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DUAL BAND RECTANGULAR DIELECTRIC RESONATOR ANTENNA FOR WLAN APPLICATION

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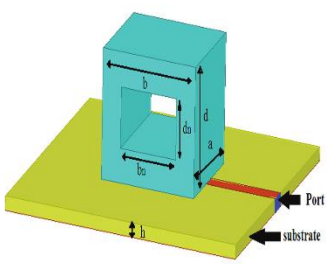
Graphical abstract



Abstract

A compact dual band ring shape rectangular dielectric resonator antenna (RRDRA) to operate at 2.4 GHz and 5 GHZ WLAN application is proposed. In this design the dielectric resonator is fed by modified 50Ω trapezoidal micro strip line situated on top of the FR4 substrate. The simulated and measured impedance bandwidth achieved at 2.4 GHZ is 12.42% (2.3149-2.6132) and 12.9% (2.21-2.52) respectively; whilst for 5 GHZ at 13% (5.1795-5.8914) and 13.2% (5.08-5.81) for S11<-10 dB. And the gain of the proposed antenna is 4.9dBi and 5.9 dBi at 2.4 GHz 5GHZ respectively. Results are simulated using Ansoft High frequency structural simulator (HFSS) for the study of impedance bandwidth, return loss, radiation pattern and antenna gain. Furthermore the antenna has been fabricated and tested. The measured characteristics of the proposed antenna are in good agreement with the simulated results.

Keywords: Dielectric resonator (DR), ring slot resonator, trapezoidal feed, WLAN.

1.0 INTRODUCTION

At present modern world, wireless communication has been part of human life; Wi-Fi, WiMAX, LTE, etc., are different forms of wireless systems, each system operating at different frequencies.

In these systems wireless local area network (WLAN) is one of the most important applications in our daily life at present day technology. The demand for WLAN application has been increased rapidly for this past few years. Wireless LAN has different frequency channels, mostly 2.4 GHz and 5 GHz is used is recommended world-wide. Today, dual-band systems are commonly found in the modern wireless communications, these features motivating the study of the dual band DRA.

Dielectric resonator antenna (DRA's) was first proposed in 1993, DRA's have many unique and attractive properties, viz., low profile, high gain, compact size and conformable of mounting structure, respectively [1]. Which increases the demand for its rapid application in the past two decades. Mostly, DRA's are made up of non-metalized high permittivity ceramic materials, with dielectric constant εrd>20 [2]. DRA's are generally more complex and costly compare to the traditional Microstrip antennas; nevertheless performance vice DRA's may provide lot of solutions not offered by other radiating elements.

At present there are different dielectric resonator shapes available, with the most popular shapes being cylindrical [3], hemispherical [4] and rectangular [5]. Among those shapes rectangular dielectric resonator antennas (RDRA) provide greater amount of flexibility in terms of (length, width and height) to the designers to achieve the desired profile and bandwidth characteristics compare to other two shapes [5-6].

DRA's are specifically designed for wide bandwidth. In addition dual bands can also be achieved through some simple modification in DRA's like, merging two different permittivity DRA's (stack DRA,s) [7] and introducing air gap into the DRA's [8]. Among those techniques Stack resonators are difficult to fabricate due to the merging of two different permittivity dielectric resonators. In this paper a rectangular ring shape notch is introduced in the center of the rectangular dielectric resonator to achieve the dual band system.

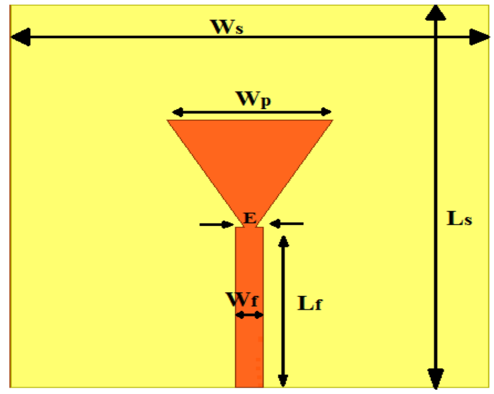
Furthermore various type of feed can be employed to excite DRA's. The Feeding techniques like, Microstrip feed line, coaxial probe, aperture coupling, coplanar waveguide and DRA loaded with Microstrip patch (Hybrid DRA) [9]. In this design rectangular ring dielectric resonator (RRDRA) load with modified trapezoidal patch feed [10] through 50Ω Microstrip line to achieve dual band system is introduced.

The configuration of the proposed antenna structures are presented in the Section II. Section III presents the design guidelines and parametric study of the proposed antenna. Simulation and experimental results are discussed in Section IV. Finally, a conclusion is given in section V.

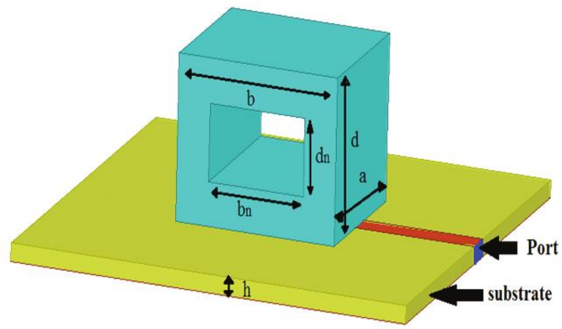
2.0 ANTENNA CONFIGURATION

The geometry of the proposed rectangular ring dielectric resonator antenna of size 50(L) ×50(W) ×1.6(h) mm3is illustrated in Figure 1, indicating both without and with DRA's view .This design consist of two important elements first modified trapezoidal Microstrip patch with 50 Ω rectangular feed line is printed on top of the FR4 epoxy substrate with the relative permittivity of ε_{rs}=4.6. The modified feed structure is achieved by uniting the 17.3 (Wp) mm triangular patch with 50Ω rectangular Microstrip transmission line.

The antenna is designed by using fully ground plane is printed on bottom of the substrate. The second element rectangular ring dielectric resonator with a relative permittivity of ε_r =30 is situated on top of the trapezoidal Microstrip patch. The exact dimension of the optimized rectangular ring resonator, and Trapezoidal Microstrip patch are noted in Table1.



(a) Top viewwithout RRDR



(b) Side view with RRDR.

Figure 1 Configuration of the proposed antenna

Table 1 Antenna dimensions

Parameter	Value
W_S	50
L_S	50
W_f	2.9
L_f	21
W_P	17.3
h	1.6
E	1.15
d_n	7
a	18
b	20
d	15
b_n	12

2.1 Design Procedure And Parametric Study

The design process of proposed rectangular ring dielectric resonator includes three steps. A compact rectangular Dielectric resonator with the dimensions of 20(L) × 18(W) ×15(h) mm3 with many adjacent resonances is first select as reference antenna 1, and fed by simple 50Ω rectangular Microstrip feed is shown in Figure 2 reference antenna 1. Figure 3 clearly shows the reflection coefficient of the reference antenna 1.

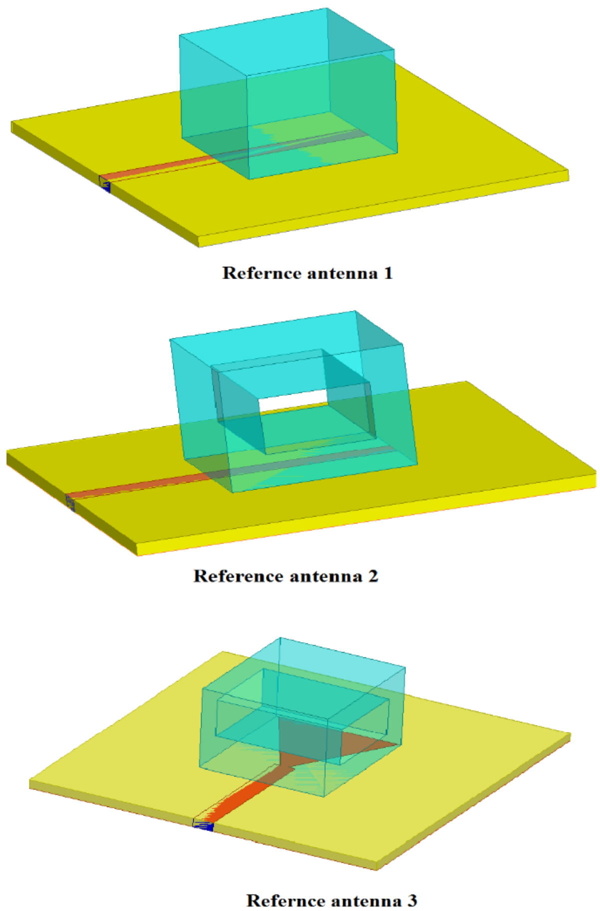


Figure 2 Geometry of the reference antennas

The resonance frequency of the reference antenna 1 is 4GHz. As the antenna is to be designed for WLAN application and also antenna need some transformation in order to achieve the desired scope of the design. Hence, reference antenna 2 presents a rectangular air gap is loaded on the RDRA, as shown in Figure 2 reference antenna 2.

The parametric study is obtained to optimize the rectangular air gap and finally 12(bn) × 7(dn) mm2 air gap is fixed. The scope of the dual band is achieved then furthermore to achieve good impedance matching in upper and lower frequency bands a modified trapezoidal Microstrip patch is introduced in the design.

The commercial 3-D full-wave electromagnetic (EM) simulation software Ansoft HFSS, based on the finite element method, is used for the antenna design.

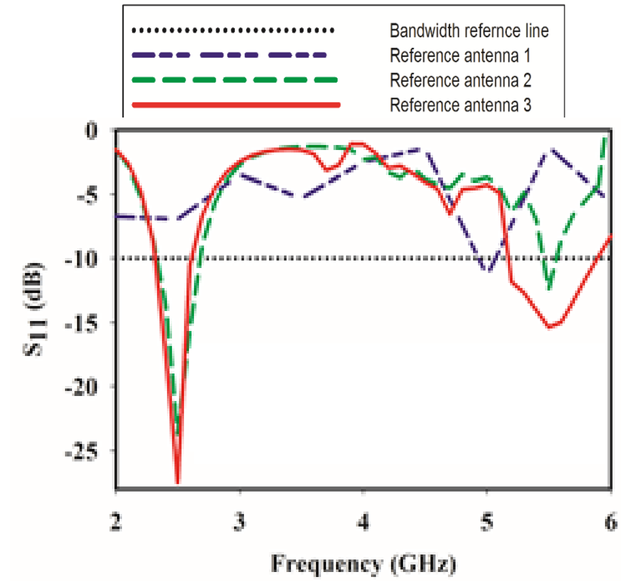


Figure 3 Simulated reflection coefficient of the reference antennas

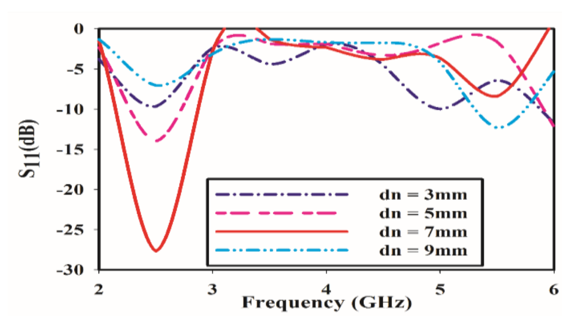


Figure 4 Parametric study between different values of dn

3.0 RESULTS AND DISCUSSION

After the design process and parametric study the proposed dual band rectangular dielectric resonator antenna has been obtained and fabricated. The prototype of the proposed antenna is shown in Figure 5.

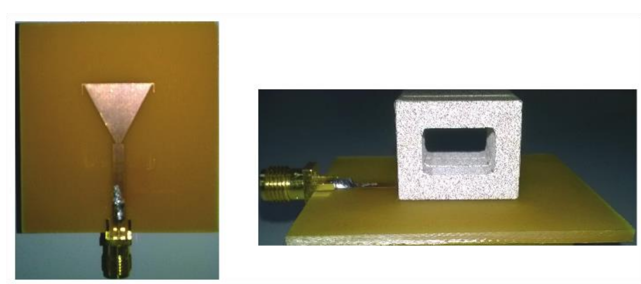


Figure 5 Prototype of the proposed antenna

The antenna is measured using vector network analyser. Figure 5 shows the comparison of the simulated and measured magnitude reflection coefficient |S11|. The simulated and measured impedance bandwidth achieved at 2.4 GHZ is 12.42% (2.3149-2.6132) and 12.9% (2.21-2.52) respectively; whilst for 5 GHZ at 13% (5.1795-5.8914) and 13.2% (5.08-5.81) for S11<-10dB, which covers the WLAN application bands. A good agreement is obtained between the measured and simulated results.

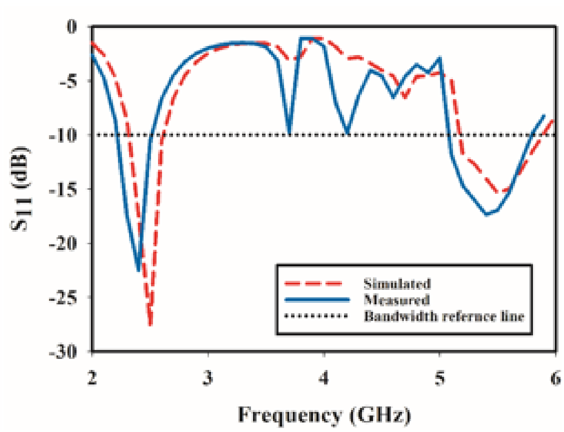


Figure 6 Simulated & Measured reflection coefficient of the proposed antennas

The parametric study is obtained to optimize the rectangular air gap and finally 12(bn) × 7(dn) mm2 air gap is fixed. The scope of the dual band is achieved then furthermore to achieve good impedance matching in upper and lower frequency bands a modified trapezoidal Microstrip patch is introduced in the design.

From the results there is some discrepancy between the simulated and measured results, this may be due to the effect of fabrication errors and the use of glue for pasting the DRA's.

The simulated electric and magnetic (E-plane and H-plane) far field radiation pattern of the proposed antenna at two different frequencies are illustrated in Figure 7 & 8. The normalized radiation pattern graph clearly shows the antenna works bore side at 2.4 GHz and 30°tilted at 5 GHz.

The proposed antenna gain at 2.4GHz and 5.2GHz frequencies are 4.9 dBi and 5.9 dBi respective. Figure 9 & 10 shows the 3-D radiation Patten of the proposed antenna.

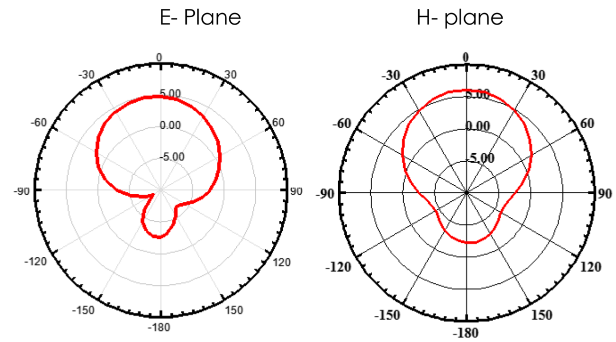


Figure 7 Simulated Radiation Patterns at 2.4 GHz

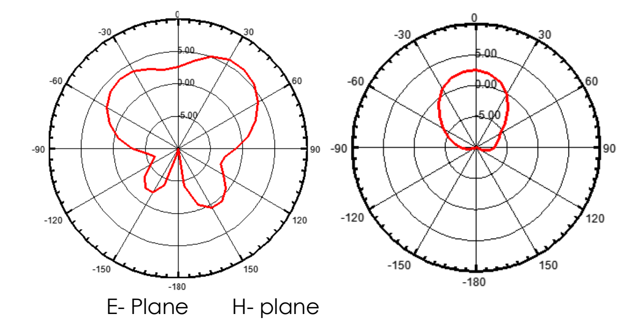


Figure 8 Simulated radiation patterns at 5 GHz

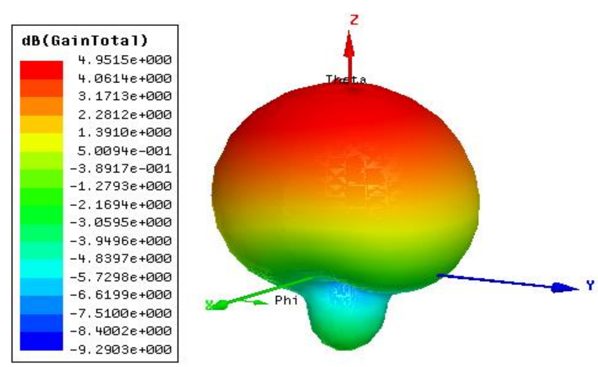


Figure 9 Simulated radiation patterns at 2.4 GHz

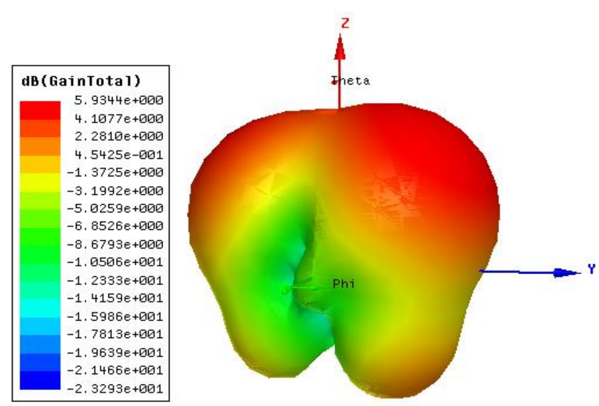


Figure 10 Simulated radiation patterns at 5 GHz

4.0 CONCLUSION

In this paper, a compact dual band rectangular ring dielectric resonator antenna has been presented. In this design, a modified 50Ω trapezoidal Microstrip feed and rectangular ring dielectric resonator has been employed. By using this design the antenna can support two wireless LAN application channels 2.4GHz and 5 GHz Simultaneously. The proposed antenna has been fabricated and tested, the good agreement between the measured and simulated (HFSS) results are presented. The presented simulated and measured results clearly show the proposed antenna has excellent characteristics and good candidates for wireless LAN applications; it is suitable for practical WLAN systems.

Acknowledgement

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