Design of Elliptical shaped patch antenna to energize low power devices

[1]Padmapriya V P, [2]Sadasivam Subbarayan S, [3]Dr. V Thulasi Bai

[1]PG Student, [2]Assistant Professor, [3]Head of the Department
Department of Electronics and Communication Engineering,
KCG College of Technology, Chennai, India

Abstract: **Energy harvesting is one of the process by which energy is derived from external sources like solar, RF energy from environment that are captured and stored for low power device uses. Most low power devices are powered by batteries and they are used by changing the batteries frequently after certain period and it will result in increase of the cost spent by the consumers, hence this work proposes energy harvesting method for which energy is available in the environment.by the portions given in this document. In this work an antenna for 8 GHz frequency is designed along with the energy harvesting circuit for RF energy harvesting. First module which is design of elliptical antenna is designed using HFSS tool and then second module which contains matching network along with harvesting circuit is designed using ADS software. For 8GHz frequency the antenna output and matching network along with harvesting circuit is matched with 50Ω line. The elliptical antenna results are gain (7.5dBi), directivity (7.4dBi) and efficiency (89%).**

Keywords: **HFSS, ADS, Energy Harvesting, Rectifier.**

I. INTRODUCTION

Energy is available everywhere in the environment surrounding us and it is available in the form of thermal energy, light energy (Solar), wind energy and mechanical energy. The energy from the mentioned sources are often found in such small quantities so that it cannot supply adequate power for any low power. So far, it has not been possible to capture such energy adequately to perform any useful work and it can be changed using a method energy harvesting. Energy Harvesting is the process by which energy from the environment are captured in small quantities capturing small amount of energy from multiple naturally occurring energy sources, accumulating them and storing them for future purpose. These devices perform accurately by capturing, accumulating, storing and managing this energy which will be supplied in a form that can be used to perform a helpful task. Typically, a module of Energy Harvesting is an electronic device that can perform all these functions to power a variety of sensor and control circuitry for intermittent duty applications. It is also known as energy scavenging or micro energy harvesting. However the energy captured is adequate for most wireless applications, remote sensing, body implants and other applications as the lower segments of the power spectrum and even if the powering device has low harvested energy, it can still be used to extend the life of a battery.

II. ARCHITECTURE

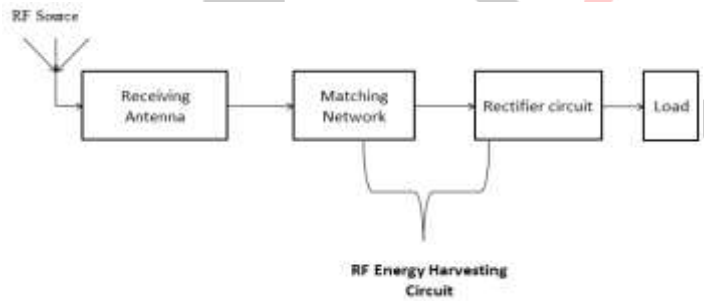

Fig. 1 Block diagram of energy harvesting circuit

Antenna Design

The antenna is segmented into three main parts; Main radiating patch, Ground patch and Feed line[1],[2],[3],[9]. The main radiating patch is elliptical shaped microstrip antenna with the dielectric constant of 2.2 and loss tangent is 0.009 and material used is RT Duroid. In this RT Duroid material is used because it will give gain of 6.8-7dB and it is used for frequency above 4GHz. Because in FR4 material upto frequency 4GHz good results are available and the gain will be 3.3dB only. If RT Duroid material is used the antenna shape can be reduced and it will be a advantage. The feed line used is inset feed because in general feeding a transition feed line is used to match the impedance of one with the impedance of other. But if inset feed is used it will avoid transition feed line and so this feeding is applied.

Energy Harvesting Rectifier Circuit

The Rectenna termed as rectifying antenna which is the combination of the antenna and a non-linear rectifying element. The two

elements are integrated into a single circuit, such a system is capable to receive RF power and to converts the RF power into dc power. Schottky diode is used for rectification. It is necessary to select a diode having high speed switching characteristics in order to follow a high frequency input signal and have a low cut off voltage to operate at a low RF input power.

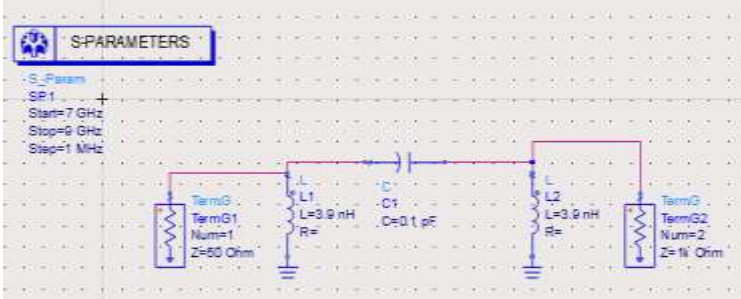

Fig. 2 Energy harvesting circuit

III. METHODOLOGY

Existing Method

In the existing method they designed a rectenna for the frequency 5.8GHz using ADS software as the simulation tool for the microstrip planar antenna[9]. The output of the antenna and rectifier circuit is matched to a impedance of 50Ω line over the ISM frequency band[9] using a matching network. The simulated antenna results are given below,

PARAMETERS	VALUES
Frequency	5.8GHz
Gain(dBi)	2.89
Directivity(dBi)	3.638
Efficiency(%)	84

Table.1 Results of antenna at 5.8GHz

Proposed Method

In this method an elliptical shaped microstrip patch antenna is designed with inset feed for frequency 8GHz using HFSS software along with matching network and rectifier circuit in ADS software. The antenna is divided into three main parts;

1. Main radiating patch
2. Ground patch
3. Feed line

The main radiating patch is elliptical shaped microstrip antenna with the dielectric constant of 2.2 and loss tangent is 0.009 and material used is RT Duroid. In this work, RT Duroid material is used because it will give gain of 6.8-7dB and it is used for frequency above 4GHz. Because in FR4 material good results will be available upto the frequency of 4GHz and the gain will be in the limit of 3.3dB only. But if RT Duroid material is used it can decrease the antenna shape as well as increase the gain of the antenna. The feed line used is inset feed because in general transition feed line is used to match the impedance of one circuit with other impedance. In inset feed transition feed line will be avoided and so this feeding is used.

The design of the antenna is given below,

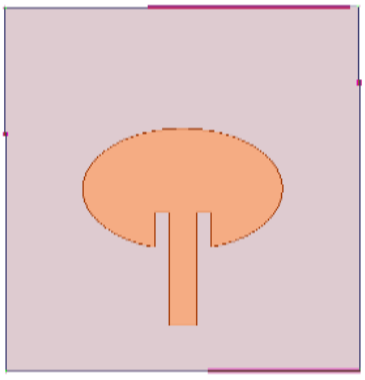

Fig. 3 Elliptical shaped patch antenna

PARAMETERS	*VALUES(mm)*
a (minor axis)	7.23
b (major axis)	8.63
Feed line width	2.426
Inset feed gap	1.213
Inset feed length	4.1
Ground length	43
Ground Width	30

Table.2 Design Parameters of antenna at 8GHz

Energy Harvesting and Rectifier Circuit

ADS software is used to design energy harvesting circuit [9]. The S11 parameter file S1P of the designed elliptical antenna is imported to the ADS RF simulator which is done to have a proper impedance matching between the output of the antenna and half-wave rectifier circuit. Rectifier circuit is build using diodes and from half-wave rectifier positive signal is the output. The monotonic frequency power source is used to excite the rectifier circuit. The S1P has two pins which are grounded and connected with the Pin 3 coupler. The rectifier device is connected with the coupler on the other side via the impedance matching network. Single tone excitation is applied as input and the matching circuit for the required device is designed similar to L-C impedance matching network, so that the rectifier is matched to the antenna at 50 ohm for the desired 8GHz frequency.

Results

In this proposed model an elliptical shaped microstrip patch antenna is designed, a matching circuit and a half-wave rectifier circuit. First the antenna is designed using HFSS software for 8 GHz frequency then a matching circuit and rectifier circuit are designed using a ADS software separately. Atlast it will be combined together and then the results is calculated for the same frequency. An elliptical antenna is designed for the frequency 8 GHz using HFSS software and inset feed is given for this antenna. It is then simulated to calculate the Return loss, VSWR, Gain and Efficiency of the antenna for the given frequency.

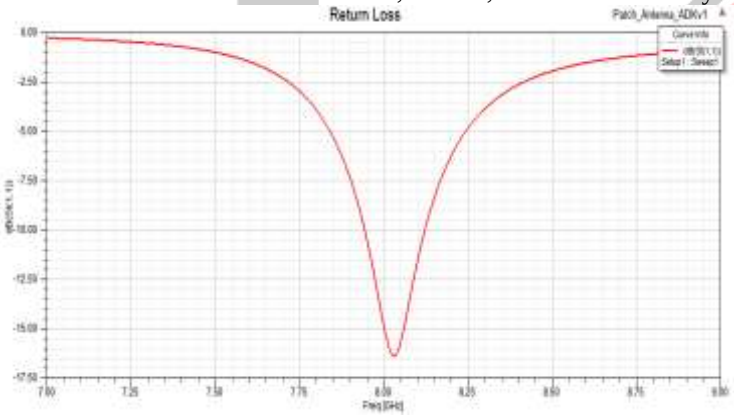

Fig.4 Return loss of the antenna at 8GHz

From the graph, for a antenna return loss should have low return loss to get maximum incident waves at the receiver side.

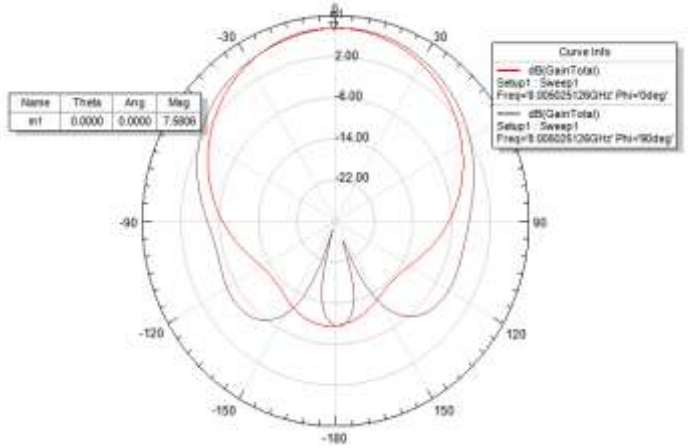

Fig.5 Gain of the antenna at 8GHz

PARAMETERS	VALUE
Frequency	8 GHz
Radiated Power (Watts)	0.00041
Directivity (dBi)	7.4
Radiation Efficiency (%)	89
Gain (dBi)	7.5

Table.3 Results of antenna at 8GHz

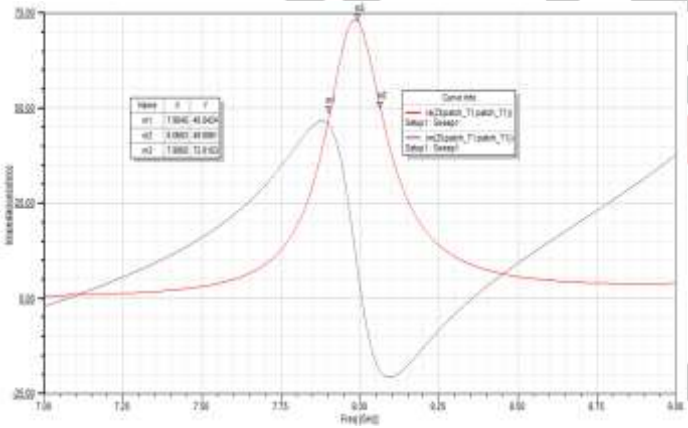

Fig.6 Impedance of the antenna at 8GHz

And then a matching network for the antenna is designed, basically the antenna is designed for 50 ohm and it will have to match the impedance of the load and for that matching network along with rectifier is used. In this, first a circuit with general 50 ohm is designed and then matched with the network to the load resistance. After matching that S(1,1) parameter of the antenna is imported from the HFSS software to ADS software and then it is tuned for the given circuit and it is matched.

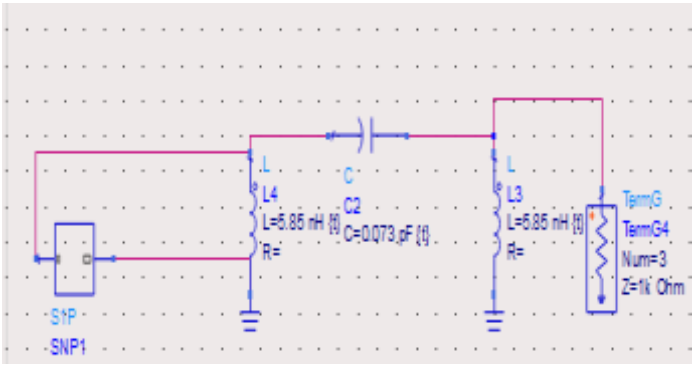

Fig.7 Matching and rectifier circuit

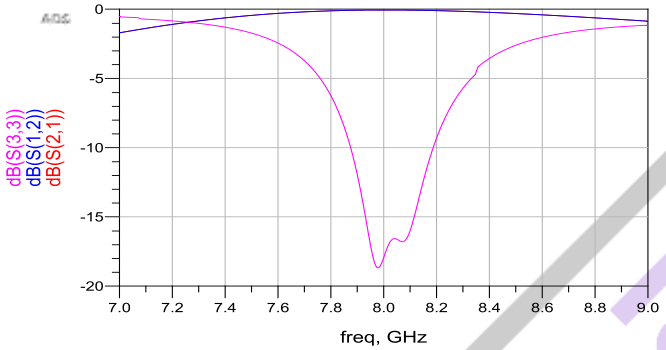

Fig.8 Frequency Vs S33, S12,S21

PARAMETERS	*EXISTING METHOD*	*PROPOSED METHOD*
Frequency	5.8GHz	8GHz
Gain (dBi)	2.89	7.5
Directivity (dBi)	3.638	7.4
Efficiency (%)	84	89

Table.4 Comparison of antenna results at 5.8GHz and 8GHz

IV. CONCLUSION AND FUTURE WORK

Energy harvesting technique is most widely used for many wireless applications and in this a frequency of 8GHz is considered and it is then designed using HFSS and then combined with a matching network and a rectifier circuit using ADS software. The simulation results have shown good performance characteristics of antenna in terms of return loss, gain, efficiency using inset feed. In future, this work can be fabricated and it can be tested for the given frequency to charge low power devices.

V. ACKNOWLEDGMENT

We are indebted to our Professor and Head of the Department of Electronics and Communication Engineering and our Project Coordinator Dr. V. Thulasi Bai, for her enthusiastic motivation and continuous encouragement which inspired us with lot in completing this project. We also thank our internal guide Mr. S. Sadasivam Subbarayan, Assistant Professor of ECE Dept., who has provided us his support , guidance and valuable suggestions that helped us to complete the project successfully. Last but not the least we are grateful to our parents and friends for their constant encouragement and support to complete project successfully.

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