Guest Editorial Special Issue on Capacitively Coupled Power Conversion Systems

FOR nearly 200 years, magnetic induction has been the bedrock of electrical and electromechanical power conversion. During this time, systems largely comprised of copper coils and permeable cores have been used to facilitate power conversion whether electrical (e.g., transformers) or electromechanical (e.g., machines). While physics has long indicated that systems based on electrostatic fields (2-D capacitively coupled surfaces, rather than 3-D magnetic cores) are possible, the practical deployment of these approaches has been limited. The limitation manifests from an orders of magnitude deficiency in field energy density when compared to magnetic systems in the open air. However, this disparity is eroding with the rise of wide bandgap (WBG) semiconductors, high dielectric constant materials and additive manufacturing, among other advances. Recent works have demonstrated that capacitively coupled wireless power transfer systems for personal electronics, small vehicles and industrial automation are possible and efficient. Electric machines have been shown to be 3-D printed entirely from plastic and robotic capacitive grippers can hold surfaces with little to no input power. These devices use WBG electronics and advanced passive components to support their high voltage nature.

This Special Issue serves to foster and collect new research achievements within the scope of enabling technologies, design methods, and experimental testing of capacitively coupled power conversion systems. In response to the call for papers, we received 25 manuscripts and 12 articles were finally selected for publication. The manuscripts were submitted from different countries all around the world such as Canada, Australia, the United States, New Zealand, Ecuador, China, Denmark, Bangladesh and Iran. The 12 articles in this Special Issue cover a variety of aspects pertinent to the selected Special Topic. While many articles address multiple aspects together, the articles can be broadly categorized as follows:

Review and strategy articles, modeling and component innovations in capacitive systems, capacitive wireless power transfer compensation network design, and rotary capacitive power transfer. We briefly discuss each article in the following sections.

A. Review and Strategy articles

1) In [1], Ludois *et al.* review the physics and engineering of electrostatic machines and craft a strategy to make them successful at the macroscale.

B. Modeling and Component Innovation of Capacitive Coupled Systems

1) In [2], Regensburger *et al.* achieve high-efficiency charging using new interleaved-foil air-core coupled inductors in the matching networks. These inductors provide a better tradeoff between quality factor, size and self-resonant frequency compared to conventional solenoidal inductors, making them suitable to compactly and efficiently process kilowatt-scale power at multi-MHz frequencies.
2) In [3], Rodríguez and Grijalva present a novel mathematical model to describe high-frequency switching dc-to-dc regulation in a power supply capacitively coupled to a medium-voltage input.
3) In [4], Ge and Ludois develop an analytical framework to model the coupling of any planar capacitive power conversion system whether rotating machines or wireless power transfer.
4) In [5], Ganjavi *et al.* present advanced techniques based on the high-frequency modeling of parasitic capacitances in motor drives to accurately predict resonances in the common-mode loop.
5) In [6], Ahmadi *et al.* show that the coupled WPT resonator structure is equivalent to a filter structure, and that filter theory has benefits in designing a capacitive WPT system.

C. Compensation Networks for Capacitive Power Transfer

1) In [7], Sinha *et al.* introduce an analytical optimization approach for the design of L-section matching networks in capacitive WPT systems, which maximizes the network efficiency while achieving the required overall gain and compensation.
2) In [8], Lian *et al.* systematically analyze the characteristics of a double-sided LCLC compensated CPT converter, which is proved to have enough design freedom to allow for predesigned voltage stresses for two kinds of coupled plates.
3) In [9], Luo *et al.* propose a compensation design method for achieving the maximum power of CPT systems under coupling voltage constraints.
4) In [10], Lillholm *et al.* employ the constant voltage property of the LCCL network, showcasing that a multiple-output CPT system can achieve output independence among different receivers.

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D. Rotary Capacitive Power Transfer

1) In [10], Rouse *et al.* use and develop multi-phase capacitive power in the rotating domain, showcasing compensation network design and coupling variation.
2) In [11], Hagen *et al.* use the surface area of the rotating rectifier board present in brushless wound field synchronous machines to form a capacitive coupling surface rather than adding a gapped rotating transformer.

The editorial team hopes that this Special Issue will provide readers with new inspirations for research and will encourage them to make further progress in capacitively coupled power conversion related topics. The editorial team believes that in the long-term, the extensive research in this challenging field will push innovation forward, accelerating the industrial uptake of promising capacitive technology.

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