YUAN Qiaowei, LUO Fa-Long

Editorial: Special Topic on Simultaneous Wireless Information and Power Transfer: Technology and Practice

Guest Editors >>>

YUAN Qiaowei received the BE, ME and PhD from Xidian University, China in 1986, 1989 and 1997, respectively. From 1990 to 1991, she was a special research student at Tohoku University, Japan. She worked with the Sendai Research and Development Laboratory, Matsushita Communication Company, Ltd., Japan from 1992 to 1995, with the Sendai Research and Development Center, Oi Electric Company, Ltd., Japan from 1997 to 2002, and with the Intelligent Cosmos Research Institute, Japan from 2002 to 2007. From 2007 to 2008, she was an associate professor with Tokyo University of Agriculture and Technology, Japan. She was an associate professor/professor with the National Institute of Technology, Sendai College, Japan from April 2009 to March 2020. Since April 2020, she has been a professor with Tohoku Institute of Technology, Japan, and since September 2021, she has also been a specially appointed professor at Tohoku University, Japan.Dr. YUAN received the Best Paper Award and Zenichi Kiyasu Award from the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan in 2009. She also received the Achievement Award from IEICE in 2015, and other Achievement Awards from the IEICE Technical Committee on Wireless Power Transfer from 2016 to 2017. Dr. YUAN severed as the secretary of the IEICE Technical Committee on Wireless Power transfer of Japan from 2012 to 2014. She also served as the vice chair of IEEE Sendai WIE from 2017 to 2018 and has been the chair of IEEE Sendai WIE from 2019 to 2022. Now she is an IEEE R10 WIE committee member and IEEE MTT-25 committee member.

LUO Fa-Long is an IEEE Fellow and an affiliate full professor with the Electrical & Computer Engineering Department at the University of Washington in Seattle, the US. Having gained international high recognition, Dr. LUO has 39 years of research and industry experience in wireless communications, neural networks, signal processing, machine learning and broadcasting with real-time implementation, applications and standardization. Including his well-received books *Applied Neural Networks for Signal Processing* (1999, Cambridge) and *Signal Processing for 5G* (2016, Wiley-IEEE), he has published seven books and more than 100 technical papers in the related fields. Dr. LUO has also contributed 105 patents/inventions which have successfully resulted in a number of new or improved commercial products in mass production. Now he serves as a board member of both the Conference Board and the Membership Board of the IEEE Signal Processing Society (SPS), as well as an IEEE Fellow Committee member. He has also served as the chairman of IEEE Industry Digital Signal Processing (IDSP) Standing Committee and the technical board member of IEEE SPS. Dr. LUO was awarded the Research Fellowship by the Alexander von Humboldt Foundation of Germany.

While having enabled human beings to realize the dream of communicating with whomever whenever and wherever, wireless technologies and applications are being developed at a very rapid speed and in a massively large scale as we have entered the 5G era and several grand 6G plans have also been clearly visible. However, most electronic products, including mobile phones, still have not gotten rid of the shackles of power wires. The wirelessization of electric energy is another major challenge for mankind following the discovery of electromagnetic waves. In the past 20 years, wireless power transfer (WPT) has once again received great attention and development. Simultaneous wireless information and power transfer (SWIPT) is a combination of wireless power transmission and wireless information transmission (WIT). With great advantages of parallel transmission of information and energy, SWIPT has broad application prospects and brings revolution in various industrial fields and our daily life.

This special issue focuses on the SWIPT technology development in terms of both WIT and WPT aspects. The topics addressed in this special issue cover a broad range from the element configuration to system design of SWIPT applications, mainly including cutting-edge high power SWIPT technologies, novel receiver and transmitter design techniques, and multiple-input multiple-output (MIMO) techniques for SWIPT applications. Especially, the compatibility and commonality among SWIPT solutions are highlighted for multiple application scenarios. The call-for-papers of this special issue have brought excellent submissions in both quality and quantity. After two-round reviews, seven excellent papers have been selected for publication in this special issue which is organized as follows.

The first paper titled "High-Power Simultaneous Wireless Information and Power Transfer: Injection-Locked Magnetron Technology" reviews the latest research findings on injection-locked magnetrons that can be used in high-power SWIPT systems developed by the authors. In this paper, the performance

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of injection-locked magnetrons using amplitude, phase, and frequency modulation is evaluated. The experimental results show that the highest data rate can reach 10 Mbit/s, demonstrating that the injection-locked magnetron can maintain high-power output and modulate the sound signal, motor control signal, and video signal simultaneously. The wirelessly powered TV system using injection-locked magnetrons is an amazing application that shows the technique could be applied to both the Internet of Things (IoT) and Internet of Everything (IoE) society. Potential SWIPT applications have been increased significantly by the proposed injection-locked magnetrons technique.

The second paper titled "An Overview of SWIPT Circuits and Systems" presents a brief overview of SWIPT from a circuit implementation perspective. What the paper mainly addresses include the technical backgrounds, problem formations, state-of-the-art solutions, circuit implementation examples and system integrations. With the combination of wireless power transmission and backscatter communications, the use of higher-order modulation formats integrates WIT and WPT systems, reducing the need for batteries significantly in these sensors and creating the path for a true Internet of Everything in the future.

Titled "Optimal Design of Wireless Power Transmission Systems Using Antenna Arrays", the third paper investigates three design methods for WPT systems using antenna arrays, focusing on optimal design for MIMO of both WIT and WPT systems. To demonstrate the optimal design processes of the three methods, a WPT system operating at 2.45 GHz is designed, simulated and fabricated. In this system, the Tx array with 36 microstrip patch elements is configured as a square, while the Rx array with five patch elements is configured as an L shape. Simulations and experiments reveal that the three optimization methods proposed for the design of WPT systems are applicable to any environment and any antenna array.

The fourth paper titled "Dynamic Power Transmission Using Common RF Feeder with Dual Supply" proposes a design concept of a dynamic charging system for electric vehicles using multiple transmitter coils connected to a common RF feeder driven by a pair of two power supplies. Using a common RF feeder for multiple transmitter coils can reduce the power electronic redundancy compared to the conventional system where each transmitter coil is individually driven by one switched mode power supply. As a result, the voltage standing wave generated by one power source is complemented by that of the other, leading to stable received power and transmission efficiency at all the receiver positions along with the charging pad. The simulation results at the 85 kHz frequency band verify the output power stabilization effect of the proposed design. The authors of this paper have indicated that the proposed concept can also be applied to simultaneous wireless information and power transfer for passive radio frequency identification (RFID) tags by raising the operation frequency to higher Industrial, Scientific, and Medical (ISM) bands, e.g., 13.56 MHz and employing similar modulation methods used for the current RFID technology.

The fifth paper titled "Polarization Reconfigurable Patch Antenna for Wireless Power Transfer Related Applications" proposes a polarized reconfigurable patch antenna composed of a dual cross-polarized patch antenna and a programmable power divider. The programmable power divider consists of two branch line couplers (BLC) and a digital phase shifter. The proposed phase-controlled power divider and the cross dual-polarized antenna are designed, fabricated, and tested. The experiments show that different antenna polarizations can be configured through the programmable phase shifter without changing the antenna gain performance. The wireless power transmission experiment demonstrates that tuning the transmitting antenna polarization to match the receiving antenna polarization can improve the efficiency of wireless power transmission.

The sixth paper titled "A Radio-Frequency Loop Resonator for Short-Range Wireless Power Transmission" proposes a microstrip loop resonator loaded with a lumped capacitor for short-range wireless power transmission applications. The overall physical dimensions of the proposed loop resonator configuration are as small as 3 cm by 3 cm. Simulation and measurement data demonstrate that the strong coupling between two loop resonators around 1 GHz can realize the power transmission efficiency of greater than 80% with a power transmission distance smaller than 5 mm. The experimental results also show that the power transmission performance is insensitive to various geometrical misalignments.

Serving as a review-style paper and the last paper of this special issue, the seventh paper is titled "Programmable Metasurface for Simultaneously Wireless Information and Power Transfer System" and presents a system solution using programmable metasurface (PMS) for SWIPT, offering an optimized wireless energy management network. Both transmitting and receiving sides of the proposed solution are introduced in detail. On the transmitting side, the WPT technique is used in versatile power conveying strategies for near-field or far-field targets, single or multiple targets, and equal or unequal power targets. On the receiving side, the wireless energy harvesting (WEH) technique can work well on multi-functional rectifying metasurfaces that collect the wirelessly transmitted energy and the ambient energy. More importantly, a dedicated numerical model based on the plane-wave angular spectrum method is investigated to accurately calculate the radiation fields of PMS in the Fresnel and Fraunhofer regions. Moreover, future research directions of the integrated PMS for wireless information and wireless power are highlighted in this paper.

As we conclude the introduction to this special issue and the content of seven papers, we would like to thank all authors for their valuable contributions. We also express our sincere gratitude to all the reviewers for their timely and insightful comments on all submitted papers. It is hoped that this special issue is informative and useful for future SWIPT technology developments and practical applications.