

Bandwidth Improvement of Rectangular Dielectric Resonator Antenna (RDRA)

Chaudhary Nikita¹ G. D. Makwana²

^{1,2}Sankalchand Patel College of Engineering, Visnagar, India

Abstract— This paper presents a design of ring type rectangular dielectric resonator antenna (RDRA), in bandwidth of 24% is described. The antenna consists of dielectric constant of 30 to obtain improved bandwidth of RDRA. A 50 Ω micro strip line is used in the proposed antenna as a feeding mechanism. Physical parameters of RDRA have been optimized by extensive simulations using Ansoft HFSS. The parameters of antenna are 15x4x2 mm³ with grounded substrate size: 50x50 mm². The proposed antenna is suitable for wireless local area networks (WLAN) applications in the frequency range 3.95-5.04 GHz. This Ring type RDRA exceeds the bandwidth requirements for WLAN applications. Parametric studies of the ring type RDRA is also presented.

Key words: Dielectric Resonator Antenna (DRA), HFSS 11, Rectangular DRA, and Micro strip Line feed

I. INTRODUCTION

Dielectric Resonator Antennas (DRA) possess some idiosyncratic properties which provide them very promising, especially for millimeter wave applications. DRAs can be designed with different shapes to accommodate various design requirements. DRAs can also be excited with different feeding methods, such as probes, microstrip lines, slots, and co-planar lines. As compared to the Micro strip antenna, the DRA has a much wider impedance bandwidth due to their many advantageous features. These include their compact size, light weight, the versatility in their shape and feeding mechanism, simple structure, easy fabrication and wide impedance bandwidth. Among the different shapes DRA, the rectangular DRA offers greater design flexibility. Fabrication is also simpler than the other shaped DRA. The ring DRA is a subclass of the rectangular DRA that offers increased impedance bandwidth performance.

Bandwidth improvement is becoming the major design considerations for most applications of Dielectric resonator antennas. There are many bandwidth improvement techniques have been reported on modified feed geometries and changing the shape of the DRA (including conical, tetrahedron, ring, triangular). Some advanced methods to achieve wide bandwidth are optimizing the feeding mechanism and the DRA parameters, use of parasitic coupling with different resonators & introduction of air gap between the ground plane and DR.

In this paper, improvement of bandwidth of the proposed ring type RDRA has been designed by removing the central portion of a rectangular DRA. As a result of which a ring RDRA is obtained. The ring dielectric resonator of the DRA is mounted on a vertical ground plane edge for broadband application. It is discussed that the introduction of air gaps between the dielectric resonator and the ground plane can improve the impedance bandwidth of the antenna significantly.

In RDRA micro strip feeding is used. With these features, this design of ring DRA is suitable for broadband wireless communication systems, as well for GPS systems.

II. ANTENNA DESIGN

A simple DRA and a ring RDRA for enhancing the bandwidth of the original DRA is schematically shown in Fig. 1. The proposed RDRA is of height (h_1) = 5mm, height (h_1) = 8.5 mm and relative permittivity (ϵ_r) = 30. The ring RDRA consists of the RDRA where a square section of height (h_2) = 2 mm has been removed. It is expected that by removing the centre portion of the RDRA, its bandwidth can be increased. The DRA is supported by Rogers RT 3010 substrate having dimension 50 \times 50 mm² ($L_s \times W$) with height (h_2) = 0.156 mm and dielectric constant (ϵ_r) = 2.2. Microstrip line feeding is there on the substrate shown in Fig. 1(b).

Here in fig. 1(a) shows single Rectangular Dielectric Resonator Antenna (RDRA) made up of Roger material having permittivity ϵ_r = 10.2 is presented. Figure shows the design for RDRA for length of micro strip line is 17 mm used. Simulated resonant frequency used is 2.4 GHz. And height d = 4.6mm, width a = 9.31mm, and length of 9.31mm.

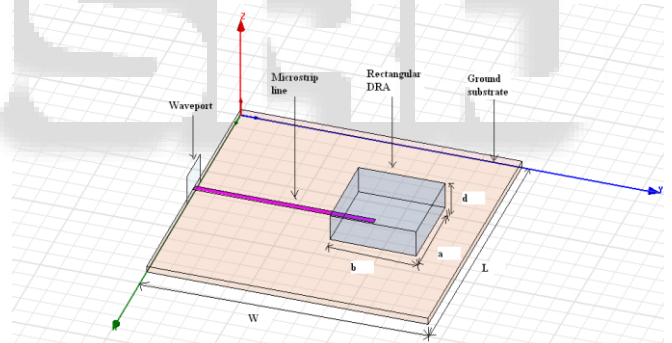


Fig. 1(a): single rectangular DRA geometry

New, in fig. 1(b) shows proposed ring type rectangular DRA made up of Roger material, having permittivity ϵ_r = 2.2. Design for ring type RDRA for length of micro strip line is 32 mm used. Simulated resonant frequency used is 10 GHz. Here length of DRA a_1 = 15 mm, height of DRA h_1 = 5 mm, length of air box a_2 = 4 mm and height h_2 = 2mm is given.

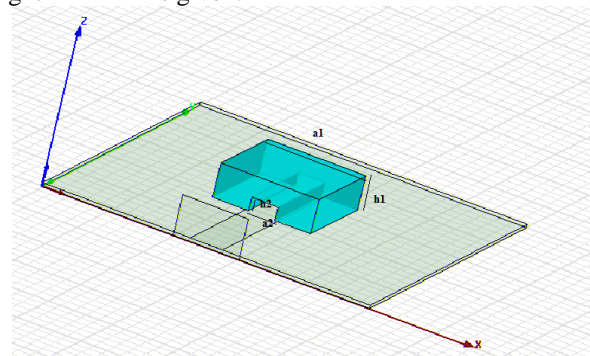


Fig. 1(b): proposed ring type RDRA geometry

The introduction of air box in rectangular DRA and ground is a simple method to enhance the bandwidth. There is generally an increase in the resonant frequency and a decrease in the Q- factor. The dimension of the ground plane is $50 \times 50 \text{ mm}^2$ ($W \times L_g$). As Microstrip line feeding offers the advantage of easy and cost-effective fabrication of DRA, so the proposed DRA is excited by microstrip line feeding shown in Fig. 1(c), which has dimensions $L_f = 32 \text{ mm}$, $W = 4.8 \text{ mm}$.

III. PARAMETRIC STUDY

As discussed in the previous section that a wide bandwidth can be achieved by modifying the basic shape of the DRA and also by introducing an air box in DRA. So the first design step was to modify the shape of a RDRA. By drilling out the centre portion from the RDRA, resulting in a wide impedance bandwidth. So to achieve optimum antenna performance, a parametric study is carried out by varying the parameters of air box as well by varying length of feeding line. Fig. 3 shows the simulated return loss for single RDRA and bandwidth improved RDRA. For the case, $L_f = 32 \text{ mm}$, a wide bandwidth with less return loss is observed.

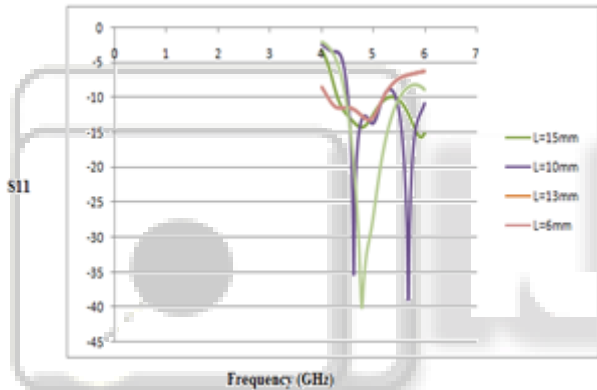


Fig. 2: S11 parameter vs. frequency for different parameters

L(mm)	S11(db)	Freq. Range(GHz)	BW (%)
6	-13.17	8.02-9.15	13
10	-35.29	5.02-6.34	23
13	-14.28	4.32-5.32	20
15	-47.25	3.96-5.04	24

Table 1: Different parameter study

IV. SIMULATION RESULTS & DISCUSSION

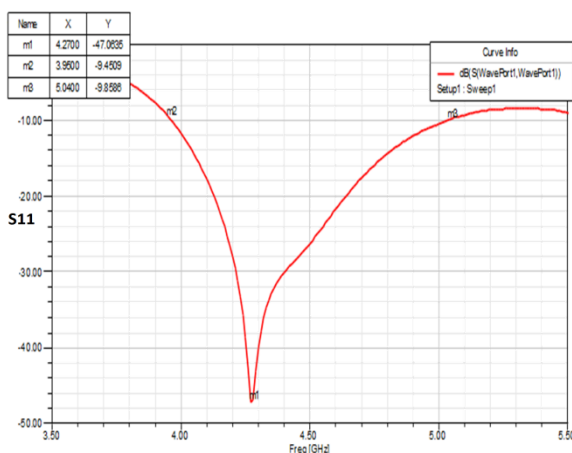


Fig. 3(a): S11 vs. frequency of ring RDRA

The proposed DRA is analyzed using ansoft HFSS 11. The simulated return loss of the ring RDRA plotted against frequency is shown in Fig. 2. An improvement of up to 24 % in impedance bandwidth can be seen from the return loss plot. As a result, the wide band achieves for $S_{11} > -10 \text{ dB}$ ranging from 3.95 GHz to 5.04 GHz.

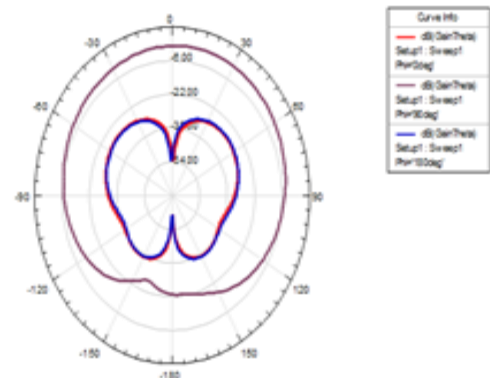


Fig. 3 (b): Simulated radiation pattern at 3.95 GHz of the antenna

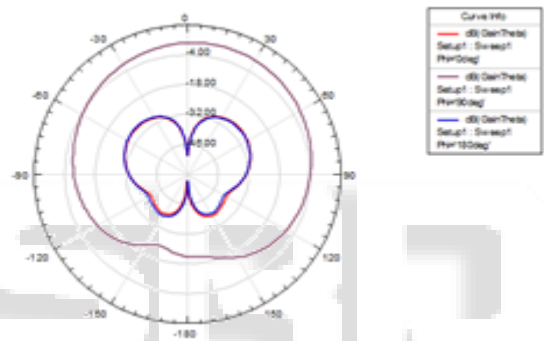


Fig. 3 (c): Simulated radiation patterns at 4.27 GHz of the antenna

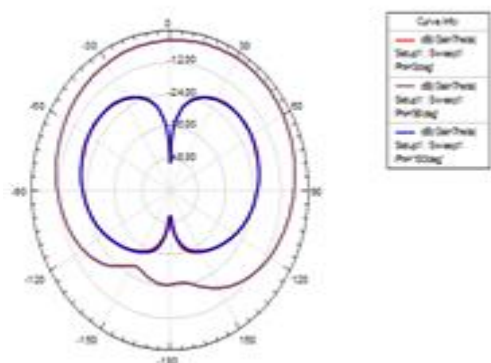


Fig. 3 (d): Simulated radiation pattern at 5.04 GHz of the antenna

V. CONCLUSION

A new ring dielectric resonator antenna is realized by drilling off the central portion of the RDRA. The ring DRA is mounted on a vertical ground plane edge for wireless applications. In this design, the impedance bandwidth of 24% ($S_{11} > -10\text{dB}$) is obtained as the band covers the range of frequency from 3.95 GHz to 5.04 GHz. Fabrication cost is reduced because of simple micro strip feeding. Considering these benefits, the antenna is proposed for

WLAN applications, Wi-Fi, cellular phones, and GPS systems.

REFERENCES

- [1] Alireza Motevasselian "Bandwidth Enhancement of Helix Excited Cylindrical Dielectric Resonator Antennas by Means of Stacking" Lough borough Antennas & Propagation Conference, 12-13 November 2012, Lough borough, UK.
- [2] Wee Fwen Hoon, Mohd Fareq Abd Male, Khairudi Mohd Juni Mohd Shaharom Idris "Enhancement of Antenna's Bandwidth With The Size Modification on Barium Strontium Titanate 130 Elements" IEEE International workshop, pp.214-244, 2012.
- [3] Sreenu Mudavath, Runa Kumari and S K Behera "A Compact CPW Fed Stacked cylindrical Dielectric Resonator Antenna for WLAN Applications" 2012 International conference on Computing, Electronics and Electrical Technologies [ICCEET], pp.818-820.
- [4] Runa Kumari, S. K. Behera "Ring Dielectric Resonator Antenna for bandwidth Application" 2010 International Conference on Computational Intelligence and Communication Networks, pp-7-10.
- [5] Runa Kumari, Kapil Parmar and S K Behera, "Conformal Patch Fed Stacked Triangular Dielectric Resonator Antenna for WLAN Applications" IEEE International conference, pp.104-107, 2010.
- [6] Mohamed M. Morsy, Muhammad R. Khan, and Frances J. Harackiewicz "Ultra Wideband Hybrid Dielectric Resonator Antenna (DRA) with Parasitic Ring", 2010, IEEE.
- [7] Raghvendra Kumar Chaudhary, Kumar Vaibhav Srivastava, Animesh Biswas, "An investigation on Three Element Multilayer Cylindrical Dielectric Resonator Antenna excited by a Coaxial Probe for Wideband Applications." 2010, IEEE.
- [8] Alef Z. Elsherbeni, Veysel Demir, "The finite-Difference Time-Domain Method for Electromagnetics with MATLAB Simulations" SCITECH Publication, INC.
- [9] Rajesh Kumar Mongia and Apisak Ittipiboon, "Theoretical and Experimental Investigations on Rectangular Dielectric Resonator Antennas", IEEE Trans. Antennas and Propagation, vol. 45, NO. 9, September 1997.
- [10] G. D. Makwana, Deepak Ghodgaonkar "Wideband Stacked Rectangular Dielectric Resonator Antenna at 5.2 GHz" International Journal of Electromagnetics and Applications 2012, 2(3): 41-45.