Study on the RF wireless power transfer between phased array transmitter and multi-rectenna receiver

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Abstract

In this paper, we have built a RF-based wireless power transfer (WPT) system equipped with the phased array antennas in the transmitter and multiple rectennas in the receiver. We have conducted the experiments based on beam focusing method to maximize the power transfer efficiency with proposed system.

I. Introduction

The internet of things (IoT) is expected to be a key enabling technology of the next industrial revolution. Long-range wireless power transfer technologies via an electromagnetic (EM) can be applied to various research area such as supplying power to Internet of Things (IoT) devices [1].

In this paper, we investigate the RF WPT between phased array transmitter and multi-rectenna receiver. The real-life testbed for proposed system is built and tested. The frequency for the RF WPT is 5.8GHz, and all hardware components are designed to work on that frequency.

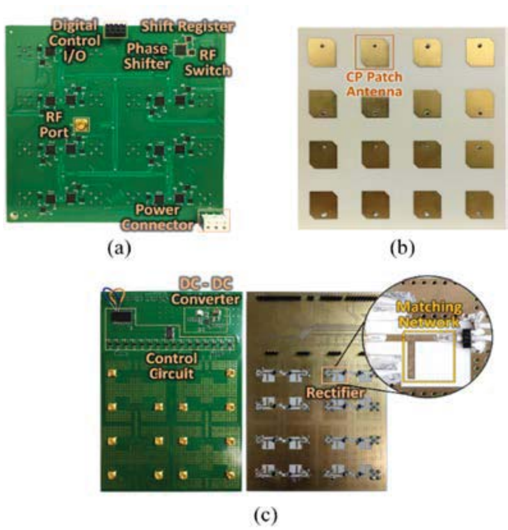

Fig. 1. (a) Phased array, (b) Antenna board, (c) Receiver board with multiple rectennas

II. RF WPT System

We have fabricated a 16-way phased array circuit board that outputs 16 RF signals with controllable phase and on/off states(Fig.1a). The RF switch enables on/off states of each path and phase shifter provides 360degree of phase coverage, with a least significant bit (LSB) of 5.625 degrees. In Table Ⅰ, we show the measured output phase values correspond to the input phase control value. The way of verifying the performance of fabricated phased array board that we have used is measuring S-parameter by using a network analyzer.

Table Ⅰ. Phase control results of phased array board

Controlled Input Phase	Measured Output Phase
0°	0°
30°	30°
60°	62°
90°	92°
120°	120°
150°	150°
180°	185°
210°	212°
240°	243°
270°	273°
300°	301°
330°	330°
360°	0°

By integrating 4 boards with a designed board which can supply digital signal and power for each board at the same time, Tx has 64 elements. Implemented Tx is controlled by LabVIEW software in a PC, through a digital controller connected to the digital I/O ports. For both transmitter and receiver, we used the circularly polarized (CP) microstrip patch antenna (Fig.1b).

And as you can see in Fig.1c, we also designed and fabricated receiver board with 4-by-4 array rectennas. Designed rectifier exhibited a conversion efficiency of 55% at an input power of 18dBm and a load of 1kΩ(Fig.2). The dc outputs of the 16 rectifiers are combined and converted by a dc-dc converter to a constant dc voltage.

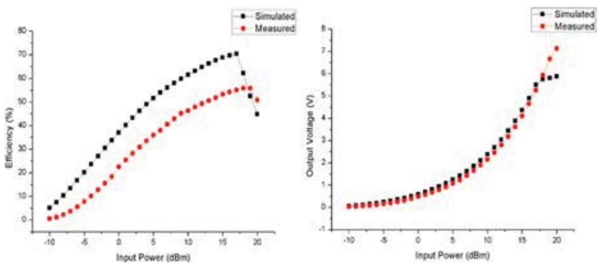

Fig. 2 Efficiency and output voltage results of fabricated rectifier

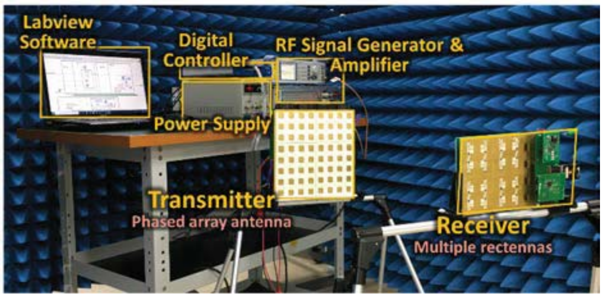

Fig. 3. Testbed setup

As in Fig.3, with fabricated transmitter and receiver, we have conducted the experiments based on beam forming algorithm which proposed in our previous work[2]. We have chosen an antenna which is in the center of the array for the beam focusing algorithm.

Ⅲ. Conclusion

In this paper, we have studied the RF wireless power transfer between phased array transmitter and multi-rectenna receiver. With the fabricated real-life setup, we have tested RF WPT between phased array transmitter and multi-rectenna receiver.

References

[1] Lu, Xiao, et al. Wireless networks with RF energy harvesting: A contemporary survey. IEEE Communications Surveys & Tutorials 17.2, 757-789 (2014).

[2] Aziz, Arif Abdul, et al. "Battery-Less Location Tracking for Internet of Things: Simultaneous Wireless Power Transfer and Positioning." IEEE Internet of Things Journal 6.5 (2019): 9147-9164.