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Editorial

Editorial for the Special Issue on Microwave Wireless Power Transfer Technology

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Generally speaking, wireless power/energy transfer technology can be divided into two different methods: near-field transfer based on coupling theory and far-field transfer based on radiating theory. Long-distance far-field transfer can be further divided into microwave- and laser-based approaches. Using current technologies, the efficiencies of direct current (DC)–DC transmission via microwave and laser are about 20% and 6%–8%, respectively. Microwave wireless power transfer (MWPT) has attracted a great deal of attention for its advantages of relative low path loss, convenience, lower cost, high transfer efficiency, and environmental frendliness. MWPT holds potential for many applications, including the construction of a space energy net; support for space computation, a moon scientific base, and long-distance exploration; and the provision of electrical power for land, sea, air, islands, and remote areas. In addition, MWPT can play an important role in providing electricity wirelessly, such as for simultaneous energy–information transfer, emergency security, and movable platforms.

There are three key performance indicators (KPIs) of MWPT. The first KPI is the transmission efficiency of DC–DC transmission which includes the microwave transformation efficiency, beam collection efficiency (BCE), and efficiency of receiving and rectification. The second is the transmission power, where it is desirable for the transmitted power to be as high as possible. The third KPI is distance, as the power transmission distance should be long enough to meet requirements.

In order to maximize these three KPIs, several key technology bottlenecks must be overcome. Aside from the efficiencies of the transmission antenna and rectenna, the most important points include high BCE, beam shape optimization, and high pointing accuracy of the beam. There are other points to be considered as well, such as miniaturization, a light weight, a high power to mass ratio of antenna, smart design, heat control, and the influence of the transmission media on efficiency. In the past three years, many high-quality papers on MWPT technology have been published in the *IEEE Transactions* series. Moreover, several special conferences and symposiums have been held on this topic, such as the IEEE Wireless Power Week, the WPW Wireless Power Week, and the Asian Wireless Power Transfer Workshop. All have played a positive role in promoting the research and engineering of MWPT.

The purpose of this special issue is to report on state-of-the-art achievements in MWPT worldwide and to clarify future research directions. The issue consists of one review article and four research articles. These manuscripts come from world-leading MWPT experts, and almost all recent research activities in this field are included.

Although sufficient review articles have been published on inductive short-range wireless power transfer (WPT), long-distance MWPT for solar power satellites, and ambient microwave wireless energy harvesting (MWEH), little research has focused on the fundamental modeling and related design automation of a receiver system. Therefore, in the review article by Prof. Yongxin Guo and coworkers, the development of MWPT and MWEH receivers is systematically reviewed with a focus on the automation design of rectennas and recent rectenna technologies for MWPT and MWEH.

Ultrashort pulse transmission has been recognized as a primary issue that fundamentally hampers the development of ultrafast electronics beyond the current timescale of nanoseconds. In this issue, a synthesized all-pass waveguide that demonstrates record guided-wave controlling capabilities, including eigenmode reshaping, polarization rotation, loss reduction, and dispersion improvement, is presented by the research team of Prof. Ke Wu. The results suggest that picosecond electrical pulses can be efficiently transmitted while signal integrity is maintained, which is

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a breakthrough in the evolution of ultrafast electronics, providing a path toward a frequency-engineered ultrashort pulse for low-loss and low-dispersion transmission.

A comparative study of retro-reflective beamforming schemes for multi-target-oriented MWPT is provided by Profs. Tie Jun Cui and Mingyu Lu and their team. The experimental results show that, when multiple targets broadcast continuous-wave pilot signals at respective frequencies, a retro-reflective wireless power transmitter is capable of generating multiple wireless power beams respectively aiming at the targets, as long as the multiple pilot signals are explicitly separated from one another by the wireless power transmitter.

In order to simultaneously achieve a rectenna with a high BCE and a high performance-to-cost ratio, the transmitted radio-frequency (RF) power should be within the area of the rectenna, and the beam can take the form of a group of circles. To achieve this, Profs. Baoyan Duan and Yongxin Guo and coworkers propose beam shape optimization design methodologies and give typical numerical examples to demonstrate the methodologies.

Aside from research focused on antennas for MWPT, Prof. Meng Jin's group propose an in-band and out-of-band MWPT characteristic analysis of a slot ring radome based on an approximate analytical method. A unified expression of the incident field on the radome surface with E-plane and H-plane scanning is mathematically derived for an approximate analysis of the ring radome. An example of a slot ring biplanar symmetric hybrid radome is given to verify the accuracy and efficiency of this methodology.

We sincerely hope that this special issue on MWPT will benefit interested researchers around the world. It is our aspiration that scientists and engineers will work together to further develop MWPT technologies so that even greater scientific achievements can be obtained. We would also like to express our special thanks to the Executive Editor-in-Chief, Prof. Shuxin Zhang, the reviewers, and the editorial staff of this special issue for their helpful discussions and great support.