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An Efficient Analysis of Rectenna Circuit for 2.45 GHz Wireless Power Transmission

Zied Harouni[1], Lotfi Osman[1], Laurent Cirio[2], Ali Gharsallah[1], and Odile Picon[2]

[1]Unity CSEHF, Faculty of Sciences of Tunis, Tunis-El Manar University, Tunis, Tunisia
[2]Laboratory of ESYCOM, University of Marne-la-Vallée, Marne-la-Vallée, France

Email: zied.harouni@fst.rnu.tn , lotfi.osman@supcom.rnu.tn, laurent.cirio@univ-mlv.fr, ali.gharsallah@fst.rnu.tn, odile.picon@univ-mlv.fr

Abstract – In this paper, we present a study of a rectenna (rectifying antenna) with two power rectifier configurations, diode voltage doubler and single diode. To achieve this system, we have designed a new patch antenna excited by electromagnetic coupling through four slots. A circular polarization is generated and optimized and a zero-bias microwave rectifier using Schottky diodes is validated. Moreover, the patch antenna is converted to a layout component using Advanced Model Composer. The antenna is placed into the schematic and the system composed of this antenna and the rectifier is co-simulated with Momentum and ADS circuit, respectively. The rectenna operating at 2.45 GHz shows at 10 dBm input power an efficiency of 86 % for diode voltage doubler and 23 % for single diode.

Keywords – Rectenna, Patch antenna, Schottky diode, Rectifier, Wireless power transmission

1. Introduction

Wireless power transmission (WPT) is a potential alternative to generate clean energy in the future [1] and the rectenna is considered as an important element for the WPT system. The technology of rectennas has been improved with many new developments [2]. To achieve a long distance for WPT, higher output DC power and reduced receiving areas, several types of rectennas have been studied with high gain property [3]-[4]-[5]. A considerable amount of work has been done in the area of wireless powering [6]-[7] including inductive powering for short ranges, high power density directive powering in the microwave frequency range, as well as low-power near-field interrogation with RFID tags [8]-[9], and medium and low-power density powering of low-power sensors [10]. This is usually accomplished by receiving incident waves with an antenna and by rectifying the received RF voltage. An integrated antenna and rectifier is usually referred to as a rectenna [11].

2. Rectenna circuit

Electromagnetic coupled patch antenna is used for building the rectenna as shown in Fig. 1. The rectangular patch antenna and the feeding line are etched on substrate ultralam 2000 with dielectric constant of 2.54. Four slots are etched in the ground plane which is localized between two substrates.

Table 1 shows the optimized design parameters obtained for the proposed patch antenna and Fig. 2 shows that return loss of the antenna is 33 dB at 2.45 GHz.

The global system shown in Fig. 3 and Fig.4 for the two topologies is simulated with ADS (Advanced Design System) of Agilent Technologies using HB (Harmonic Balance) simulator.

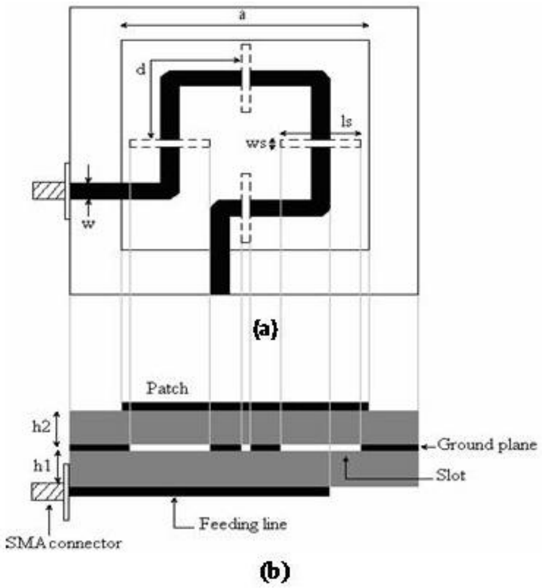

Figure 1. Geometry of proposed patch antenna. (a) Top view, (b) Side View.

For the RF-DC conversion, an HSMS2820 zero bias Schottky diode [12] was used and the circuit was optimised in order to obtain a good impedance matching and an important conversion efficiency for the both topologies at the 2.45 GHz desired frequency.

Table 1. Proposed patch antenna design parameters (in millimeters)

	a	d	w	ws
Dimension (mm)	36.12	λ/4	4.26	1.1
	ls	h1	h2	
Dimension (mm)	9	1.524	1.524	

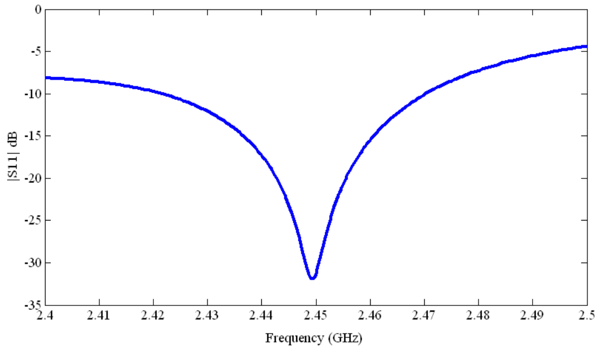

Figure 2. Simulated return loss of the proposed patch antenna.

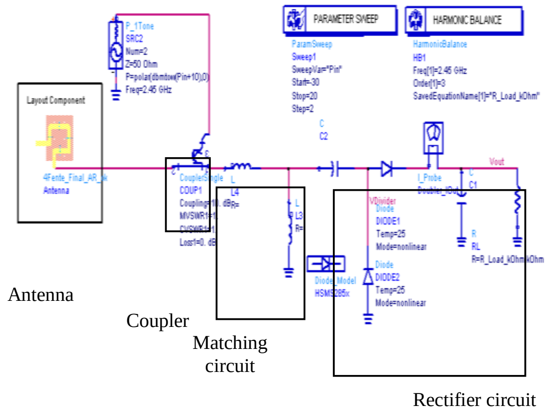

Figure 3. Topology of the rectenna with diode voltage doubler rectifier.

A 10 dB directional coupler is used to join the inputs (antenna's S-parameters and V1tone source) only as simulation purpose.

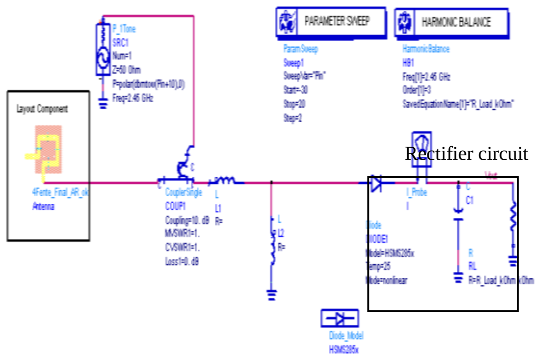

Figure 4. Topology of the rectenna with single diode rectifier.

3. Result and discussions

After the final tuning process, optimum values are achieved for the circuit components.

Figure 5 exhibits the obtained efficiency calculated for the two rectenna configurations versus input power at 2.45 GHz.

Figure 6 shows the DC output voltage as a function of input power for the two configurations which are respectively around 1.8 V and 0.93 V for 10 dBm.

The curves show two peaks at 10 dBm giving $\eta = 86\%$ and $\eta = 23\%$ for diode voltage doubler and single diode configurations, respectively.

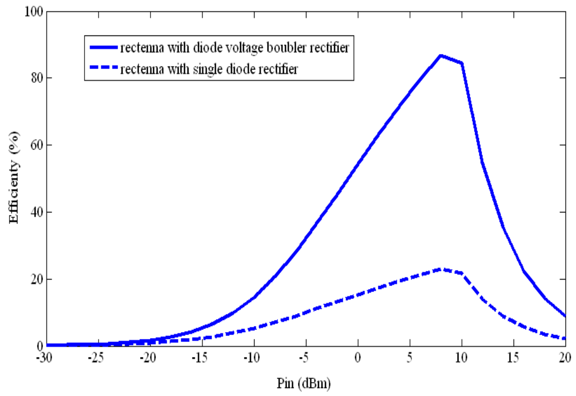

Figure 5. Rectenna efficiency versus input power.

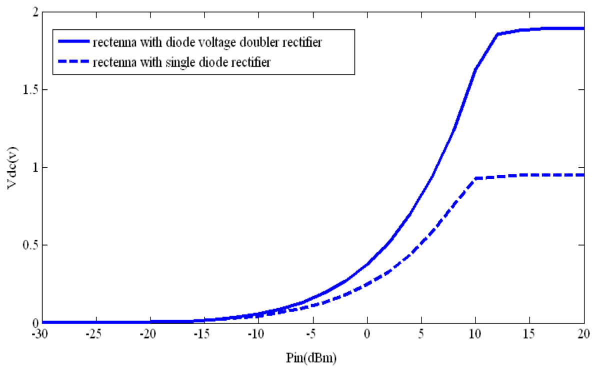

Figure 6. Rectenna's DC output voltage versus input power.

4. Conclusion

In this study, we designed and manufactured a rectenna with two configurations rectifier. A new multilayer patch antenna with four slots to generate circular polarisation is designed. We used a co- simulation method for the global system including Momentum and ADS schematic. The maximum conversion efficiency obtained at Pin=10 dBm is 86% for the rectenna with diode voltage doubler rectifier and about 23% for the rectenna with single diode rectifier.

The comparison and analysis of each rectenna designed and achieved in this study indicates that the first configuration of rectenna generally has superior characteristics than the second one.

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