energies

Editorial

Wireless Power Transfer and RF Technologies

Dong-Wook Seo

Interdisciplinary Major of Maritime AI Convergence, Division of Electronics and Electrical Information Engineering, Korea Maritime & Ocean University (KMOU), 727 Taejong-ro, Yeongdo-gu, Busan 49112, Korea; dwseo@kmou.ac.kr

check for updates

Citation: Seo, D.-W. Wireless Power Transfer and RF Technologies. *Energies* **2021**, *14*, 8301. https://doi.org/10.3390/en14248301

Received: 7 November 2021
Accepted: 8 December 2021
Published: 9 December 2021

1. Introduction

This book contains the successful submissions [1–5] to a Special Issue of the Journal *Energies* on the topic of "Wireless Power Transfer and RF Technologies".

Wireless power transfer (WPT) technologies have been developed to wirelessly supply power to various devices such as mobile devices, electric vehicles, home appliances, and bikes. Despite several decades of progress in WPT technologies, the inductive WPT system still provides a short transmission distance, as large as the transmitting/receiving coils. This is why various links and structures, from multiple links of the multiple-input–multiple-output (MIMO) structure to RF links, have been used in attempts to expand the transmission distance. RF technologies have been highly anticipated as potentially being able to realize the breakthrough transmission distance.

The topics of this Special Issue include, but are not limited to:

- Recent advances and emerging technologies for WPT;
- RF energy-harvesting;
- Coil/antenna structures for WPT;
- Inductive wireless power transfer;
- RF/mmWave-based wireless power transfer;
- Near-Field Focused Antenna for wireless power transfer;
- Algorithms or schemes to improve the power transfer efficiency;
- Optimum displacement of coils/antennas for multiple receivers;
- Applications of wireless power transfer system.

The geographical distribution of the authors of the five published research articles [1–5] is as follows:

- Japan (1)
- Korea (2)
- China (1)
- Taiwan (1)

2. Short Review of the Contributions in This Issue

The scope of this issue is not constrained to the inductive link and a specific operating frequency; various operating frequencies and links are investigated. The articles in this issue are summarized in Table 1. Four out of five articles are related to the inductive WPT, with operating frequencies in the low-frequency (LF) band or the high-frequency (HF) band. Only one is related to piezoelectric energy generation. Most of the articles handle a relatively low power of 10 W or less, and one article focuses on a WPT system that delivers a high power of up to 2 kW. In addition, all the transfer distances between the transmitting and receiving resonators are relatively short distances of 20 cm or less.

Liu et al. [1] proposed a predictive controller for a three-winding inductive power transfer system (IPT). As the third winding can improve the misalignment performance and provide a high current, the three-winding IPT was implemented using an H-bridge, three windings, a full-wave rectifier, a DC/DC buck converter, a filtering capacitor, and a resistor. In addition, a predictive voltage controller and a predictive current controller were designed based on augmented variables and a performance index. To verify the control algorithm, a digital signal processor was used as the control center of the IPT system. The IPT system with the input and output voltages of DC 220 V and 130 V was implemented. The proposed system achieved an efficiency of 88% at 2 kW with an air gap of 20 cm. The proposed controller had fast transient responses and good load disturbance responses.

Table 1. Comparison of the published papers in terms of system parameters and performance.

Reference	Operating Frequency	Output Power	Transfer Distance	Max. Efficiency
[1]	77 kHz	200 W–2 kW	20 cm	88%
[2]	1–4 Hz	Up to 2 W	NA	NA
[3]	6.78 MHz	13.7 W	5–25 cm	83.2%
[4]	1 MHz	5 W	NA	~25%
[5]	85 kHz	10 W	10.5 cm	~60%

H. Han and J. Ko [2] measured the power generated by a specific piezoelectric element according to the size of the piezoelectric ceramic, depth and speed of compression. From the measurement, the three parameters contributing to the deformation are as follows:

- The size of piezoelectric ceramic is proportional to the generated power, but the rate of increase is not linear;
- The generated power continues to increase with the increase in the compression depth of the piezoelectric ceramic;
- The longer the depth of deformation, the shorter the frequency, and, depending on the depth of deformation, there is a specific frequency at which the charging power is maximum.

Based on the results, it is expected that PZT-based elements can be applied to cases that receive indirect force, including vibration energy and wave energy.

Y. Zhang et al. [3] investigated the impedance-matching method of a 6.78 MHz Class-E2-based WPT system to maintain high system efficiency over a wide range of coupling coefficients and load variations. The load-pull technique, double-L-type impedance matching network, and high-Q coils were adopted to validate the proposed design method. The experimental results showed that the system efficiency was maintained over 55% and the peak system efficiency reached 83.2% with 13.7 W output power.

K. Kim et al. [4] investigated the influences caused by the intra-coupling of multiple transmitting coils in the multi-input–single-output (MISO) WPT system for the magnetic beamforming. The influences can be summarized as follows:

- The intra-coupling makes it necessary to adjust the amplitude and phase of transmitting voltage for the magnetic beamforming;
- The intra-coupling causes power factor attenuation for each transmitting resonator.

From the analysis, when the intra-coupling can be ignored, the magnetic beamforming can be achieved by adjusting the amplitude of the transmitting voltage without phase adjustment. The analytical studies were verified by numerical and circuit simulation and experiments.

S. Nakamura et al. [5] proposed an automatic resonance compensation system for WPT via magnetic resonance coupling using flexible coils. The proposed system automatically compensates the inductance variation caused by coil deformation by controlling the equivalent capacitance. To verify the potential of the proposed system, the prototype was fabricated. From the measured results, it was demonstrated that the transmission efficiency can be improved and maintained at a comparable level to that of ideal resonance.

3. Conclusions

Despite the research on continuous WPT technologies, algorithms that are less sensitive to changes in the environment and load at short distances are mainly studied. In future, it is expected that RF and infrared-based WPT technology, which are less efficient than the current WPT technology but can wirelessly transmit power over a longer distance, will become more active.

Funding: This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education(2021R1I1A3044405).

Data Availability Statement: Not applicable.

Acknowledgments: The author is grateful to the MDPI Publisher for the invitation to act as a guest editor of this Special Issue and is indebted to the editorial staff of *Energies* for their kind co-operation, patience and committed engagement.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Liu, T.-H.; Mubarok, M.S.; Liu, Z.-J. Predictive Controller Design for a Three-Winding Inductive Power Transfer System. *Energies* **2021**, *14*, 1549. [CrossRef]
2. Han, H.; Ko, J. Power-Generation Optimization Based on Piezoelectric Ceramic Deformation for Energy Harvesting Application with Renewable Energy. *Energies* **2021**, *14*, 2171. [CrossRef]
3. Zhang, Y.; Feng, Y.; Liu, S.; Wu, J.; He, X. Impedance Matching Method for 6.78 MHz Class-E2-Based WPT System. *Energies* **2021**, *14*, 4289. [CrossRef]
4. Kim, K.; Kim, H.-J.; Seo, D.-W.; Choi, J.-W. Analysis on Influences of Intra-Couplings in a MISO Magnetic Beamforming Wireless Power Transfer System. *Energies* **2021**, *14*, 5184. [CrossRef]
5. Nakamura, S.; Baba, K.; Miyaura, T. Automatic Resonance Compensation for Efficient WPT via Magnetic Resonance Coupling Using Flexible Coils. *Energies* **2021**, *14*, 5254. [CrossRef]