Guest editorial

Advances in conductive and wireless powering and charging technologies for transportation applications

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GUEST EDITORIAL

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1 | INTRODUCTION

Charging systems for electric transports are becoming more and more prevalent and are reaching increasingly high power levels now approaching megawatts in heavy-duty vehicle-related applications. This evolution is not only concerning conductive type systems commonly referred to as plug-ins. Alongside such systems, we are witnessing an increasing diffusion of wireless charging (WPT) systems that allow extreme flexibility in charging processes and open up the possibility of sending power to vehicles as they move. This would effectively eliminate the need for stops for charging and allow in some cases to drastically reduce the size of on-board batteries. For similar reasons, several projects are investigating the possibility of applying conductive type charging during vehicle motion as an alternative to the wireless option.

The development of all the technologies mentioned is not only in the automotive field but is touching all areas of electric mobility, from industrial handling to aerial and submarine vehicles.

Power electronics play a key role in all these applications. New possibilities, such as novel magnetic designs, wideband gap devices, advanced control techniques, and high-frequency magnetic materials, are being explored and developed.

This special issue aimed to collect articles presenting experimental studies, new ideas, and concepts, and providing a summary of all these aspects related to advances in conductive and wireless powering and charging technologies for all transportation applications.

2 | PAPERS IN THE SPECIAL ISSUE

The special issue received fifteen submissions. Nine of the originally submitted papers have been accepted after peer review, while six have been rejected. All of the papers mainly addressed power electronics control and the development of innovative conversion structures. One paper addressed a related aspect namely that of confinement of stray magnetic fields generated by charging applications. Finally, two papers are review papers on two different application areas of WPT technologies. A brief presentation of each of the papers in this special issue follows.

Yang et al. develop, in the form of a review, an analysis of the behaviour of inductive-type wireless systems in different media. The work focuses mainly on underwater applications and analyses the behaviour of the same WPT system immersed in fresh and seawater through experiments and simulations.

Mohamed et al.[1] present a review that examines three different wireless technologies applicable to electric vehicles that are inductive and capacitive WPT and magnetic gearing. The paper also provides a comparative analysis of the technologies based on factors like power transfer efficiency, cost, and operating frequency. Research and development issues, capabilities, limitations, and potential applications, are also discussed.

Corti et al. introduce an approach for the design of LCC-S compensated inductive WPT systems based on a genetic algorithm. The approach aims to identify multiple feasible combinations of components that can allow achieving the desired output power. Furthermore, the paper evaluates the effect of passive components' tolerances through a sensitivity analysis based on the Monte Carlo method.

Solimene et al. explore the use of a magnetic-controlled inductor to regulate the output power in an LCC-S compensated inductive WPT system. The work discusses the design and regulation principles of the controlled inductor and the whole system validating the effectiveness of the proposed magnetic control via experimental analysis.

Bajelvand et al. present a control approach that aims at guaranteeing contemporary high-efficiency and unity power factor at the input of an inductive WPT system while maintaining voltage regulation capability over a wide range of load variation. This control is based on a dual-function compensator made by a semi-active rectifier and a switch-controlled capacitor on the receiving side of the system.

Vinod et al. also focus on the control strategy for WPT applications. Specifically, this paper analyses different primary-side control schemes such as asymmetric clamped mode, asymmetric duty cycle, and fixed-frequency phase-shift. The different control schemes are analysed and compared in terms of voltage regulation capabilities and the ability to maintain zero-voltage switching in the entire control range. The paper outlines the

[1] This paper has been handled by independent Editors outside the organizers of the special issue.

procedure for designing the system controller based on a proposed small signal modelling.

A third novel control scheme for WPT systems is presented by Kiyani et al. This control is based on a fuzzy supervisory proportional-integrative (PI) controller and a phase-shift modulation technique. This control proved to maintain a more robust voltage regulation capability than a traditional PI controller when dealing with variations of circuit elements and changes in the magnetic coupling of the coils.

Canova et al. propose an innovative passive shielding technique to mitigate the leakage magnetic field generated by inductive power transfer systems to mitigate human exposure to hazardous magnetic fields. The paper describes the design of such shielding and analyses its impact on the performance of the charging system.

Different from the other works of this special issue, the paper authored by Pesantez et al. deals with conductive electric vehicle fast charging proposing a transformerless DC–DC type I partial power converter. In the proposed topology, the commonly adopted transformer for this kind of converter is replaced with an impedance network. The experimental validation proved that the proposed converter resulted in a more efficient, simpler, and cheaper solution.

3 | SUMMARY

The papers collected in this special issue indicate how the technical and scientific interest in electric vehicle charging and power systems is extremely relevant to date. Eight of the nine accepted papers analyse different aspects of wireless charging systems emphasizing how such technology is increasingly penetrating the world of electric mobility in its different forms and application contexts.

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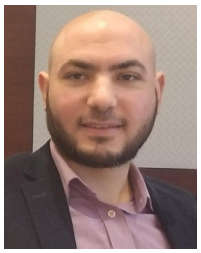
The authors would like to thank all the authors who contributed to this special issue with their scientific results and synthesis work. The authors express their heartfelt thanks to the reviewers whose contributions enabled the selection and improvement of the content of each paper and thus the success of this special issue. Last, the authors would like to express their appreciation to the journal's Editors-in-Chief, the Special Issue Editor, and the Editorial Office for their unparalleled support.

GUEST EDITOR BIOGRAPHIES

Vincenzo Cirimele in 2013 received the M.Sc. in Electrical Engineering (summa cum laude) from the Politecnico di Torino, Turin, Italy where he held the position of Assistant Professor at the Department of Energy from November 2017 to September 2020. To date, he is a Senior Assistant Professor at the Department of Electrical, Electronic, and Information Engineering of the Alma Mater Studiorum University of Bologna. From September 2020 to November 2021, he was a technical responsible for the R&D and Innovation group of the company Movyon s.p.a. of Autostrade per l'Italia group where he supervised projects related to energy sustainability and development of highway electric mobility. In February 2017, he received the Ph.D. in Electronics Engineering (with honours) from the Politecnico di Torino and the Ph.D. in Electrical Engineering from the Université Paris-Saclay. His research interests mainly concern technologies for electric mobility, inductive power transmission, electromagnetic modelling and simulation, and power electronics.

Jianning Dong received the B.S. and Ph.D. degrees in electrical engineering from Southeast University, Nanjing, China, in 2010 and 2015, respectively. He was a Postdoctoral Researcher with the McMaster Automotive Resource Centre, McMaster University, Hamilton, Ontario, Canada. Since 2016, he has been an Assistant Professor with the DC System, Energy Conversion and Storage (DCE&S) Group, Delft University of Technology, Delft, The Netherlands. His research interests include electromechanical energy conversion and contactless power transfer.



Ahmed Mohamed is currently a Senior Engineering Specialist at Eaton Research Labs, CO, USA, and an Adjunct Professor at the Electrical Engineering department at the Colorado School of Mines (CSM). Prior to his current position, Ahmed was with the National Renewable Energy Laboratory (NREL), CO, USA for 4 years, most recently as Senior Research Engineer. Dr. Mohamed received his B.Sc. (2008) and M.Sc. (2012) degrees in Electrical Engineering from Zagazig University (ZU), Egypt, and Ph.D. degree in Electrical Engineering from Florida International University (FIU), FL, USA, in December 2017. From 2008 to 2013, he was a faculty member at ZU, Egypt. His research focuses on transportation electrification, electric vehicle charging, power electronics, as well as DERs. He holds two U.S. patents, authored five book chapters, and published more than 60 articles in peer-reviewed journals and international conferences.

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