", *ECCE 2018*, Portland (USA), Sept. 23-27, 2018, accepted for publication.

SMART GRIDS & MICROGRIDS

Keywords: Smart Grids, Energy Management Systems, Photovoltaic systems, Resilience of smart grids and microgrid

The research activity consists in the development of novel methods for energy control in smart grids and microgrids, for identifying microgrid in a distribution system characterised by a significant renewable energy production and for estimating the resilience of the novel multi-microgrid and smart grid configuration.

References

- [1] M. Gawronska, C. Sanna, S. Casula, A. Salimbeni, A. Damiano, "A Test Bench for Microgrids Powered by Concentrator Photovoltaic Systems", in Proc. *ICCEP 2017*, Santa Margherita Ligure (Italy), June 27-29, 2017, pp. 274-280.
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