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Optimization of Wireless Power Transfer Systems with Passive Performance Enhancement

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Extended Abstract

Wireless power transfer (WPT) opens many interesting possibilities for untethered charging, operating and communicating with devices. One of the most important figures of merit of such WPT systems is their electrical performance, measured by the power transfer efficiency (PTE). For many practical applications, in order to achieve a sufficiently large PTE, the distances between transmitter(s) and receiver(s) have to be confined to fractions of the wavelength at the operating frequency as well as to dimensions comparable to those of the transmitter and receiver coils [1].

Various attempts to help mitigate this problem and increase the PTE or extend the range of high PTE have been proposed, ranging from adding intermediate passive elements in the proximity of the system all the way to inserting metamaterials and/or metasurfaces into the space between the transmitter(s) and receiver. Passive intermediate elements can act as reflectors or relays, and multiple elements can be used cooperatively to guide ("beamform") the magnetic (near-) field from the transmitter(s) to the receiver.

Rigorouos optimization of such systems is not a trivial task, as the standard formulations of the required power constraints are nonconvex. This means that the problem cannot be solved reliably and efficiently, as global optimization methods (such as genetic algorithms) cannot guarantee finding the optimum, while computational cost increases exponentially with the number of unknowns. However, a convex relaxation formulation has been found, which essentially constitutes a general, rigorous and work-around to this problem. A simple test of the solution confirms tightness (meaning exact representation of the original problem) and, hence, that the true global optimum has been found. This optimum solution entails both the maximum PTE achievable with the system under consideration, as well as its optimum operating parameters, such as reactive loading components, currents and voltages.

This powerful and rigorous optimization method generalizes previous optimization techniques for WPT systems with multiple active transmitters [2]. It provides a new component of the WPT optimization framework, which can be used to investigate WPT systems with multiple active transmitters and multiple passive intermediate elements, including metasurfaces.

References

[1] E. Waffenschmidt and T. Staring, "Limitation of inductive power transfer for consumer applications," in *13th European Conference on Power Elecctronics and Applications, EPE*, 2009.

[2] H.-D. Lang, A. Ludwig, and C. D. Sarris, "Convex optimization of wireless power transfer systems with multiple transmitters," *IEEE Trans. Antennas Propag.*, vol. 62, no. 9, pp. 4623–4636, September 2014.