International Journal of Engineering & Technology, 7 (2.33) (2018) 647-649

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Power harvesting through flexible rectenna at dual resonant frequency for low power devices

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Abstract

In Wireless power transmission, the transmission of electrical energy can be done without using any conductor or lead. After the simulation of wearable antenna, two resonant frequencies are obtained, i.e. 9.94 GHz and 7.35 GHz. For the designing of antenna, instead of using glass epoxy material, textile material is used having dielectric constant 1.7. The places where it is difficult to transfer the electrical energy, textile antenna is useful in those places. Ambient radio frequency can be converted in DC signal through the rectifier. All the graphs related to rectenna, such as return loss, output voltage and current at load are presented in this paper. Textile antenna for energy harvesting is de-signed in CST software and further rectenna circuit can be designed in Pspice Software.

Keywords: *Textile; Pspice Software; Rectenna Circuit and CST Software.*

1. Introduction

The electrical energy is obtained through textile antenna to operate the sensors and charging the battery by using number antennas [1]. It requires some amount of energy can be gathered from the antenna, to operate the small devices without taking energy from supply or battery [2-3]. The receiving energy is depends upon the changes in environment and also on the mobility of receiving devices [4]. To set up the particular process between the harvesting circuit and electronic usage, such as (sensor and operate the less power consumable device) the better management should be required [5]. There is a basic need to get the max power output with proper management [6-9].

2. Rectenna designs

2.1. Dual band wearable antenna

On behalf of this paper, the textile antenna is simulated by using microstrip technique. These type of antenna are generally used in very small frequencies says the microwave frequency. To determine the construction of the antenna there are two metallic foils are joined by using textile substrate. The upper foil is named as patch, where the multiple types of patches are jointed together. On the other side of the substrate the metallic foil is cut in a particular manner which named as a ground. To construct the antenna, the textile antenna is connected with either transmitter or receiver through (foiled) microstrip lines. In the case of transmitter the radio frequency current is applied and in the case of receiver the received signal is produced between the antenna and ground plane. This type of antenna is becoming popular in recent decades because these are also mounted on the consumer product. The simulation of this textile antenna is made by using CST studio, which is shown in Fig 1 & Fig 2 and the parameter of the design is given below in the table 1.

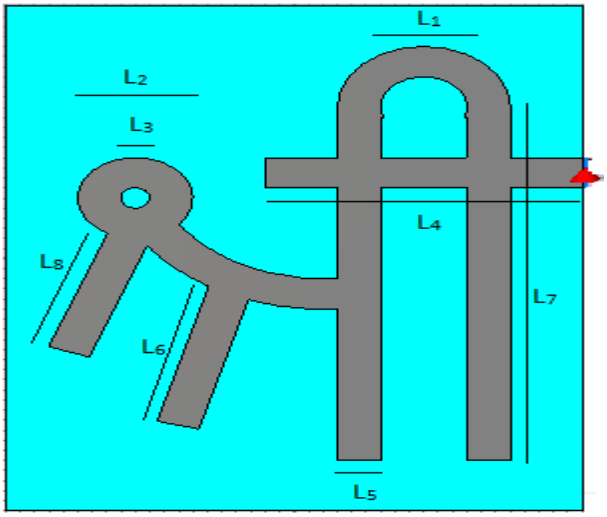


Fig. 1: Front View of Proposed Antenna Geometry.

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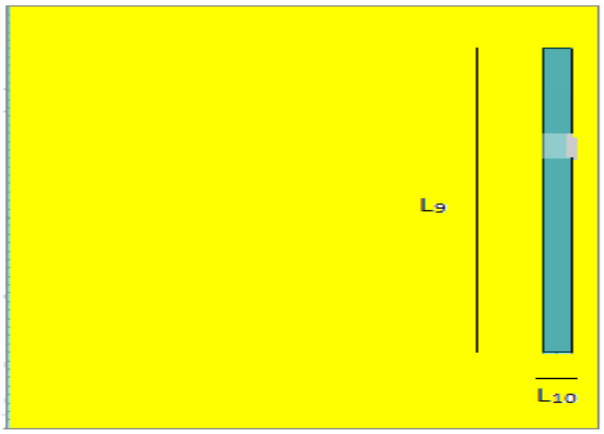


Fig. 2: Ground Plane of Proposed Antenna Geometry.

Table 1: Dimension of Proposed Textile Antenna

S. No.	Antenna Parameter	Values
1.	Relative permittivity (ε_r)	1.7
2.	Substrate thickness (h)	1 mm
3.	Ground Plane Dimension	36 x 2 mm
4.	Substrate Height	1 mm
5.	Semi-Circle Diameter (L_1)	6 mm
6.	Vertical Rectangle (L_4)	18 mm
7.	Horizontal Rectangle (L_7)	35 mm
8.	L_7 x L_5	35 x 3 mm

2.2. Rectification circuit

By using second order low pass filter a rectifying circuit with textile antenna is designed which is used for impedance matching between the Schottky diode and antenna. It is essential to get power with improved harvesting efficiency; to get maximum efficiency, the impedance should be matched. So the Schottky diode is used which have the threshold value 150 mV. The input side impedance of the Schottky diode is depending on the radio frequency power (RF Power).

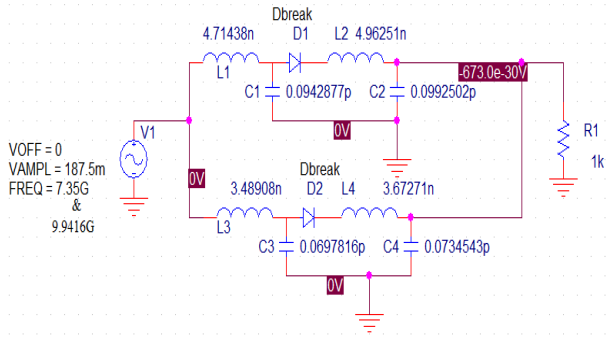


Fig. 3: Schottky Diode Rectifier Circuit.

For the dual band frequency L & C filter element are calculated with the separation. The proposed low power rectenna electrical circuit is shown in Fig 3.
The circuit elements for 7.35 GHz and 9.94 GHz are L_1 = 4.71438 nH, C_1 = 0.0942877 pF, L_2 = 4.96251 nH, C_2 = 0.0992502 pF, L_3 = 3.48908 nH, C_3 =0.067816 pF, L_4 = 3.67271 nH and C_4 = 0.0734543 pF.

3. Result and discussion

Fig 4 shows the return loss Vs frequency graph in which there are two bands at two resonant frequencies 7.35 and 9.94 GHz. The rectenna circuit converts the RF power into DC power. The distance between the textile antenna and the rectenna circuit is 1m having gain of 11 dBi. The textile antenna transmits the power of 100 W. Through the equation given below we can calculate the Power density or the input power at the rectenna circuit.

$$P_D = (P_t * G_t)/4 * 3.14 * R^2 \quad (1)$$

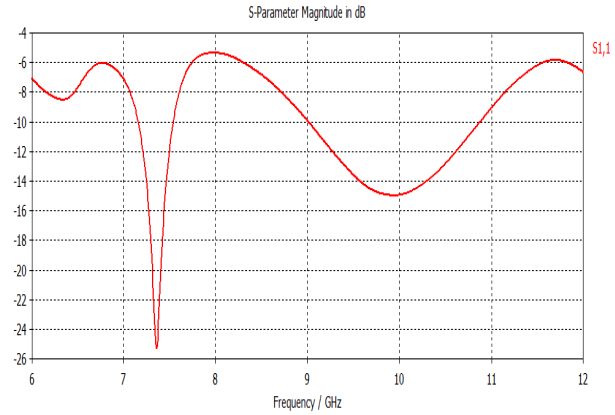


Fig. 4: Return Loss vs. Frequency Plot of Proposed Textile Antenna.

Fig 5 and Fig 6 shows simulated results using Pspice software in which it can be calculated the value of output current and output voltage at load resistance of 1 K ohm. The overall efficiency η_{EH} of the rectenna circuit against power density are calculated by equation (2).

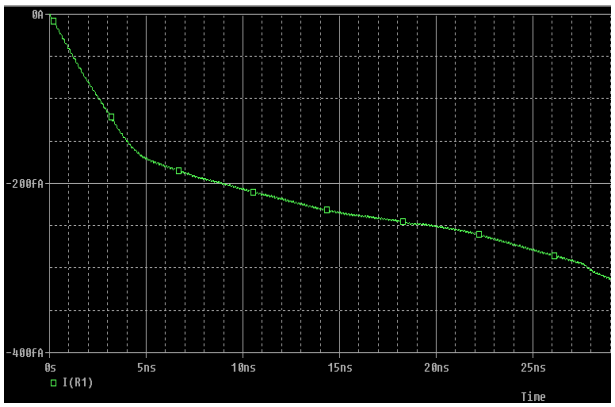


Fig. 5: Output Current at Rectenna Load.

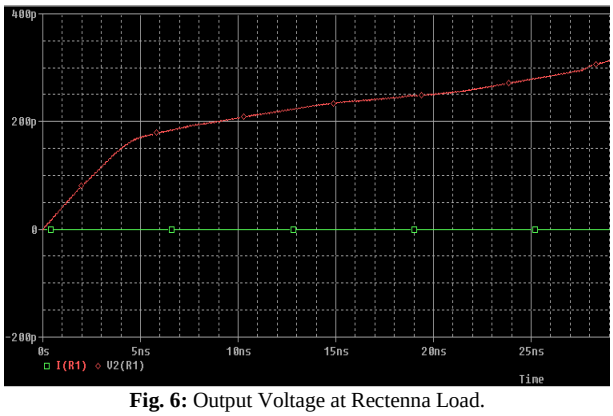


Fig. 6: Output Voltage at Rectenna Load.

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

4. Conclusion

The rectenna circuit is designed at two resonant frequencies 7.35 GHz and 9.94 GHz. This article explains the construction of the textile antenna on CST software further lead to the retina circuit having dual band. The output directivity of the textile antenna at 7.357 GHz and 9.9416 GHz resonant frequencies is 6.229 dBi and 5.229 dBi.

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