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Low Profile HMSIW Rectenna for Energy Harvesting

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Abstract— Widespread use of electronic circuits for various applications will increase the power demand in future. One of the solution for this problem is to get a power from Wi-Fi which most commonly uses the 2.4GHz and 5GHz ISM radio bands. In thispaper the antenna is designed for 2.4 GHz when combined to rectifier forms the rectenna which will convert the RF energy from WiFi hotspot to DC. Initially half mode substrate integrated waveguide(HMSIW) antenna is designed for 2.45GHz using dumbbell shape resonator embedded with open loop resonator integrated with one side vias. Coplanar waveguide(CPW) feed is used to give the input to the antenna. Then the rectenna can be designed by combining antenna with rectifier. The rectifier gendrally consists of silicon Schottky diode and matching network. This antenna model is simulated using ADS software. The designed rectenna is having the good return loss of nearly 20dB at 2.5GHz and 5.75GHz and the size of the antenna is 10mm x 16mm which is 50% reduction in size compared to conventional layouts.

Keywords— WiFi hotspot; substrate integrated waveguide; rectenna; Schottky diode.

I. INTRODUCTION

It is understandable that the whole world is in pursuit of developing ways to meet their energy needs, this particular issue is more relevant and challenging for emerging economies such as India, China, South Africa etc. because of the fact that the scale of interventions needed are of higher order.

Since then, considerable research has been conducted on rectenna for various applications. In the 1970s, P. E. Glaser proposed the idea of wireless power transmission(WPT) [1]. Since 2001 NASA undergoing many programs to make solar power satellite(SPS) a maturing technology [2]. These programs focus on finding high level techniques that helps the forthcoming SPS systems [3]. In 2002 WPT at dual frequency using coupling method was presented [4]. Till 2011 rectenna was developed relating significance in WPT [5]. The rectenna consist of antenna and a rectifier consisting of diode for the purpose of rectification. Where more than one rectifier makes the antenna to operate at dual bands. In the year 2012 safe and reliable WPT [6] and in 2014 the different types of energy harvesting in EM waves were studied [7].

In this paper the antenna is designed by incorporating the HMSIW technology. The structure of the HMSIW is similar to that of the SIW, but with the waveguide width half of conventional SIWs. Wi-Fi commonly uses ISM radio band having no physical connections, it is more vulnerable to attack than wired connections, such as Ethernet.

I. DESIGN OF HMSIW ANTENNA

A. Design of Cross Dumbbell Shape Resonator

The dumbbell shape resonator consists of high impedance line connected with low impedance line at both ends. Basically it is a stepped impedance resonator with low pass characteristics. In this design two dumbbell shape resonator are cross coupled to resonate at a particular frequency is shown in Fig. 1 consisting of vertical and horizontal dumbbell cross section each consist of vertical and horizontal line.

The dimensions of the cross dumbbell shape resonator are L1=8.161mm, L2=9.713mm, L3=4.391mm, L4=0.803mm, L5=2.649mm, L6=3.669mm, L7=0.999mm, L8=5.413mm, L9=1.194mm and L10=0.326mm. The length and width of the transmission lines can be optimized to tune a particular frequency.

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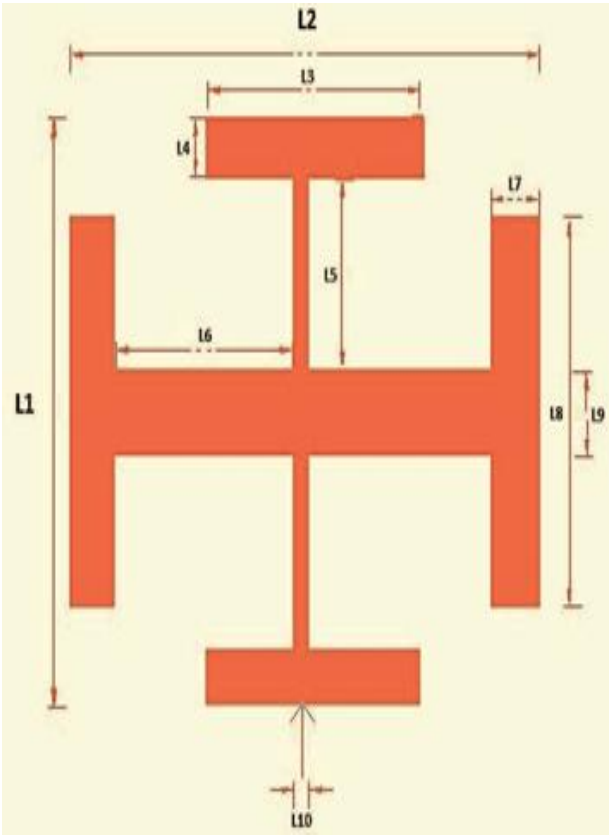
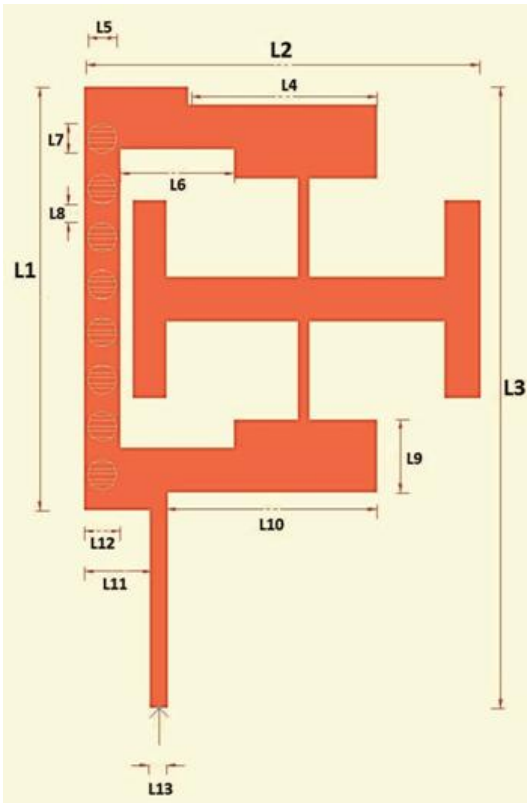


Fig. 1. Layout of cross dumbbell shape resonator

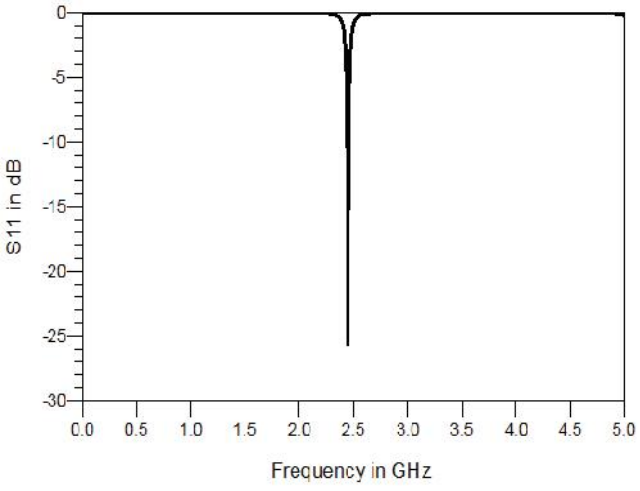
B. Design of HMSIWantenna

The substrate integrated waveguide (SIW) is a low cost realization of the traditional waveguide. The HMSIW antenna is designed by embedding cross dumbbell shape resonator with open loop resonator as shown in Fig.2(a).

In this design one side of the open loop resonator integrated with series of eight number of vias to introduce HMSIW characteristics which will give the size reduction and increase in return loss in antenna, which is designed by selecting the vias dimension and spacing between vias are 0.800mm(L7) and 0.500mm(L8) respectively. The open loop resonator dimensions are L1=11.600mm, L2=11.026mm, L3=17.010mm, L4=5.200mm, L5=0.800mm, L6=3.200mm, L9=2.000mm, L10=5.900mm, L11=1.900mm, L12=1.000mm and L13=0.500mm. The dumbbell shape resonator dimensions are similar to that of dimensions used in Fig. 1. By choosing the proper via dimension and gap between via the operating frequency is made to resonate at 2.45GHz with good return loss of 26dB which is shown in Fig. 2(b). The designed antenna is optimized for 2.45GHz frequency which is very narrowband is suitable for the application.



(a)



(b)

Fig. 2. Layout of HMSIW antenna (a) and its simulated S11 result (b).

A comparison of various papers on the various application is shown in Table I. Where the overall dimension of the antennas are large when compared to the proposed HMSIW antenna.

Therefore, the proposed HMSIW antenna is very compact when compared to other antenna size. A size reduction of greater than 50% is achieved by using the HMSIW technology.

TABLE. I Comparison of overall dimension of the proposed antenna and other antenna types

Title	Frequency with return loss	Size
Proposed Low Profile HMSIW Rectenna for Wireless Power Transmission	2.45GHz with return loss of 26dB	11 x 17mm
Design Analysis of an Electromagnetic Band Gap Microstrip Antenna, 2011	2.45GHz with return loss >10dB	34.5 x 34.5mm
Design of Stacked Microstrip Dual- band Circular Polarized Antenna, 2012	2.45GHz and 5.8GHzwithreturn loss>10dB	60 x 60mm
Dual-band Transparent Antenna for ISM Band Applications, 2013	2.45GHz and 5.8GHzwithreturn loss>10dB	60 x 60mm
Swastika Shaped Microstrip Patch Antenna for ISM Band Applications, 2015	2.45GHz with return loss >10dB	29.95 x 38.13mm
Microstrip Patch Antenna for ISM Band Applications, 2015	2.45GHz with return loss >10dB	30.14 x 39.92mm

II. CONCLUSION

In this paper, the performance of a HMSIW antenna has been presented. The antenna operates well at return loss of -30dB at 2.45GHz and the size is 46mm x 18.5mm which is very compact compared to other design. The narrow band and good return loss of the antenna is achieved by proper matching.

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