IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p-ISSN: 2278-8735
PP 06-10
www.iosrjournals.org

Design Of A Compact Voltage-Doubler-Type Rectenna

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Abstract: *The rectenna is an important element for wireless power transmission. Rectenna or rectifying antenna contains a receiving antenna followed by an RF- dc rectifying circuit. Current use of rectenna is in RFID tags, Proximity cards and Contactless smart cards as a power source provider. Simple, compact and lightweight voltage doubler type rectenna, operating at 2.4Ghz frequency range is designed. Here the united configuration of a dipole antenna with a rectangular section on both arms of dipole is used for improving the most nergative return loss . Dipole antenna is widely used because of its simplicity and effectiveness for a wide range of communication. To make the structure cost effective FR4 substrate (ε_r =4.4) is used. The antenna modeling is analyzed by using an electromagnetic simulator HFSS. The obtained maximum return loss also indicates the antenna is having good matching at the output port. The measured return loss and gain from the circuit simulation is -27.63dB and 2.2 dB respectively. From circuit simulation of proposed rectenna doubled output voltage of 4.5V is obtained under the input power 12.9dBm .*

***Keywords**: RF energy harvesting, Rectenna, voltage doubler*

I. Introduction

Over the past two decades, many wireless systems have been developed and widely used around the world. The most important examples are cellular mobile radio and Wi-Fi systems. Just like radio and television broadcasting systems, they radiate electromagnetic waves/energy into the air but a large amount of the energy is actually wasted, thus how to harvest and recycle the ambient wireless electromagnetic energy has become an increasingly interesting topic. One of the most promising methods to harvest the wireless energy is to use a rectenna. Rectenna is a power receiving device. There are at least two advantages for rectennas such as the life time of the rectenna is almost unlimited and it does not need replacement (unlike batteries) and it is "green" for the environment (unlike batteries, no deposition to pollute the environment)[5].

RF energy harvesting is one type of energy harvesting that can be potentially harvested such as solar, vibration and wind. The RF energy harvesting uses the idea of capturing transmitted RF energy at ambient and either using it directly to power a low power circuit or storing it for later use. The concept needs an efficient antenna along with a circuit capable of converting RF signals to DC voltage. The efficiency of an antenna mainly depends on its impedance and the impedance of the energy converting circuit. If the two impedances aren't matched then it will be unable to receive all the available power from the free space at the desired frequency band. Matching of the impedances means that the impedance of the antenna is the complex conjugate of the impedance of the circuit (voltage doubler circuit)[3].

The main component of an RF energy harvester is called rectenna, for rectifying antenna. A block diagram of such a system is illustrated on Fig 1. It contains a receiving antenna followed by an RF-to-DC rectifying circuit and optionally an energy storage device. A rectifier is often made up of a combination of schottky diodes, an input RF filter and an output bypass capacitor. The input filter localized between the receiving antenna and diodes, is a low- pass filter which rejects unwanted higher order harmonics created by the non- linear behavior of the diodes. It also acts as an impedence matching network between the antenna and the rectifier.

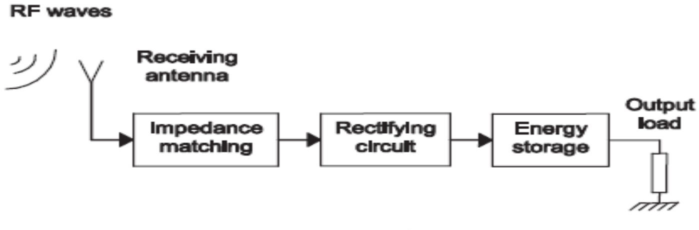

Fig 1. Block diagram of RF energy harvester

The objective of the present study is to evaluate the return loss and gain of the proposed antenna. In this paper describe the configuration of the modified dipole antenna, measurement results and graphical simulations relating various antenna parameters.

II. Outline Of A Voltage-Doubler-Type Rectenna

2.1 Rectenna configuration

A Schematic diagram of a proposed voltage-doubler type rectenna is shown in Fig 2. A microwave transmitter is defined as an ac source composed of the microwave power $P_{t,}$ the angular frequency w, and the source impedence Z_s. The proposed antenna is taken as a dipole antenna in which both arms are united with a rectangular section. A schottky diode HSMS-276C is connected to the antenna feed point. Two schottky diodes are packaged in HSMS-276C in the manner d_1 and d_2 respectively.

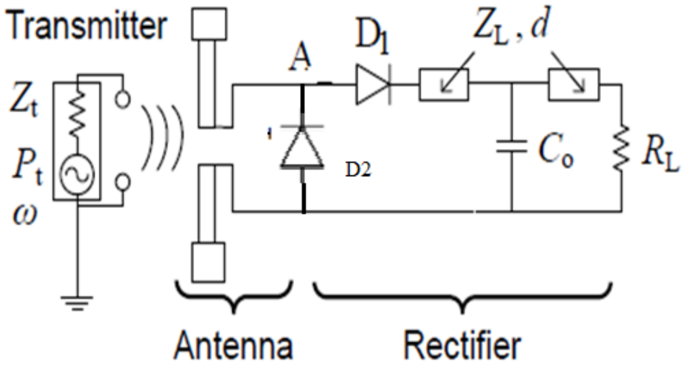

Fig 2: A schematic diagram of a voltage- doubler type rectenna

2.2 Overview of rectenna

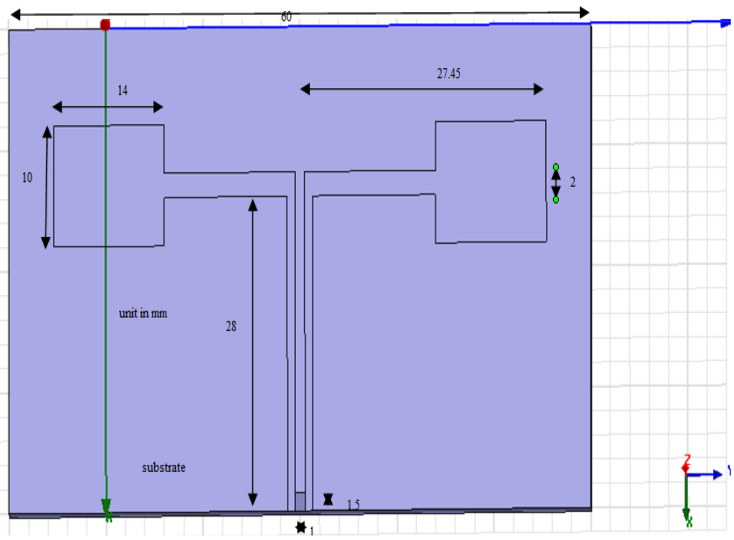

Fig 3. Proposed voltage doubler type rectenna

Dimensional drawing of the proposed rectenna is shown in Fig 3. The schottky diode is depicted as D_1 in Fig 2. The rectenna were assembled on a substrate named FR-4epoxy. The relative permittivity of the substrate is 4.4. The dipole antenna length was 27.45mm + 27.45 mm. A rectangular section of width 10mm and length 14mm is united with both arms of dipole.

III. Simulation Results And Measurements

The S parameter result of the proposed antenna is shown in figure 4. The measured return loss is -27.63 dB at 2.4GHz frequency. This means that the antenna is radiated best at 2.4Ghz frequency range.

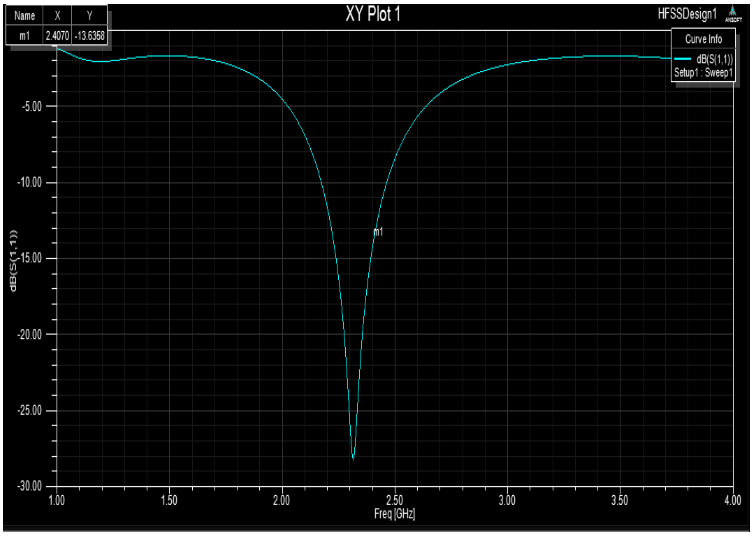

Fig 4. Simulated reflection coefficient verses frequency

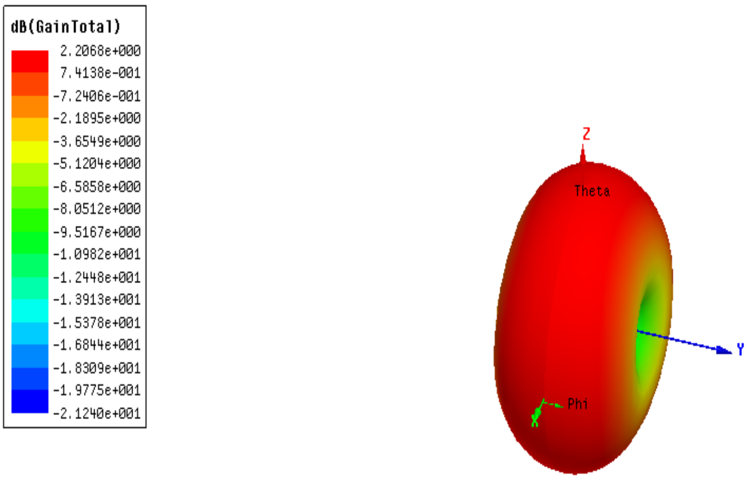

Fig 5. Radiation pattern of proposed antenna

This plot is similar to the normal dipole antenna. From this figure understand it's a omni directional antenna with gain 2.206 dB.

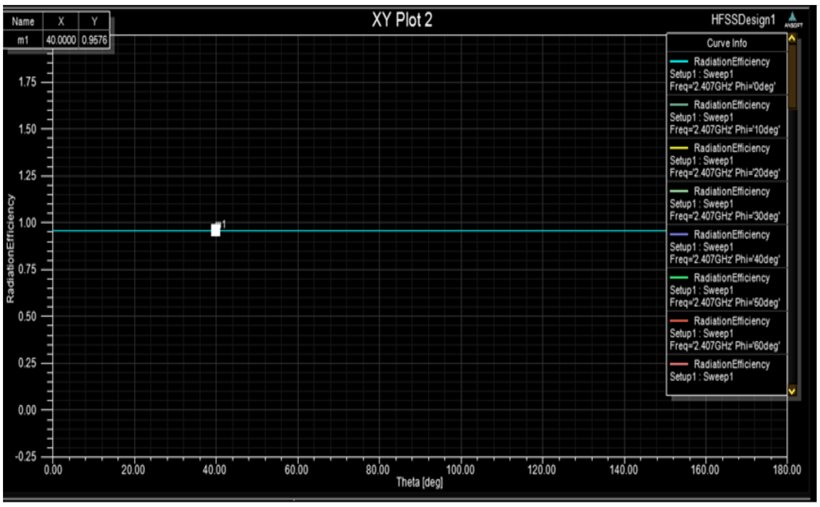

Fig 6. Efficiency characteristics

The radiation efficiency of the proposed antenna is 95.7%

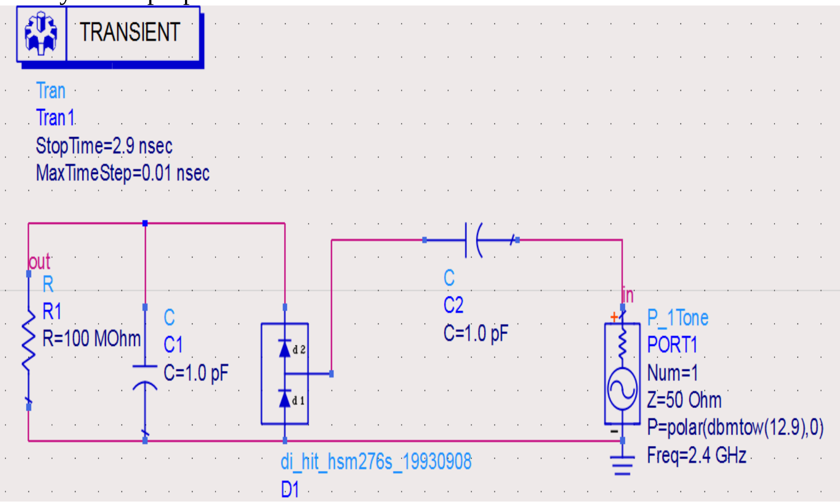

Fig 7. A Schematic diagram of an equivalent circuit of a voltage-doubler-type rectenna

Above figure provided an equivalent circuit of the voltage-doubler-type rectenna. The source impedence Z is set to 50Ω. The input power P is set to 12.9 dBm. Here used the schottky diode as Avago HSMS- 276C. 1p F capacitor is used as smoothing capacitor and the load resistance is taken as 100 MΩ

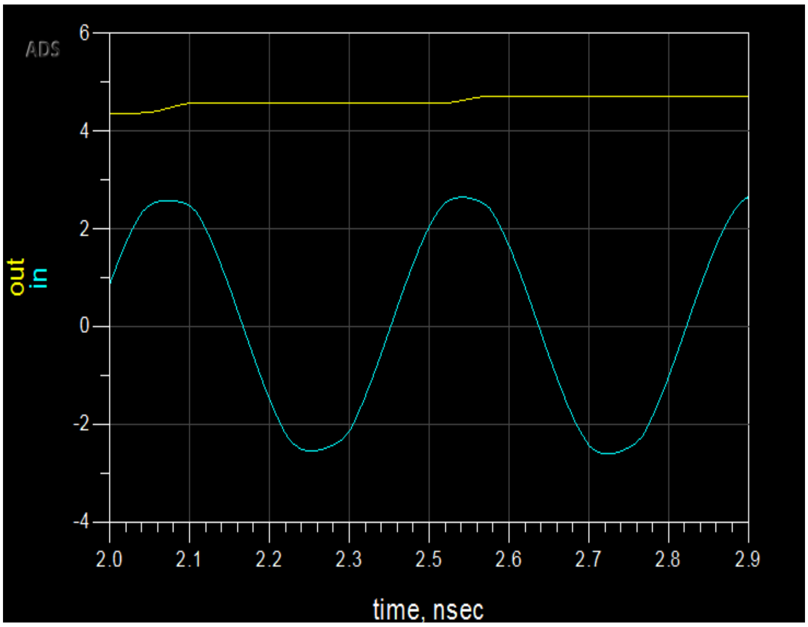

Fig 8. Simulation results of the input and output voltage waveforms of the voltage doubler type rectenna (R_L= 100 MΩ P_i= 12.9 dBm)

The observed output voltage of 4.5V for corresponding 2.531V is obtained at time 2.102 nseconds.

IV. Conclusion

A compact, light weight and simple voltage doubler type rectenna operating at 2.4Ghz frequency range is designed. Here the united configuration of a dipole antenna with a rectangular section on both arms of dipole is used for improving the most negative return loss. To make the structure cost effective FR4 substrate (ε_r =4.4) is used. The antenna modeling is analyzed by using an electromagnetic simulator HFSS. The return loss of -27.63dB is obtained from the circuit simulation. Rectifier section is analyzed by using ADS software. The observed output voltage of 4.5V for corresponding 2.531V is obtained at time 2.102 nseconds.

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