Investigation of Time-Reversal Far-field Wireless Power Transfer from Antenna Array in a Complex Propagation Environment

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We present an experimental investigation on the performance of time-reversal (TR) based far-field wireless power transfer (WPT) in a complex propagation environment (e.g. indoor) in comparison to conventional beamforming (BF) using the transmit array.

Recent studies have demonstrated that transmitting TR signals can deliver higher peak power compared to transmitting narrowband signals in complex propagation environment (R. Ibrahim et al., IEEE Trans. Microw. Theory Tech., 64, 7, 2159-2170, 2016 and S. K. Hong et al., Phys. Rev. Applied, 2, 044013, 2014). However, the transmit antenna configuration utilized in these studies was limited to a single transmit antenna case. Since many recently proposed far-field WPT approaches are based on using an antenna array, an investigation into the performance of TR based far-field WPT compared with array-based BF is necessary.

Our experimental investigation involves two-stages, namely a) the wave propagation stage where the signal transmission between the transmit array and receive antenna are measured in an indoor environment, and b) the rectification stage where the resulting signals from the propagation stage are fed into a broadband rectifier to measure DC voltage and rectification efficiency. In the propagation stage, it is demonstrated that TR results in higher peak voltage compared to BF given the same average transmit power. Moreover, while BF loses the ability to selectively send waves due to impaired beam from multipath, TR allows selective wave focusing at the receiver by taking advantage of multipath. In the rectification stage, it is shown that the received signals from TR produce higher DC voltage and rectification efficiency. The overall results indicate that TR can outperform BF with higher rectification efficiency given the same average transmit power in a complex propagation environment. Optimization of the TR pulse interval, array configuration and transmit power may further improve the performance of TR based WPT.

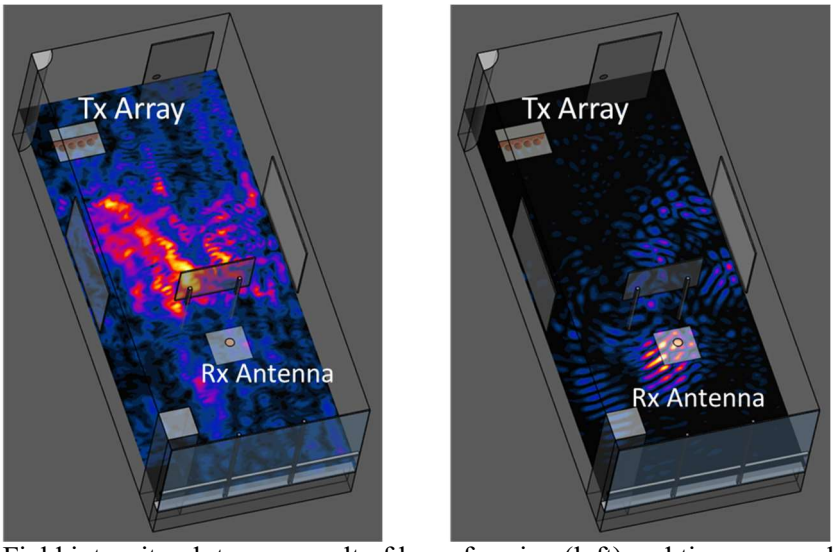

Figure 1. Field intensity plots as a result of beamforming (left) and time-reversal (right).