Investigation of Surface Wave Propagation along a Multiple-Repeater Wireless Power Transfer System
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B. Xu[(1)] and Y. Li [(1)]
(1) Department of Electrical and Computer Engineering, Baylor University

Wireless power transfer (WPT) is attracting more and more attention in recent years due to its important applications in charging biomedical sensor implant, mobile devices and electric vehicles. The biggest challenge of applying this technique is to achieve high power transfer efficiency (PTE) over extended delivery distance. One promising method to help address this challenge is to insert multiple repeaters in between transmitting and receiving antennas [W. Zhong, IEEE Transactions on Industrial Electronics, Vol. 60, 261-270, 2013]. Different theories have been developed to analyze the performance of multi-repeater WPT system such as the coupled mode theory [A. Kurs, Science, Vol.317, No.5834, 83-86, 2007] and the bandpass filter model [B. Luo, IEEE Transactions on Circuits and Systems, Vol. 61, No.11, 2014]. However, it is not trivial to derive equivalent circuit parameters for the above theoretical model since cross coupling exists in a multi-repeater WPT system.

In this study we investigate surface wave propagation along a multi-repeater WPT system, and correlate its propagation characteristics (propagation constants, decay constants, and field distributions) with the PTE of the system. Two kinds of multi-repeater WPT systems are examined respectively: coil and folded cylindrical helix (FCH). First we simulate and measure the PTE of WPT systems with different number of repeaters. Next the near field distribution along the structure is simulated and a surface wave passband is identified. Then a super-resolution ESPRIT algorithm is applied on the simulated near field to extract both propagation and attenuation constants of the surface wave. Finally, we correlate the PTE with the surface wave characteristics to gain physical insights of multi-repeater WPT system.

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