Optimal Microwave Power Transfer through Unknown Region Based On Time Reversal Technique

Ce Zhang*, Akira Ishimaru, and Yasuo Kuga
Department of Electrical Engineering University of Washington,
Seattle, WA, 98195

The techniques of wireless power transfer can be divided into three categories: inductive coupling, laser beaming and microwave power transfer (MPT). The MPT has its unique advantages of supplying power to devices which are far away from transmitter and moving. However, the power transmission efficiency is seriously constrained due to the inherent radiation of microwave. For this reason, the array antenna has to be employed at both transmitting end and receiving end in order to maximize the transmission efficiency so the weigh distribution on array elements is the key problem to achieve optimal transmission efficiency.

The traditional array synthesis technique is actually mathematical optimization method based on the assumption that the medium is free space and antenna is uniform radiator. These two assumptions are not always valid and even poor in some cases, which is demonstrated in our paper. Thus, in our paper, a new method for finding optimal weight distribution is proposed to resolve the aforementioned problem. Our method is inspired by time reversal technique and based on the measurement of transfer matrix and solution of the eigenvector and is demonstrated with both mathematical derivation and numerical simulation. It has been shown that our method is adaptive to the medium of channel and can be applied to any directive antenna structures without degradation of efficiency. In addition, our array synthesis method is better than the retrodirective/ phase conjugate. The superiority of our method in these aspects is justified with some examples array in terms of transmission efficiency and collected power at receiver. The numerical simulation is made using Hertzian Dipole as antenna in HFSS-IE (new MoM-Integral Equation module in HFSS).

Furthermore, the time reversal DORT (decomposition of time reversal operator) technique in applications of radar and imaging system is also modified for the scenario with multiple receivers. This method achieves the power delivery at different frequency from probing signal and selective power focusing at different receivers. This method is also demonstrated with numerical simulation in HFSS-IE.