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A Polarization-Reconfigurable Rectenna for Microwave Power Transmission

Ping Lu, Xuesong Yang, Jia-Lin Li and Bingzhong Wang
University of Electronic Science and Technology of China
Chengdu, China

***Abstract* — A polarization reconfigurable rectenna, which consists of a polarization reconfigurable planar monopole antenna and a planar rectifying circuit, is proposed for microwave power transmission (MPT). The planar monopole is designed with one linear polarization (LP) and two circular polarizations (CPs). The rectifying circuit is connected to the antenna with a 50 Ohm microstrip line. The rectenna can harvest the RF power from 5.07 GHz to 5.86 GHz and convert it to DC power efficiently, exhibiting conversion efficiency from 40.2 % to 57.4 % with input power of 16.5 dBm. Simulated results are confirmed through the experiment.**

Keywords—Polarization-reconfigurable rectenna; linear polarization (LP); circular polarizations (CPs)

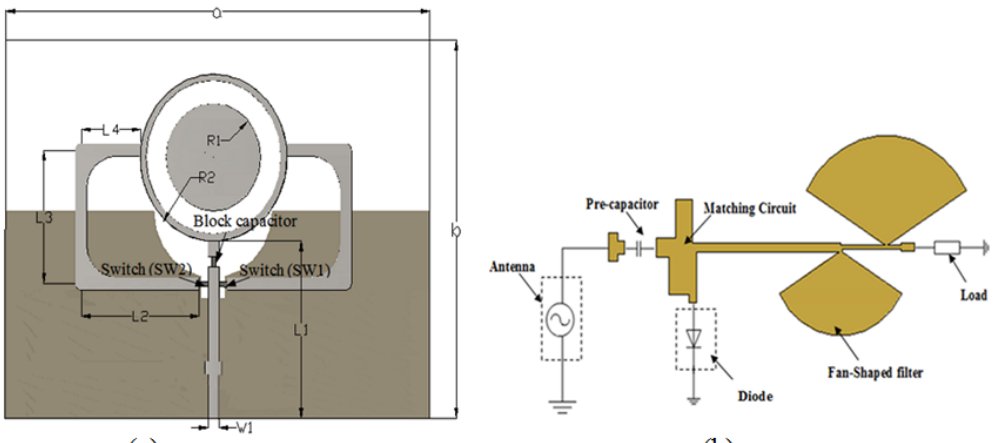
Introduction

To improve the system performance of microwave power transmission (MPT), the multi-polarization rectennas have particular advantages in the complex electromagnetic circumstances, where the electromagnetic waves have many polarizations. The rectenna that can capture arbitrarily-polarized electromagnetic waves usually has an array structure, and then is large sized. Furthermore, due to the strong mutual coupling between the array elements, the efficiencies are a little low. A polarization-reconfigurable broadband rectenna is proposed for compact size and high efficiency[1]-[5].

Rectenna Design

The schematic view of the reconfigurable planar monopole antenna is shown in Fig. 1 (a). It consists of a circular patch and some reconfigurable feed branches, and is fed by a microstrip feedline. Two diode switches are installed on the bilateral feeding branches. The radiating patch and feeding branches are printed on the top side of a R04003C substrate, and the partial ground etched with a half-circular slot is printed on the back side of the substrate. By controlling the states of switches (SW1 and SW2), the antenna achieves one linear polarization (LP) and two circular polarizations (CPs).

The rectifying circuit plays an important role in the rectenna, whose topology structure is shown in Fig. 1 (b). The whole rectifying circuit is also printed on the same R04003C substrate as the antenna. The rectifying circuit consists of a pre-capacitor, a shunt diode, two fan-shaped stubs and an impedance matching circuit.



(a) (b)

Figure 1. Configuration of the reconfigurable rectenna (a) the receiving antenna, (b) the rectifying circuit.

Simulated and Measured Results

Reconfigurable Receiving Antenna

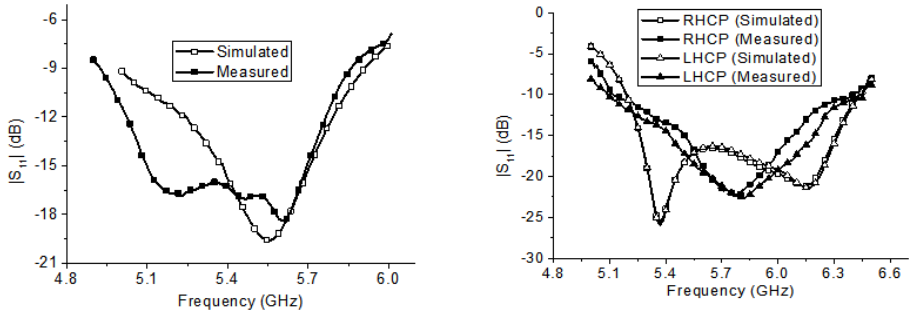


Figure 2. Simulated and measured S-parameter

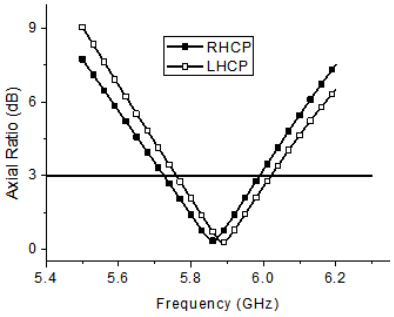


Figure 3. Simulated axial radio at the CP Modes

Simulated and Measured Results

Rectenna Efficnecy Result

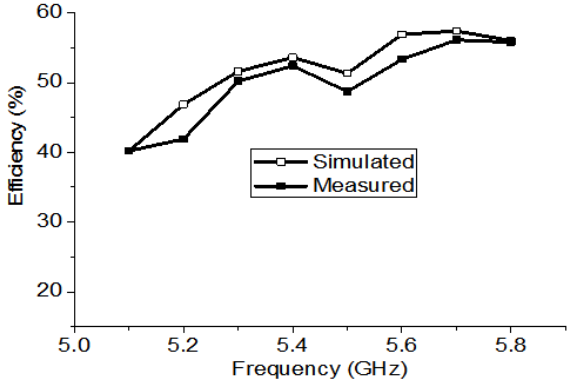


Figure 4. Simulated and measured efficiency of the proposed rectenna at LP Mode.

The simulated efficiency under 16.5 dBm input power at LP mode, which varies from 40.2 % to 57.4 % with the frequency changing from 5.1 to 5.8 GHz. Only the efficiency of the rectenna at LP mode is measured to validate the simulated result. The efficiency varies from 40.1 % to 56.1 % with the frequency increasing from 5.1 GHz to 5.8 GHz.

Since the operation frequency varies from 5.73 GHz to 6.02 GHz at CP modes, the efficiencies fluctuate between 54.2 % and 56.1% at the CP modes working frequency band.

Conclusion

A planar compact polarization-reconfigurable rectenna has been presented. The rectenna includes a reconfigurable antenna and a conventional rectifying circuit. The antenna is excited with a reconfigurable feeding network. By changing the states of switches, the polarization of the antenna can be switched among LP, LHCP and RHCP. The proposed rectenna is not only compact, but also muti-mode and with high conversion efficiency. It is suitable for the MPT application.

References

[1] K. Niotaki, K. Sangkil, J. Seongheon, and et al., "A compact dual-band rectenna using slot-loaded dual band folded dipole antenna, " IEEE Antennas and Wireless Propagation Letters, pp.1634-1637, 2013.

[2] M. Ali, G. Yang, and R. Dougal, "A new circularly polarized rectenna for wireless power transmission and data communication," IEEE Antennas and Wireless Propagation Letters, vol. 4, pp.205-208, 2005.

[3] J. A. Hagerty and Z. Popovic, " An experimental and theoretical characterization of a broadband arbitrarily-polarized rectenna array," IEEE MTT-S International Microwave Symposium Digest, vol.3, pp.1855-1858, 2001.

[4] Hagerty, A. Joseph, Lopez, et.al., " Broadband rectenna arrays for randomly polarized incident waves," 30th European Microwave Conference, pp.1 -4, 2000.

[5] R. Nakashima, E. Nishiyama, and I. Toyada, "Performance of 5.8-GHz multi-polarization rectenna for linearly/circularly polarized wave reception," IEEE Wireless Power Transfer Conference (WPTC), pp. 208-211, 2014.