

# Comparison of Rectenna Array Configurations for Enhanced Efficiency

<sup>[1]</sup>Mathew M. John, <sup>[2]</sup>Pooja S, <sup>[3]</sup>Ritchie Johnson, <sup>[4]</sup>Sneha Thankom Thomas, <sup>[5]</sup>Prof.Jaison C.S, <sup>[6]</sup>Prof. G. Senthil Kumar

<sup>[1][2][3][4][5]</sup>Dept. of Electronics and Communication Engineering, Amal Jyothi College of Engineering Koovappally Post, Kanjirappally, Kerala, India

<sup>[6]</sup>HoD, Dept. of Electronics SNR Sons College Ganapathy Post, Coimbatore, Tamil Nadu, India

<sup>[1]</sup>mathewmjohn1993@gmail.com ,

<sup>[2]</sup>16pooja16@gmail.com, <sup>[4]</sup>snehatt123@gmail.com, <sup>[5]</sup>ritchiejohnsont@gmail.com, [csjaison@amaljyothi.ac.in](mailto:csjaison@amaljyothi.ac.in),

<sup>[6]</sup>[gs\\_snr@hotmail.com](mailto:gs_snr@hotmail.com)

**Abstract:** A rectenna is a rectifying antenna, that is used for converting microwave energy to DC. This can be used for the transmission of electric power to a long distance, without physical cabling, i.e., by using microwaves [2]. DC power generated by multiple rectennas can be used for reliable device operation. Two recent methods adopted for rectenna array configuration are RF Combiner and DC Combiner. In this proposal we are planning to make more detailed investigations on some novel methods for improving the efficiency of rectenna in various coupling combinations so that we can attain a more reliable RF power harvesting method.

**Keywords:** Array configuration, rectenna array, RF power transmission, zero-bias diode.

## I. INTRODUCTION

A **rectenna** is used to convert microwave energy into direct current electricity. Rectennas are used in RFID tags thereby eliminating the incorporation of a battery. They can also be used as charger for mobile phones, digital cameras etc., without the aid of AC mains [3], and power unmanned aircrafts. Application includes solar space satellites, which would collect solar radiation, convert to microwave and then send to earth [2]. The earth station would have an array of Rectenna to produce electricity and then link to a common electric grid system. Here we consider two configurations: RF combiner and DC combiner. In one configuration, multiple antennas can be arranged to channel the RF power to a single rectifier [3]. In another approach, each antenna can incorporate its own rectifier to separately harvest DC power [6] [see Fig. 1(b)]. The harvested DC power from all rectifiers can then be combined in parallel, series, or a hybrid manner [7]. A single Rectenna consists of a Microstrip patch antenna, a zero-biased Schottky diode for rectification. A single stub matching network is needed to match the diode's complex impedance with the filter.

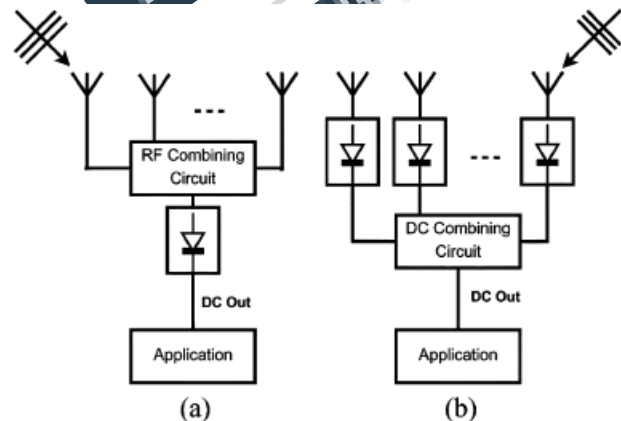


Fig. 1. Schematics of the investigated rectenna array configurations. (a) RF-combiner. (b) DC-combiner [1].

## II. DESIGN

The design of antenna and rectifier were done using Ansoft

HFSS and Agilent ADS

The software used to model and simulate the microstrip patch antenna is HFSS. HFSS is a high-performance electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling. It integrates

simulation, visualization, solid modeling, and automation in an easy-to-learn environment.

HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give unparalleled performance and insight to all of 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields [4].

Advanced Design System is the world's leading electronic design automation software for RF, microwave, and high speed digital applications. In a powerful and easy-to-use interface, ADS pioneers the most innovative and commercially successful technologies, such as X-parameters\* and 3D EM simulators, used by leading companies in the wireless communication & networking and aerospace & defense industries [5].

#### A. Antenna Design

Antenna is designed using Ansoft HFSS as well as Agilent ADS. Rogers RT/duroid 5887 is used as the substrate of antenna. Thickness of substrate used is 3.2mm. On the substrate a small patch is placed at the centre on top of the substrate. Thus a patch antenna of 2.45 GHz is designed in HFSS. After designing model boundaries were assigned as perfect E for ground and patch. Radiation boundary is also assigned. Excitation for the antenna is given using the waveport. Radiation pattern, S11 and VSWR of the designed antenna is analysed.

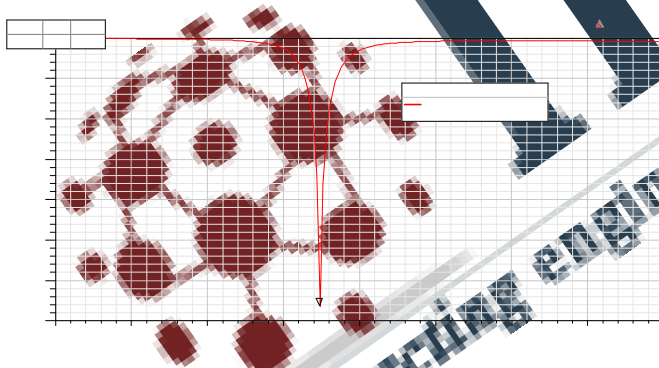


Fig. 2. S11 plot of antenna showing frequency of operation at 2.45GHz

Antenna arrays are used to increase the directivity, gain, and enhance various other functions which would be difficult with single antenna. Microstrip patch antennas can be fed by a variety of methods. In this case, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is made smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate as provided a planar structure.

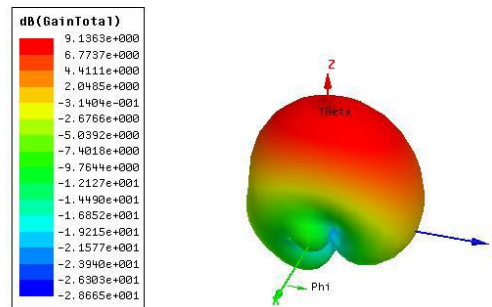


Fig. 3. 3D polar radiation pattern of 2x1 microstrip patch antenna array *B. Rectifier Design*

To convert the RF power received by antenna to DC a rectifier circuit is designed. The rectifier used is Modified Greinacher rectifier. The diodes used for the rectifier are zero biased Schottky diode. The rectifier circuit acts as a voltage doubler also. In order to match the output impedance of the antenna and the input impedance of the rectifier a matching network is used. To measure the output DC power a resistive load is added at the output terminal.

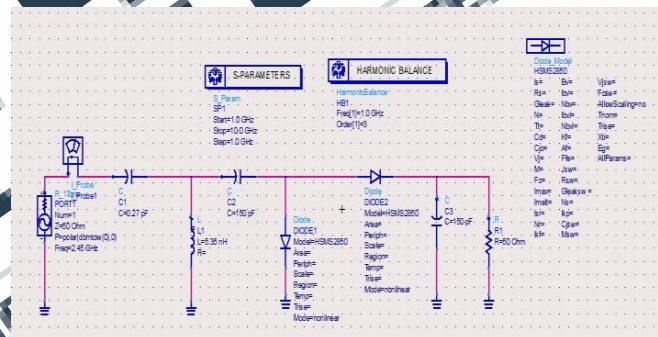


Fig. 4. Schematic diagram

Output obtained as a result of simulation in ADS is shown below.

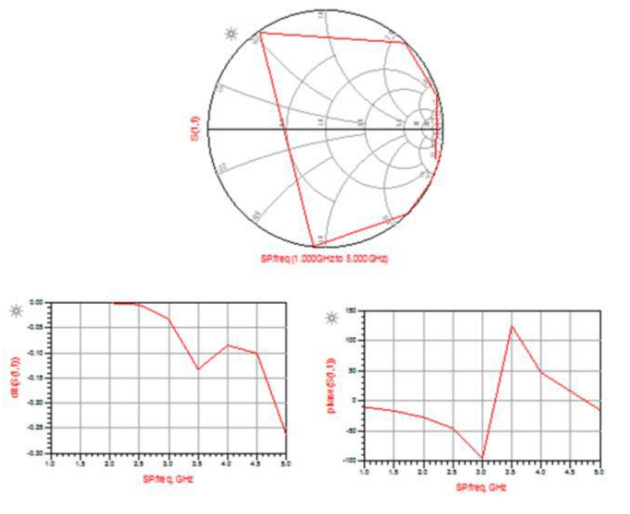


Fig.5. Obtained Rectenna outputs

### CONCLUSION

Comparison of rectenna efficiency in two different configurations was done to find the most reliable power harvesting method.

It was found that RF combiner topology was efficient compared to DC combiner. In RF combiner, the combined RF output from antenna array was given directly to the rectifier circuit. As a result, power delivered to the rectifier was high. But in case of DC combiner, RF power from individual antennas were rectified separately and rectified DC power was then combined. Since RF power from a single antenna is given to the rectifier, the combined output power will be low comparatively. Also in DC combiner topology the broader radiation pattern of separate antennas can be utilized. In RF combiner topology more power can be harvested near the main beam. Future work will be to increase the efficiency of rectenna, by increasing the antenna gain and also considering the polarisation effects.

### REFERENCES

- [1] Olgum, U., C. C. Chen, and L. Volakis, "Investigation of rectenna array configurations for enhanced RF power harvesting," *IEEE Antennas and Wireless Propagation Letters*, Vol. 10, 262-265, 2011.
- [2] Roy Want, "An introduction to RFID technology", *Pervasive Comput.*, vol.5. no.1, pp.25-33, Jan-Mar 2006.
- [3] G.R. Duncan, "Nokia developing phones that recharges itself without mains electricity", 2009 (Online). <http://www.guardian.co.uk/environment/2009/jun/10/nokia-mobile-phone>.
- [4] I J. Zbitou, M. Latrach, and S. Toutain, "Hybrid rectenna and monolithic integrated zero-bias microwave rectifier,"

*IEEE Trans. Microw. Theory Tech.*, vol. 54, no. 1, pp. 147–152, Jan. 2006.

[5] [www.AnsoftHFSS.com](http://www.AnsoftHFSS.com)

[6]

<http://www.agilent.co.in/about/newsroom/presrel/2014/08may-em14069.html>

[7] J. Hagerty, F. Helmbrecht, W. McCalpin, R. Zane, and Z. Popovic, "Recycling ambient microwave energy with broad-band rectenna arrays," *IEEE Trans. Microw. Theory Tech.*, vol. 52, no. 3, pp. 1014–1024, Mar.2004.

[8] N. Shinohara and H. Matsumoto, "Dependence of dc output of a rectenna array on the method of interconnection of its array elements," *Elect. Eng. Jpn.*, vol. 125, no. 1, pp. 9–17, 1998.