A Multiband Rectenna for Self-sustainable Devices

Zhao Wang[1], Heng Zhang[1], Zhenzhen Jiang[1], Mark Leach[1], Kalok Man[2], Eng Gee Lim[1]
[1]Dept. of Electrical and Electronic Engineering,
[2]Dept. of Computer Science and Software Engineering,
Xi'an Jiaotong-Liverpool Univeristy. Suzhou, P.R.China
Enggee.lim@xjtlu.edu.cn

Abstract—**This paper is aiming at the design of an energy harvesting antenna. A new multi-band cross-polarized dipole antenna is designed, fabricated and measured, with its simulation and measurement results. It works from 1.53 GHz to 2.47 GHz at the lower frequency band and 4.90 GHz to 5.63 GHz at the higher frequency band, covering the GSM1800/1900, UMTS2100, 2.4G Wifi, and 5G Wifi bands. Moreover, this antenna is cross-polarized and has omnidirectional radiation patterns.**

Keywords: Rectenna; cross-polirization; multiband.

I. Introduction

With the rapid development of the wireless communication systems, the wireless RF energy is used widely during past decades, including the radio signals, cellular mobile signals and WLAN signals [1]-[3]. Duet to the explosive increment of the ambient RF signals, the ambient wireless power density is growing and some researchers started to pay attention to the feasibility of harvesting energy from ambient RF signals.

For some low-power electronic devices, such as electronic sensors, limited battery life becomes the bottle-neck for their extensive application. In the meanwhile, the power sources of these devices, the batteries, add the size of the whole device and also cause the environment pollution [4]. Harvesting ambient wireless RF energy is a solution for this situation. Powering low-power electronic devices by using energy harvesting antenna not only environmentally friendly but also self-sustaining [5]. It has been proved that the network of low-power wireless electronic sensors can be powered by energy harvesting system, which harvests energy from ambient RF signals [6]-[7].

"Rectenna", i.e. the rectifying-antenna system, is the combination of an antenna and a rectifier circuit, which is popular in harvesting ambient wireless RF energy [1]-[3]. The antenna can collect the ambient wireless signals, and the rectifier circuit can convert these energies into a useable DC power [3]. In general, this DC power will be stored in an energy storage device, and then it can be delivered to the load. Block diagram of the general rectifying-antenna system is shown in Figure 1.

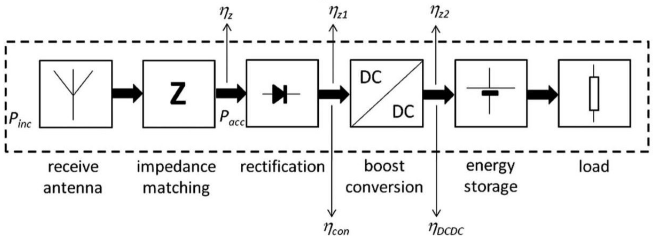

Figure 1: The block diagram of the rectifying-antenna system.

The primary purpose of this paper is to design an antenna which is able to operate over the frequency bands including GSM1800/1900, UMTS2100, 2.4G Wifi, and 5G Wifi bands.

II. Antenna Design

In this paper, CST microwave studio has been used to perform simulations of the antenna designed to meet the band requirements specified. The antenna has been manufactured for the proof of design.

The proposed multiband antenna is designed to cover the GSM1800/1900, UMTS2100, 2.4G Wifi, and 5G Wifi bands. The basic structure of the antenna is divided into three main sections; the square substrate made of FR4, the irregular diamond-shaped copper radiators on the front side of the substrate (as shown in Figure 2), and the H-slotted microstrip line perpendicular to the substrate to feed the antenna (as shown in Figure 3).

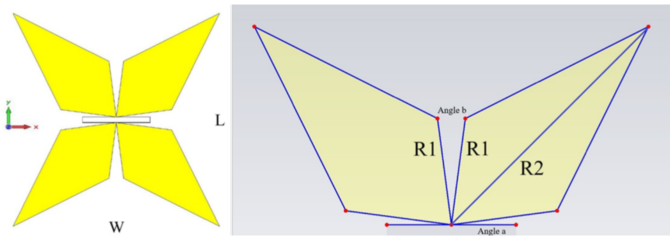

Figure 2: Front view of the cross-polarized dipole antenna with feed line.

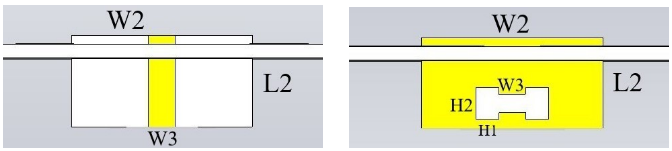

Figure 3: Top and Bottom view of the antenna feed line with H-slot.

The four irregular diamond-shaped quadrangles formed four arms of the planar dipole antenna, providing the cross-polarization to the antenna. The size of the irregular diamond-shaped quadrangle (*R1* and *R2*) and two angles between this quadrangle with two axes (angle *a* and *b*) are crucial to the antenna performance. The H-slotted microstrip line is selected as the feeding to suppress these higher order harmonics from rectifier [3].

The parameters of them are all examined and optimized according to the simulation. The fabricated antenna is shown in Figure 4.

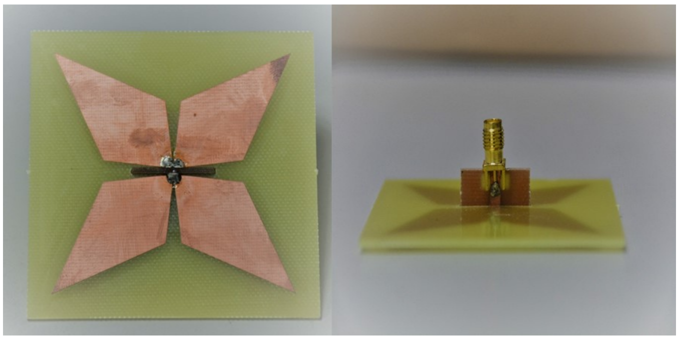

Figure 4: The fabricated cross-polarized dipole antenna with feed line.

III. RESULTS

A. Return Loss

The proposed multiband antenna is designed to cover the GSM1800/1900, UMTS2100, 2.4G Wifi, and 5G Wifi bands. From the simulation and measurement results shown in Figure 5, it can be seen that the antenna works from 1.53 GHz to 2.47 GHz at the lower frequency band and 4.90 GHz to 5.63 GHz at the higher frequency band, covered the frequency bands as required.

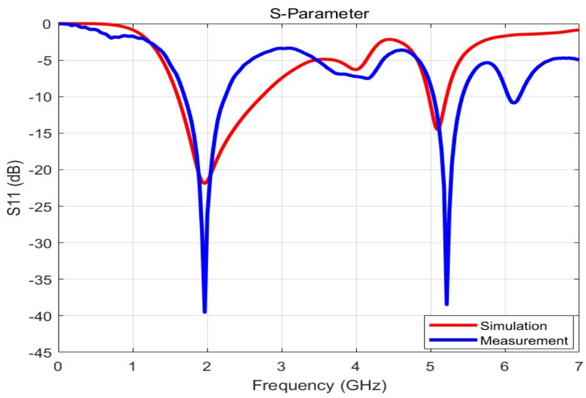

Figure 5: Return loss of the cross-polarized dipole antenna

B. Radiation Pattern

The simulated results of the co-polar and cross-polar radiation patterns of the antenna at 2.2 GHz are plotted in Figure 6. It can be seen that this antenna can receive RF waves with either vertical polarisation or horizontal polarisation at this frequency, which means this antenna is indeed dual-polarized by using the cross-polarized dipole structure.

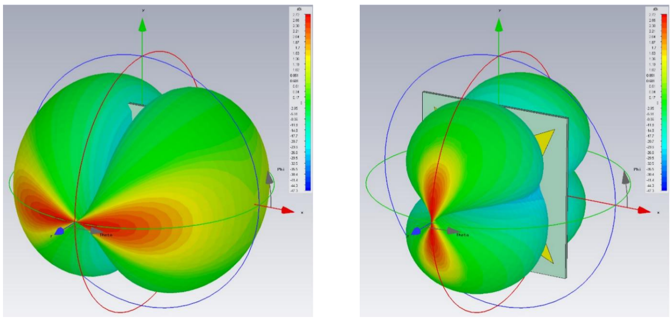

Figure 6: Simulated 3D Cross-polarization and Co-polarization RP at 2.2 GHz.

The 2-D radiation patterns of the antenna are shown in Figure 7. It shows that the antenna is omnidirectional at this frequency, meaning it can receive the signals indented from different angles.

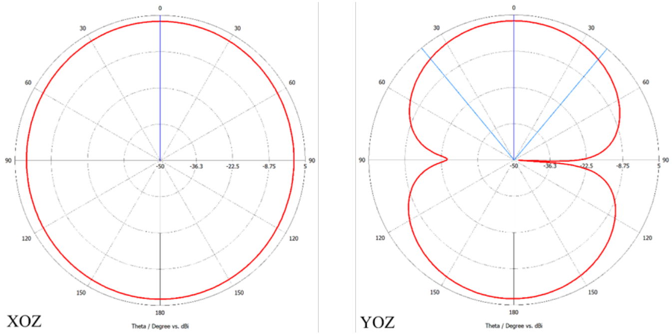

Figure 7: Simulated 2D radiation patterns at 2.2 GHz.

The radiation patterns at 5 GHz are distorted slightly, but show similar features of cross-polarization and omni-directional.

IV. CONCLUSION

A new multi-band cross-polarized dipole antenna has been designed and tested able to cover the GSM1800/1900, UMTS2100, 2.4G Wifi, and 5G Wifi bands. Simulation and practical results are in good agreement. This antenna is cross-polarized and has omnidirectional radiation patterns. As for the future work, the high frequency performance can be further improved to cover the ISM 5800 band.

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