2.4GHz High Efficient Rectenna using Artificial Magnetic Conductor (AMC)

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Abstract

A high efficient rectenna is designed by a microstrip patch antenna with an artificial magnetic conductor (AMC) at 2.4 GHz. The antenna with the AMC structure provides high directivity which results in high efficiency for the rectenna application. The proposed rectenna achieves RF to DC conversion efficiency of 61.4% at 2.4 GHz.

Keywords : Rectenna, artificial magnetic conductor (AMC), microstrip antenna.

1. Introduction

Recently, many researchers have studied microwave power transmission. One of the most important devices for microwave power transmission is a rectenna. In general, a rectenna consists of an antenna, a band-pass filter (BPF), low-pass filter (LPF), diode, and a resistive load. Many researches of rectenna design have been conducted to convert efficiently RF power to DC power.

Especially, an antenna is a crucial factor in order to design a high efficient rectenna because it can receive and deliver the RF power to the rectifying circuit. Various antennas have been reported in previous literatures. A dual-band antenna [1], circular sector antenna [2], and broadband antenna [3] are introduced for rectennas.

In this paper, a high gain antenna is introduced for the high efficient rectenna design. It is known that the antenna's directivity can be increased by using the artificial magnetic conductor (AMC) as the superstrate [4]. Since more RF signal can be received with the high gain antenna, more RF power can be wirelessly transmitted. In addition, the bandpass filter is employed in order to suppress 2nd and 3rd harmonics.

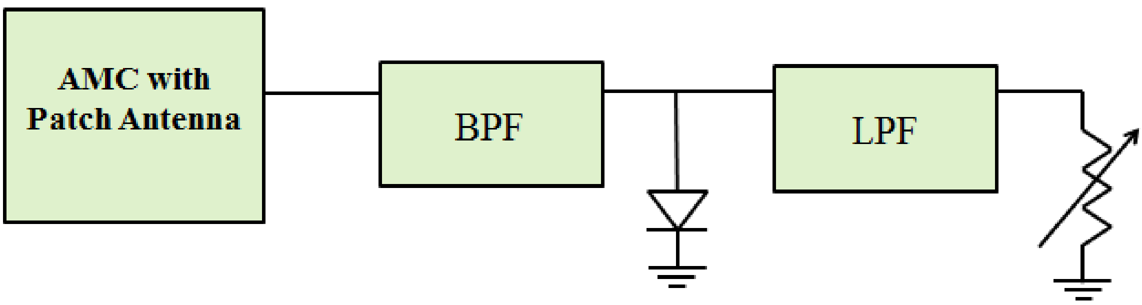

Figure 1 : Block diagram of the rectenna.

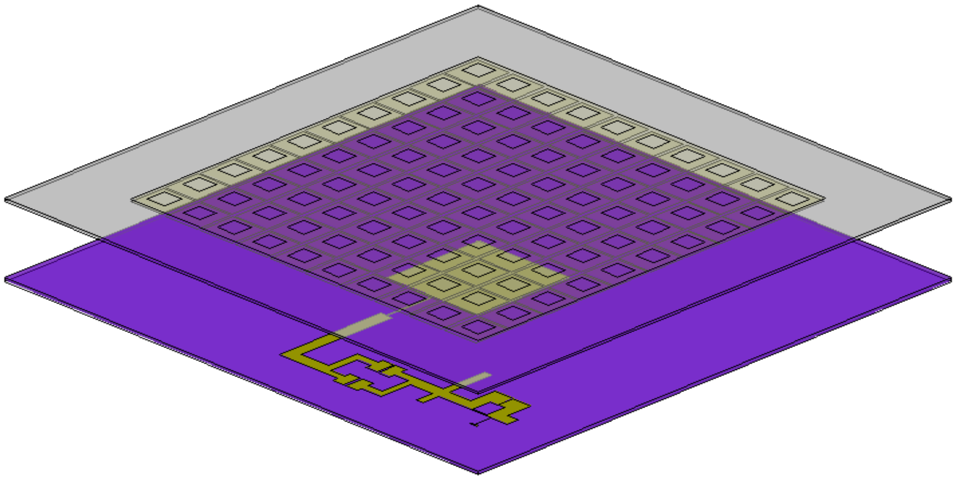

Figure 2 : Layout of the proposed rectenna using the AMC as the superstrate.

2. Rectenna Design using AMC Superstrate

Generally, high gain antenna is useful in order to increase the rectenna's transmission efficiency especially for a long distance transmission. When the AMC is employed as the superstrate of the antenna, the antenna's directivity can be increased. Therefore, the microstrip antenna with the AMC is employed for the rectenna in this paper. Fig. 2 illustrate the layout of the proposed rectenna. The AMC is stacked on the top layer and the air substrate with a quater-wave thickness is inserted between the AMC and the rectenna layer.

For the BPF, 2nd and 3rd harmonic rejection capability is considered for high RF-DC conversion efficiency while passing a 2.4 GHz fundamental frequency. The AMC is fabricated on RT duroid 6010 with a dielectric constant of 10.2 and substrate thickness of 1.27mm. High dielectric constant enables small size of the 10 by 10 AMC. Each unit cell is a square patch. Its size is 14.5mm $\times$ 14.5mm to have the AMC characteristic at 2.4 GHz.

The microstrip patch antenna is designed on RT duroid 5880 with a dielectric constant of 2.2 and substrate thickness of 1.6 mm. The low dielectric constant enables good radiation performances. The size of microstrip patch antenna is 40.5mm $\times$ 40.5mm. The BPF, rectifying circuit, and LPF are fabricated on the RT duroid 5880 with a dielectric constant of 2.2 and substrate thickness of 1.6mm. HSMS-2820 is employed for a rectifying diode.

3. Rectenna Performances

Before measuring the rectenna performances, the antenna's radiation pattern is first measured. Figure 3 shows the simulated and measured radiation patterns at 2.4 GHz. As expected, high gain (10 dBi) is achieved thanks to the AMC superstrate.

In order to see the rectenna performance, 2.4 GHz continuous wave (CW) signal is transmitted through a standard gain horn antenna. The conversion efficiency is defined as follows equation (1).

$$\eta = \frac{p_o}{p_I} \times 100 \qquad (1)$$

, where p_O and p_I are the output DC power and input RF power, respectively. When the load resistance is 932 Ω, the calculated conversion efficiency is shown in Fig. 4.

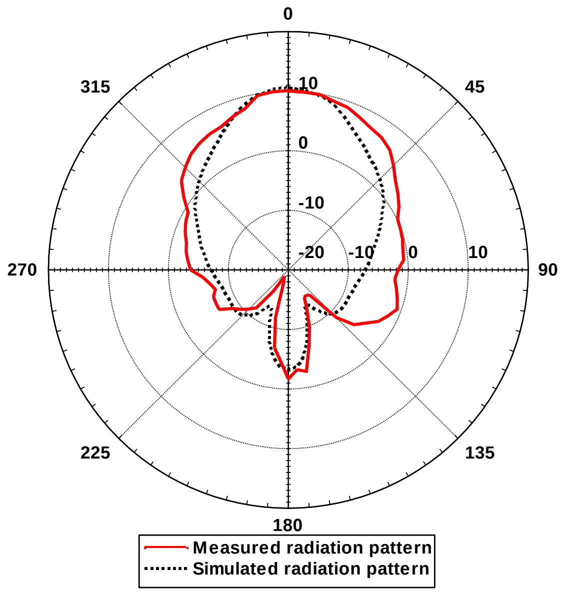

Figure 3 : Radiation pattern of the microstrip antenna with the AMC superstrate (E-plane)

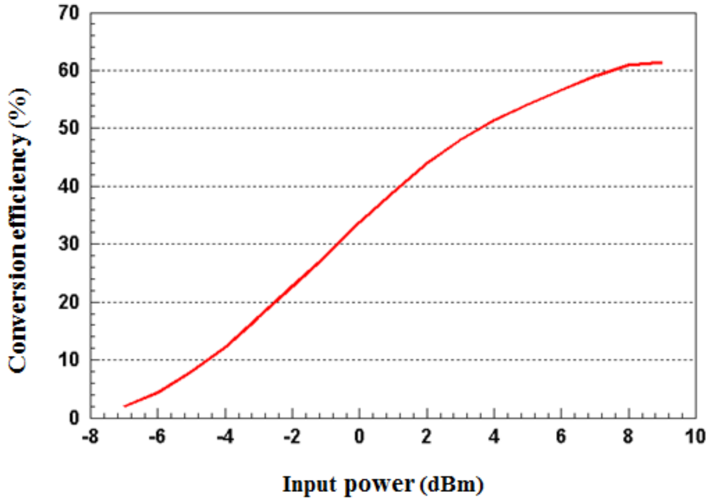

Figure 4 : Conversion efficiency versus input power

4. Conclusion

A 2.4 GHz high efficient rectenna is proposed. The AMC is used as a superstrate of the rectenna in order to increase the transmission efficiency, especially for a far-distance transmission. The 2^{nd} and 3^{rd} harmonic rejection of the BPF increased the conversion efficiency. A 61.4% of RF to DC conversion efficiency is achieved at 2.4GHz by applying the AMC and harmonic rejecting BPF. The efficiency can be further increased when RF power level is increased.

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Acknowledgments

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology (2010-0004315).

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