Design of an Efficient RF Energy Harvesting Multiband Rectenna

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ABSTRACT: A Rectenna can provide wireless electricity to the home appliances, medical equipment's in the healthcare centers, electronic systems in the school/colleges, etc. This paper proposes the design of a novel rectenna system, which involves developing a multi band rectenna with a fractal structured antenna to facilitate an increase in energy harvesting from various sources like Wi-Fi, TV signals, mobile networks and other ambient sources, eliminating the limitation of a single band technique. The usage of Fractal antennas effects certain prominent advantages in terms of size and multiple resonances. Even though, a fractal antenna incorporates multiple resonances, controlling the resonant frequencies is an important aspect to generate power from the various desired RF sources. Hence, this paper also describes the design parameters of the fractal antenna and the methods to control the multi band frequency.

***Keywords*: Energy harvesting, Rectenna, Multiband antenna, Fractal antenna**

I. Introduction

In the early 1960's, the first receiving device for efficient reception and rectification of microwave power emerged Microwave power transmission MPT has been developed since the half of the previous century. A large number of investigations presents the MPT technology as a possible solution for the problems caused by decreasing of fossil energy resources. The first circuit converting RF energy to exploitable DC energy was developed by W.C. Brown and called Rectenna. The rectenna rectifying antenna is an important device for converting microwave signal into useful DC power. A rectenna contains an antenna as the receiver which collects microwave signal and a rectifying circuit to convert RF power into DC power. A rectifying circuit is often made up of a combination of Schottky diodes, an input HF filter, an output bypass capacitor and a load resistor. In this approach, filter components are made by varying geometric parameters of connected lines. This method constrains us to use electromagnetic simulations coupled with circuit simulations to design the rectenna circuit.

II. RF Energy Harvesting

The energy efficiency of an RF harvester depends on the available input power levels and the characteristics of the energy storage device attached to the sensor node. The storage element should have a small form factor to fit in the dimensions of the sensor, a high energy density and low leakage to extend the discharge cycle life. Nowadays, the most promising solutions for energy storage in WSN nodes, including solid-state thin-film rechargeable batteries [4], [5] or super-capacitors [6], [7], require a minimum charging current on the order of a few tens of μ as to combat leakage [4], [8], [9]. Hence, considering a supply voltage of 1 V, charging a rechargeable battery or super capacitor requires a minimum DC power on the order of 25W [8]. It means that an incident RF power of about 100μ W(-10dBm) is needed for RF energy harvesting if conversion losses are taken into account [2]. This makes RF harvesting less effective in dense ad hoc networks where a large area must be flooded with RF radiation to power many wireless sensor nodes, further considering the small antenna sizes employed [10]

Energy harvesting by RF-DC conversion may be incorporated into a wireless node by adding a dedicated antenna [2], [12], [13] or, more elegantly, by re-using the antenna of the TRX, as shown in Fig. 1. The latter facilitates system miniaturization but requires some kind of decoupling between the harvesting and communication operations. This can be accomplished by using two different carrier frequencies and a dual band antenna [14]. However, this requires bulky LC matching networks to make the impedance looking into one functional unit high at the frequency the other functional unit is tuned.

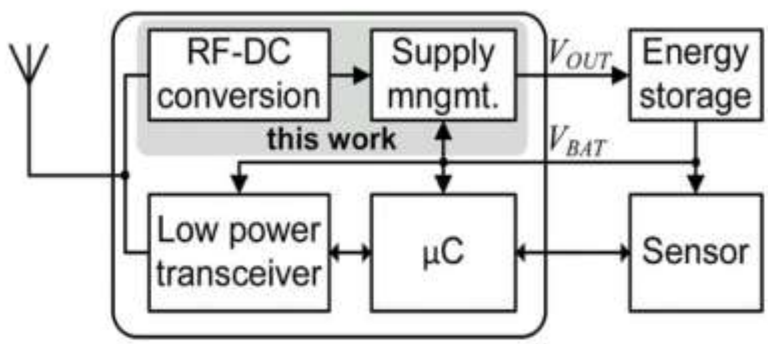

Fig. 1. Architecture of the wireless sensor node with RF energy harvesting.

RF power harvesting is a process whereby Radio frequency energy emitted by sources that generate high electromagnetic fields such as TV signals, wireless radio networks and cell phone towers, but through power generating circuit linked to a receiving antenna, captured and converted into usable DC voltage. A radio frequency power harvesting system can capture and convert electromagnetic energy into a usable direct current (DC) voltage. The key units of an RF power harvesting system are the antenna and rectifier circuit that allows the RF power or alternating current (AC) to be converted into DC energy.

III. Design of Fractal Structured Antenna

A Rectangular elementary shape is iteratively shaped, and then removed from the original shape in order to generate a fractal. To obtain multiband characteristics and best performance, Sierpinski fractal geometry is applied to rectangular micro strip patch antenna. A rectangular micro strip antenna is designed using a substrate material "FR4 epoxy "

i)Rectangular Patch design of Iteration 0 For patch design and simulation Ansoft Ansys HFSS is used. The rectangular patch antenna is designed using calculated dimensions. Hence, a large dimension rectangular patch is chosen. The main aim is to increase the size of Antenna within the same area and to increase the bandwidth. This can be done by practical by replacing of substrate with another material. A slot is inserted at right side of patch.

ii) Rectangular Patch design of Iteration 1 Here, Ansoft Ansys HFSS is used for designing the patch and for its simulation. A rectangular substrate material is chosen for rectangular patch to be placed on the substrate. The micro strip patch antenna's performance is been enhanced by the radiating elements, the rectangular patch's 1/3rd slot is removed at the center of the patch for to obtain the multiband characteristics.

iii) Rectangular Patch design of Iteration 2 Here, Ansoft Ansys HFSS is used for designing the patch and for its simulation. A rectangular substrate material is chosen for rectangular patch to be placed on the substrate. The micro strip patch antenna's performance is been enhanced by the radiating elements, the rectangular patch's 1/3rd slot is removed at the center of the patch and also few more smaller slots are removed from the rectangular patch around of the central slot. This process is repeated.

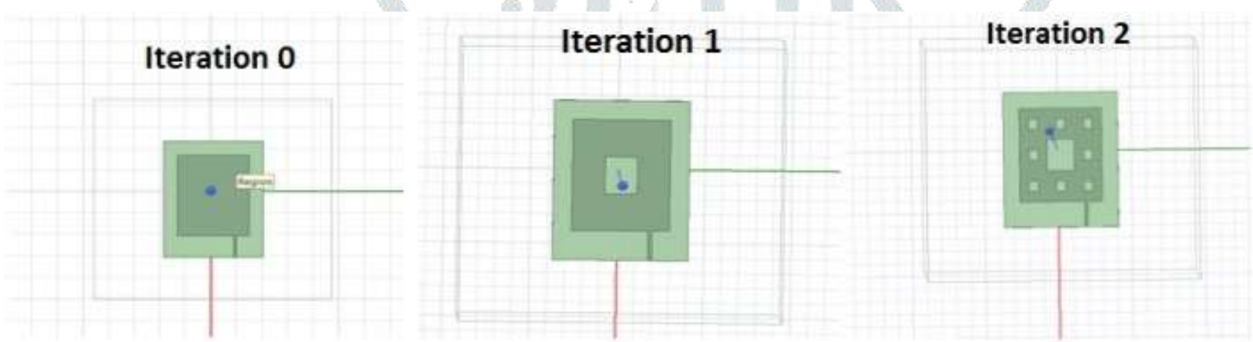

Figure 2 . Rectangular Patch Design for Iteration 0,1,2

IV. Results

The Antenna designs are simulated in ANSYS Electro magnetics Suite 18.2, and results are summarized below. The Sierpinski fractal rectenna was simulated at 2.4Ghz frequency and inspected for return loss characteristics(S11), VSWR, radiation pattern, normalized gain.

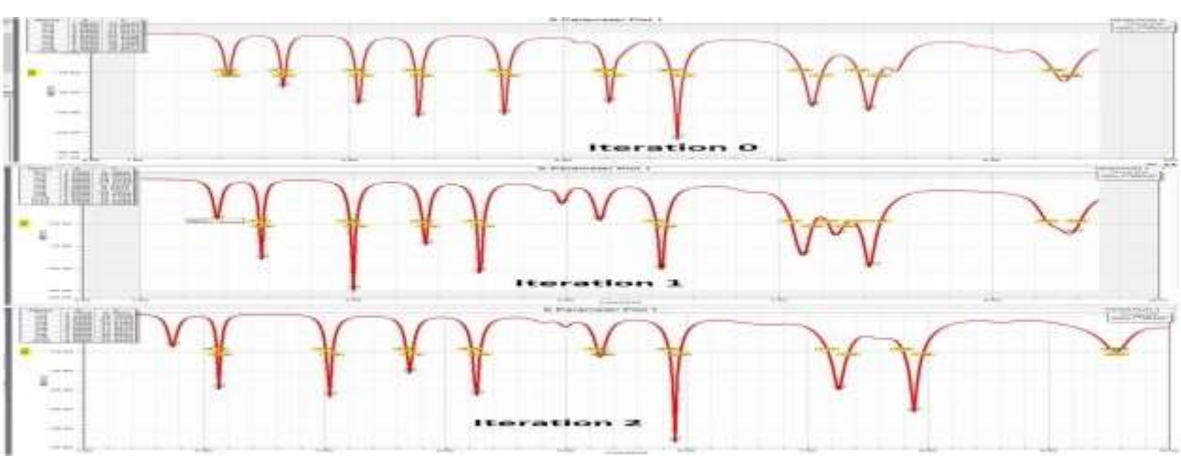

Figure 3 Return loss for Iteration 0 ,1,2

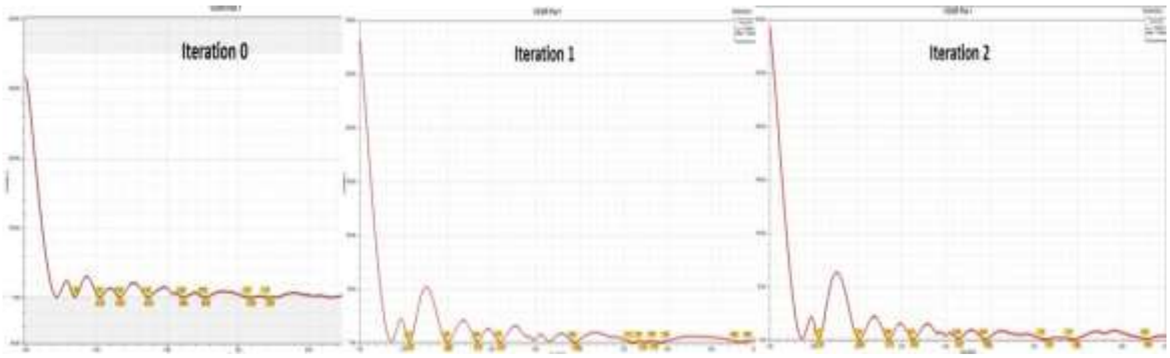

Figure 4 : VSWR for Iteration 0,1,2

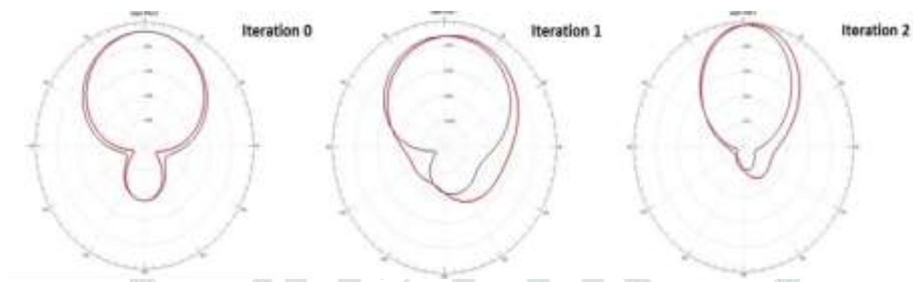

Figure 5 : Radiation pattern for Iteration 0,1,2

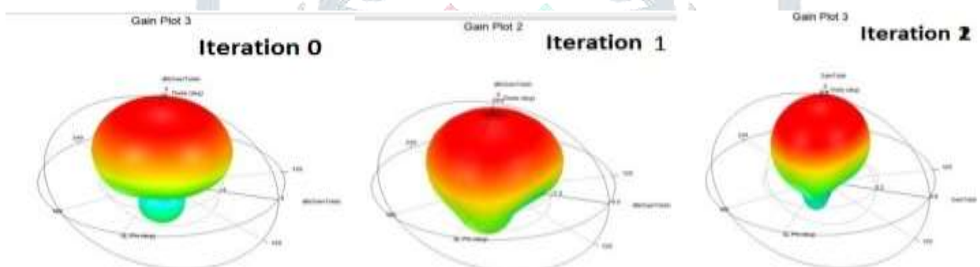

Figure 6 Gain for Iteration 0,1,2

Table 1: Practically Obtained Values using HFSS

Parameters	Iteration 0	Iteration 1	Iteration 2
Return loss	-13.6877	-18.0050	-19.7859
VSWR	1.8077	1.2879	2.1105
Gain	Max-2.8	-1.7	0.6

V. Conclusion

In this paper, RF energy harvesting of rectenna by fractal structured antenna is designed this antenna is to be operated at the frequency of 2.45Ghz and iterated up to 2nd iteration by the factor of 1/3. The performance of antenna such as Return losses, Gain, Radiation pattern, are obtained by observing these when compared to microstrip patch antenna performance characteristics of fractal antenna gives best performance and can captures more RF energy which converts into DC.

VI. References

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