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Tutorial Title:

Advanced power conversion systems for next-generation wireless battery charging

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Abstract:

Electrification of the transportation sector is essential to avoid irreversible climate change. As electrified transport systems proliferate, the development of battery chargers and their infrastructure is becoming crucial for the long-term and commercial success of these systems. The batteries in the electrified vehicles are recharged through on-board/off-board conductive and wireless chargers, which are fed from the grid and/or renewable energy resources. Conductive battery chargers are well established and more popular due to their high efficiency; however, handling high-power cables during adverse weather conditions is a risk of electric shock. Furthermore, wireless charging is considered to be the notable solution for opportunity charging of electrified vehicles especially for brief stops or traffic intersections and reduce the battery size under in-motion charging. While there have been many articles published on power conversion systems including power converters and couplers, this tutorial approaches the problem from basic to advanced levels. Understanding wireless chargers and their application from basic and advanced level for future transportation are crucial. Additionally, this tutorial will discuss the design process and simulations through case studies.

Power converters convert AC to high-frequency AC (HFAC) and HFAC to DC on the vehicle side in WPT charging. Coupling devices are equipped to transfer power through electro-magnetic/static coupling, and compensation circuits are connected on-road and vehicle side to reduce VA rating. The primary converter is operated corresponding to the feedback signal from the battery through wireless communication. This tutorial provides a practical introduction and technical advancements in wireless power transfer (WPT) based battery charging systems regarding the theoretical analysis, design, modelling, control, and simulation. Its focus is on the summary of inductive, capacitive and hybrid EV battery charging architecture with related examples and an in-depth discussion of WPT chargers design on various simulation platforms. It provides a step-by-step design of different WPT systems including the inductive and capacitive couplers, and then a comprehensive understanding and design of dual-stage and single-stage power conversion systems. The objective is to expose the audience to all facets of WPT systems with an emphasis on the hands-on tools required for executing academic research and for meeting industry expectations.

Bio:

Deepak Ronanki (S'01–SM'13) received his Ph.D. degree in electrical and computer engineering at the University of Ontario Institute of Technology, Oshawa, Canada in 2019. He worked as a post-doctoral fellow at the University of Windsor in 2020. From 2012 to 2016, he was a Power Converters Design Engineer with Electronics Division, Bharat Heavy Electricals Ltd., Bengaluru, India. He is currently working as an Assistant Professor at the Indian Institute of Technology Roorkee, India since 2020. He received the Best 3-min Ph.D. Thesis Award from IEEE Transportation Electrification Community in 2021, the Outstanding Doctoral Thesis Award from the University of Ontario Institute of Technology in 2020 and the Outstanding Reviewer Award for the year 2019 from the IEEE Transactions on Power Electronics in 2020. He has published more than 50 peer-reviewed technical papers, and five book chapters. He is currently serving as an associate editor for IEEE Transactions on Industry Applications, IEEE Transactions on Transportation Electrification and Transportation Electrification Community (TEC) eNews Letter. His current research interests include power conversion systems for renewable energy, electric vehicle power trains, electric vehicle charging infrastructure, electric energy storage systems, and transportation electrification.

Sheldon S. Williamson (S'01–M'06–SM'13–F'20) received his Bachelors of Engineering (B.E.) degree in Electrical Engineering with high distinction from the University of Mumbai, Mumbai, India, in 1999. He received the Masters of Science (M.S.) degree in 2002, and the Doctor of Philosophy (Ph.D.) degree (with Honors) in 2006, both in Electrical Engineering, from the Illinois Institute of Technology, Chicago, IL, specializing in automotive power electronics and motor drives, at the Grainger Power Electronics and Motor Drives Laboratory. Currently, Dr. Williamson is a Professor at the Smart Transportation Electrification and Energy Research (STEER) group, within the Department of Electrical, Computer, and Software Engineering, at Ontario Tech University, in Oshawa, Ontario, Canada. He also holds the prestigious NSERC Canada Research Chair position in Electric Energy Storage Systems for Transportation Electrification. His main research interests include advanced power electronics and motor drives for transportation electrification, electric energy storage systems, and electric propulsion. Prof. Williamson is a Fellow of the IEEE.

Mauricio Esguerra was born in Bogotá and holds a degree in physics from TU München and Ohio State University. He has more than 26 years of experience in the field of soft magnetic materials and applications, modeling, testing, inductive components, power electronics and LED lighting. He held various positions at various companies including Siemens, EPCOS, Dialight, Pulse, Falco and Eglo and is an active member of IEC standard committees. Mr. Esguerra holds fourteen patents and has published over 70 papers and is CEO and co-founder of MAGMENT UG.