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Research paper

Rectenna design for electromagnetic energy harvesting and wireless power transfer

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Abstract

Under this article,an antenna with rectifier circuit is intended and simulated to energize the wireless feeler systems at resonant fre-quency 5.3838 GHz. The antenna substrate is prepared with textile material. The dielectric constant of material is 1.7.The rectenna circuit has been simulated on the Jeans substance and examined for power level -5dBm. The presented antenna has a gain of 4.861 dBi. The antici-pated antenna is designed with CST software. The value of L and C are calculated from MATLAB programming.

Keywords: *Rectenna Circuit; CST Software; Pspice Software; Wireless Power Transmission; Antenna.*

1. Introduction

Over the past several years, with the increase of technology various technology related to wireless systems have been developed and working in the region. The vital examples of wireless system are cellular mobile radio and Wi-Fi systems which are commonly available everywhere[1-4]. Most capable techniques to gather the wireless energy is to utilize a rectenna which is a mixture of a rectifier and an antenna. The antenna received the wireless energy further connected to rectifying diode in which filters are connected for removing the ripples. The rectifying diode converts the collected wireless RF into DC. The low-pass filter will used for obstruct the harmonics caused by the diode in order to attain high-energy conversion efficiency, which is the most vital constraint of such a gadget [5-7]. The block diagram of rectenna circuit is given in figure 1. There are two genuine advantages for rectenna such as the life span of the rectenna is almost limitless and it does not need substitution. Secondly it is green for the surroundings.

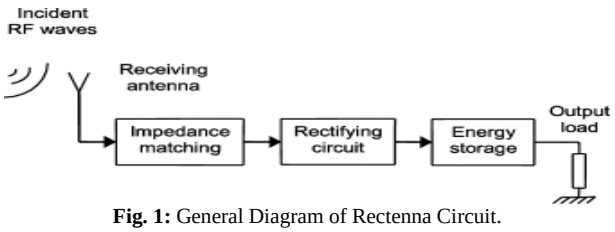


Fig. 1: General Diagram of Rectenna Circuit.

2. Rectenna designs

2.1. Wearable antenna

The simulation of textile antenna was intended in CST software. Table.1 shows the various dimensions of presented textile antenna. The designed antenna obtains the RF power at 5.3838 GHz resonant frequency which is used for rectification with the help of matching circuit. The matching circuit consists of inductors & capacitors which values are calculated with the MATLAB programming.

$$r = \frac{87.94}{fr\sqrt{\varepsilon_r}} \quad (1)$$

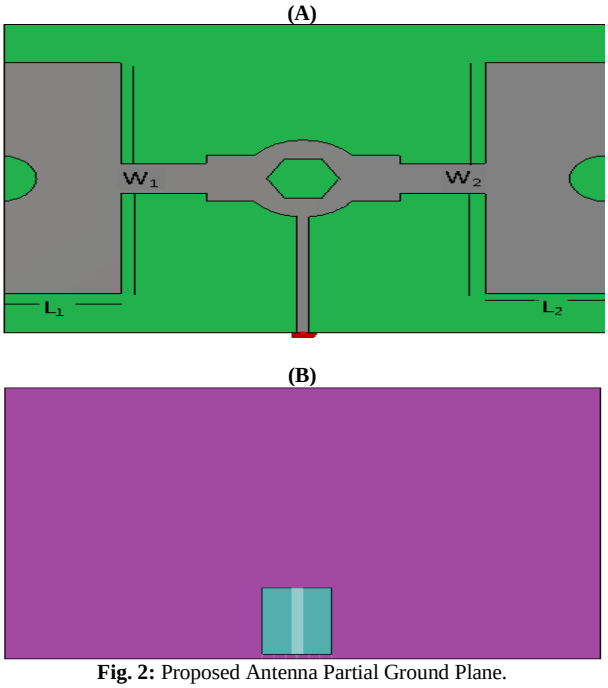


Fig. 2: Proposed Antenna Partial Ground Plane.

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Table 1: Antenna Parameters

Antenna Parameters	Values
Substrate Thickness(h)	1
Relative Permittivity(ε_r)	1.7
Pentagon diameter[mm]	3
Center circle[mm]	5
Rectangle width[mm]	10
Rectangle length[mm]	30
Vertical rectangle[mm]	16×6
Ground Area	6×10

2.2. Circuit for rectification

An impedance matching between Schottky diode and antenna ensures the development of rectification circuit which uses first order low pass filter with the help of Pspice software. The Schottky diode's impedance depends on radio frequency power which has threshold voltage of 150 mV.

3. Result and discussion

The reflection coefficient with frequency plot is achieved from CST software which shows minimum return loss. The 3-D plot of receiver antenna is given below in figure 3 and 4 which shows the directivity of 4.861dBi. Figure 5 shows rectifying circuit. For the single band frequency L & C filter element are calculated with MATLAB programming. The circuit element for 5.3838 GHz are L_1=6.44285 nH, C_1=5.3 pF, L_2=6.78195 nH, and C_2=50pF.
Figure 6 and Figure 7 shows the graph of output current and output voltage at load.

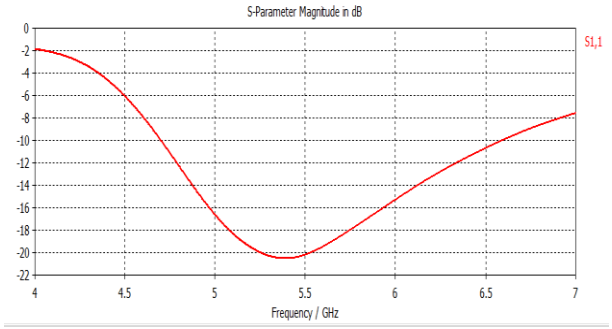


Fig. 3: Return Loss vs Frequency Plot of Proposed Antenna.

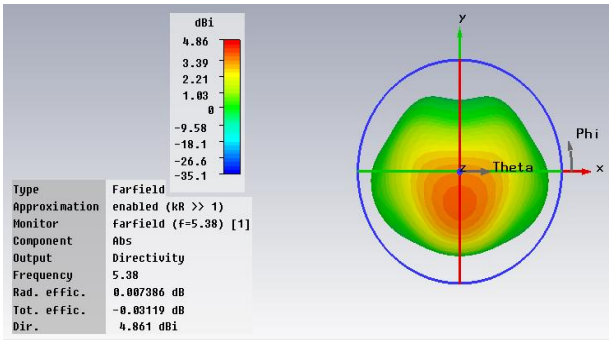


Fig. 4: 3-D Radiation Pattern Showing Directivity of Proposed Receiver Antenna.

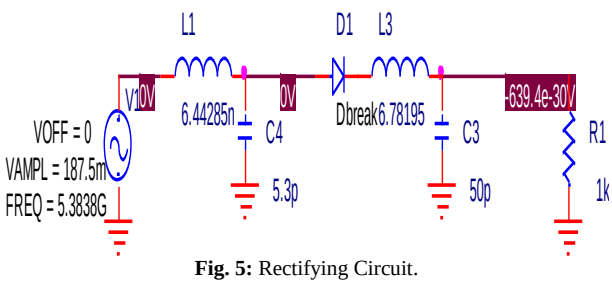


Fig. 5: Rectifying Circuit.

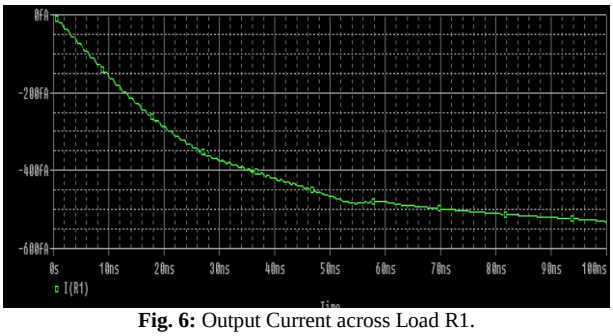


Fig. 6: Output Current across Load R1.

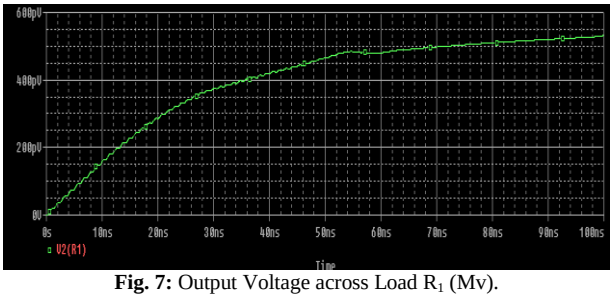


Fig. 7: Output Voltage across Load R_1 (Mv).

4. Conclusion

An energy harvesting system efficient in converting a low energy radio wave into a working DC voltage has been offered, with superior conversion efficiency at very low occurrence power levels, analogous to those available at a span of several tens of meters in an urban area. The rectenna circuit is intended to receive the RF power at a resonant frequency of 5.3838 GHz. The received radio wave power is further transformed into DC power using schokkty diode & matching circuit.

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