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Research paper

Rectenna circuit at 6.13 GHz to operate the sensor devices

Anurag Saxena [1] *, V. K. Singh [1], Mohini, Sonam Bhardwaj [1], Gyoo-Soo Chae [2], Ashis Sharma [3], Akash Kumar Bhoi [4]

[1] Dept. of Electrical Engineering, SR Group of Institutions Jhansi, U.P. India
[2] Division of Information and Communication, Baekseok University, Cheonan, South Korea
[3] Sikkim Manipal Institute of Technology (SMIT), Sikkim Manipal University, India
[4] Department of Electrical & Electronics Engineering, Sikkim Manipal Institute of Technology (SMIT), Sikkim Manipal University, India
**Corresponding author E-mail: singhvinod34@gmail.com*

Abstract

There are various types of transmission through wire and wireless but wireless power transmission is the transmission of electrical energy without using any conductor or lead. At resonant frequency, 6.13 GHz wearable antenna is fabricated and tested. For making wearable an-tenna, textile material (substrate) i.e. Jeans is used for the simulation having dielectric constant 1.7. At the places where it is hard to transmit energy, wearable antenna is best suitable for this purpose, but before doing this RF is converted into DC with the help of the rectifier. Vari-ous types of graph in this paper are shown in the comparison between the power and efficiency. For simulating and design purpose of an-tenna CST, software is used. Implementation of antenna with rectifier circuit is known as rectenna and the rectenna circuit can be designed in Pspice software.

Keywords: *CST Software; Rectenna; Pspice Software and Jeans*

1. Introduction

William C Brown was the first US electrical Engineer who invents rectenna in 1964 which was patented in 1969 [1-2]. In the last few years, the requirement of power consumption has been raised which increase the necessity of alternate energy source. Different type of energy sources such as thermal, wind, solar, and RF energy is available. This paper deals with the harvesting of RF energy using textile antenna [3-4]. The process of collecting energy from the environment in order to convert it into usable electrical energy is called energy harvesting. This technology of wireless energy transfer changes the way of supplying energy and create a great interest as this allow low power wireless devices to run with low preservation for long periods of time [5]. A very low power miniature device is available with variable impedance and variable output power source because of the portability of receiving devices [6-8]. FM/AM radio signals, Wi-Fi, wireless LANs and broadcasting television signal are the source of RF energy available in surrounding from which RF energy is collected by a receiving antenna and it is converted into measurable DC voltage [9-11].

2. Rectenna designs

2.1. Dual band wearable antenna

CST software is used for the simulation of this anticipated textile antenna. By using slotting technique, a textile antenna is simulated on textile material. The dielectric material is used in textile antenna which plays a crucial role in rectenna design. Basically, the design of rectenna circuit is divided into three elements, namely antenna, matching network and rectifier circuit. Each microstrip antenna has a patch of metal foil of various shapes which are fabricated on the surface of the textile with a ground metal foil on the other side of the textile. A foil of feed line is usually connected between antenna and receiver. Common ground is shared by both patch antenna and rectifying circuit which are located on different layer. This rectenna has two main functional parts. One part of rectenna circuit is to receive the RF energy and the second part for rectification of AC energy. Figure 1 shows the geometry of proposed antenna and Table 1 shows the dimension of proposed antenna.

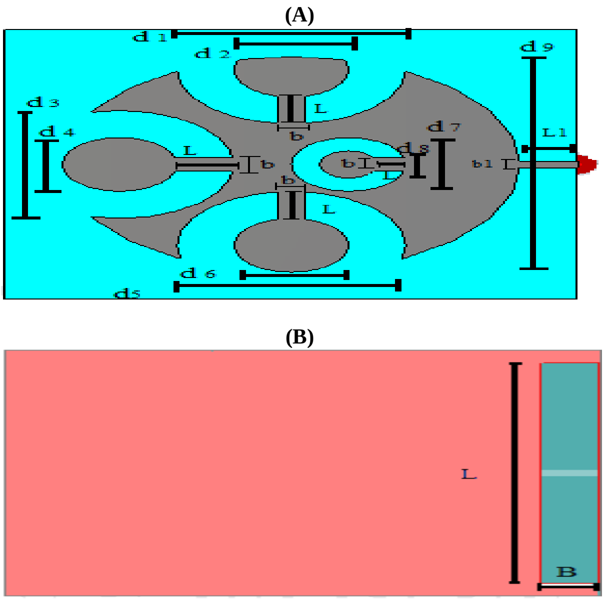

Fig. 1: Textile Antenna Geometry of Front View (A) and Ground Plane (B).

Table 1: Dimension of Proposed Textile Antenna

S. No.	Antenna Parameter	Values
1.	Ground Length(L)	18 mm
2.	Ground Breadth (B)	2 mm
3.	Substrate Dimension	20 mm x 20 mm
4.	Substrate Height	1 mm
5.	Patch Large Circle Diameter (d_9)	16 mm
6.	Patch Smaller Circle Inner Diameter (d_2,d_4,d_6)	4 mm
7.	Patch Smaller Circle Outer Diameter (d_1,d_3,d_5)	8 mm
8.	Patch Middle Circle Inner Diameter (d_8)	2 mm
9.	Patch Middle Circle Outer Diameter (d_7)	4 mm
10.	Main Strip Line	3 mm x 1 mm

2.2. Rectification circuit

In this section, a first order low pass filter is designed in rectenna for impedance matching between textile antenna and diode. In rectifier circuit P-N junction diode is used for the rectification but in rectenna circuit schottky diode is used for rectification with low threshold voltage of 150 mV. Matching is essential in the circuit otherwise efficiency will reduce. After generating DC signal from signal L-C filter is used for removing ripples (AC Component) in the DC output. First order low pass filter is used for this purpose. In L-C filter, the values of inductor and capacitor can be generated by MATLAB software through resonant frequency 6.13 GHz. Also the rectenna circuit can be designed in Pspice software as shown in figure 2. The values of element at 6.13 GHz frequency are L_1 = 5.65128 nH, C_1 = 0.113026 pF, L_2 = 5.94872 nH and C_2 = 0.118974 pF.

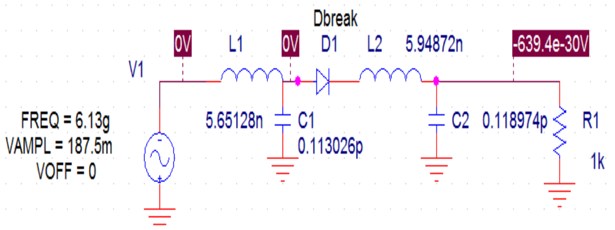

Fig. 2: Half Wave Diode Rectifier Circuit on Pspice Software.

3. Result and discussion

The simulated graph of return loss and frequency at resonant frequency 6.13 GHz is shown in Figure 3, which has only single band having better bandwidth. After receiving the RF power from designed Textile antenna, Radio frequency is converted into DC Signal through rectenna circuit. For the calculation of Input power or power density we use the equation given below which consists the transmitting power of antenna i.e. P_t = 100 W, transmitting gain G_t = 11dBi and the distance between the rectenna circuit from designed textile antenna R = 1 m.

$$P_D = (P_t * G_t)/4*3.14*R^2$$

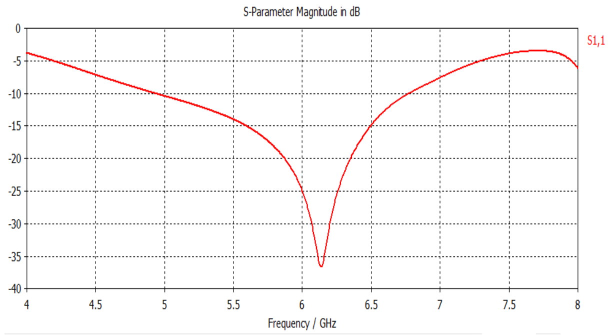

Fig. 3: Return Loss vs. Frequency Plot of Proposed Textile Antenna.

Figure 4 and Figure 5 shows the output current and output voltage at load resistance of rectenna i.e. 1 K ohm through Pspice software. The output DC voltage (VoutDC) and overall efficiency η_{EH} of the rectenna against power density are calculated by equation (1).

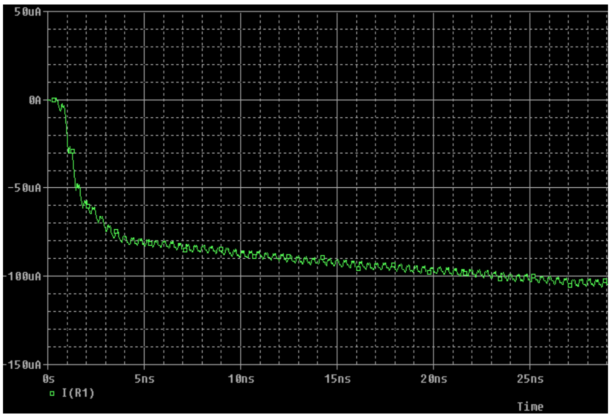

Fig. 4: Output Current at Load 1 Kohm.

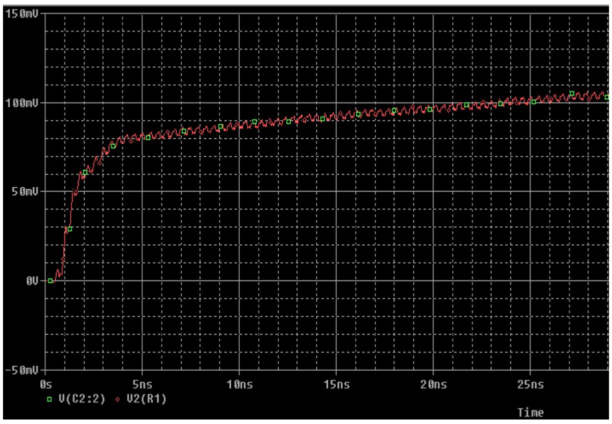

Fig. 5: Output Voltage at Load 1 K Ohm.

$$\eta_{EH} = P_{outDC}/P_{RX} = (V^2_{outDC}/R_L)/P_{RX} \quad (1)$$

4. Conclusion

Wireless power transmission can be done by the simulated textile antenna have resonant frequencies 6.13 GHz which having input power converted into DC power with the help of rectenna circuit. Antenna is designed in CST Software by Textile Jeans material which easily wearable. The directivity of proposed antenna at 6.13 GHz is 2.606 dBi. Also the main lobe magnitude at 6.13 GHz is 2.4 dBi. The overall efficiency of rectenna circuit has around 60%.

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