Wide-Band Rectangular Dielectric Resonator Antenna with Two Symmetrical Gaps

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ABSTRACT

In this paper, a very wide band rectangular dielectric resonator antenna is proposed using Alumina (Al2O3, εr = 9.8) as radiating element and fed by a simple network technique named the strip-fed method (probe + conducting strip). A new bandwidth enhancement method is presented, which provides a bandwidth enhancement of 29, 76%. As a result, the characteristics of a new wide band antenna operating at 2.765-5.047 GHz are presented, providing higher gain values (more than 9 dBi) and an impedance matching bandwidth of 58.43%.

Key words: Dielectric resonator antenna, Bandwidth enhancement method, Rectangular gaps.

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INTRODUCTION

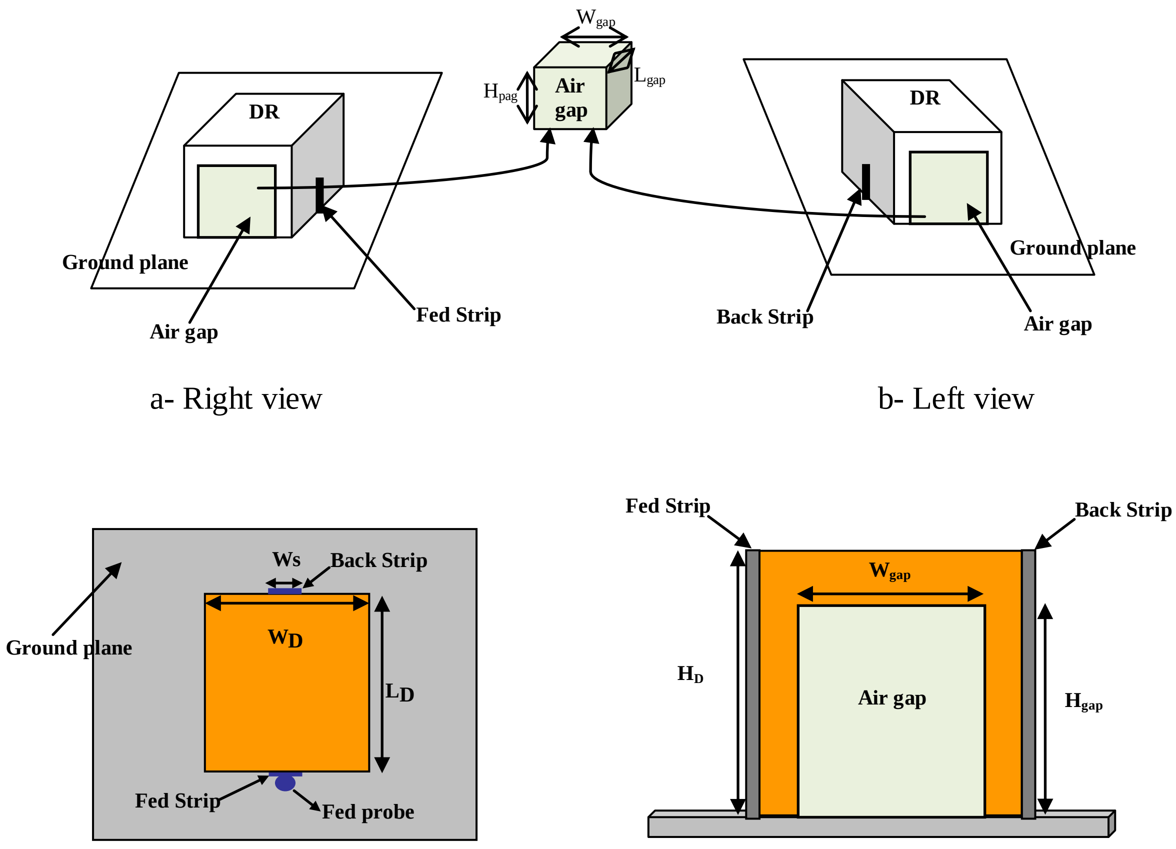
In the last years the demand of wide band had increased exponentially for that many antenna engineers have been tried to design antennas with wide bandwidth performance. The dielectric resonator antenna (DRA) is a good candidate for these requirements. DRA's was proposed for the first time by the professor S. A. Long in 1983 [1] and it has received increasing attention in the last two decades. The DRA has many common advantages to micro strip antennas (MSA) such small size, low loss, light weight and ease of excitation. Additionally, DRA's have wider bandwidth than conventional MSA [2], since they do not use metallic radiators. As consequence, DRA's radiation efficiency (more than 98%) [3], radiation pattern performances and antennas directivity become higher compared to those of micro strip antennas operating in the same frequencies in millimeter wave band [4] or in microwave range [5].

A lot of works where carried out to achieve wide bandwidth enhancements using different techniques and different geometries such as conical [6], elliptical [7-8], tetrahedral [9], well [10], stair [11], H-shaped [12], A-shaped [13] and cylindrical [14]. In this work, a new shape which provides a UWB (>25%) is presented. The studded structure consists in a rectangular DRA which contains two symmetrical rectangular air gaps and fed by a simple network technique named the strip-fed method (probe + conducting strip) [15-16]. The analysis in this paper is performed using the commercial simulators Ansoft HFSS and CST microwaves studio.

ANTENNA DESIGN

Fig.1 (a) shows the rectangular DRA excited by a probe connected to a conducting strip [15-16]. An identical strip is placed at the back face in front of the first one (Fig.1 (b)) to excite a new resonance and enhance the bandwidth [16]. Fig.1 (c) shows the rectangular DRA with two symmetrical rectangular air gaps, the first one ismade in the left side and the second in the right side. Adding air gaps to the DRA provides a wider bandwidth and a good gain compared to the first antenna in Fig.1 (a).

The dimensions of the proposed antenna are WD= 14.3 mm as width, LD= 34 mm as length and HD= 15 mm as height, with a dielectric constant of 9.8. The dielectric resonator is supported by a 104.3 x 124 mm2 ground plane.



a- Right view b- Left view

c- Up view d- Cross-secional view

Fig 1: EVolution of the studded DRA.

The rectangular air gaps dimensions are W_{gap}=12 mm as width, L_{gap}= 14 mm as length and H_{pag}= 11 mm as height. The dimensions of the front and back strips are Ws = 0.9 mm as width and Ls =HD = 10 mm as length.

RESULTS

Fig.3 compares the reflection coefficients of the rectangular DRA and the modified DRA which has two rectangular gaps in right and left sides. While the first rectangular DRA model provides a 20.03% impedance matching bandwidth, the DRA with two rectangular air gaps provide much wider impedance matching bandwidth of around 49.79%, so the bandwidth is increased about 29,76%.

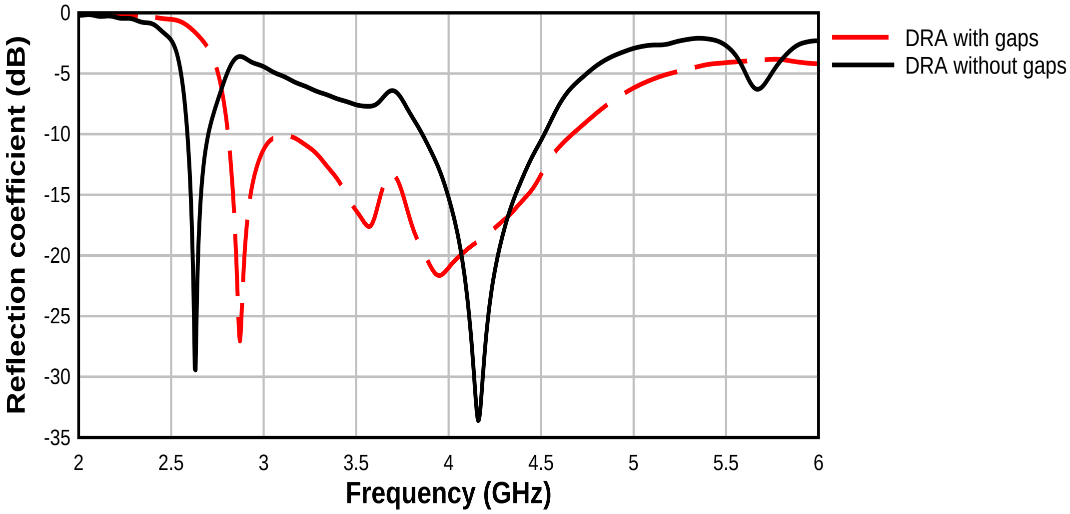


Fig 3: Reflection coefficient for the rectangular DRA with and without gaps.

In fig.4, we can find a comparison between the reflection coefficients of the modified rectangular DRA simulated in the CST and HFSS simulators.

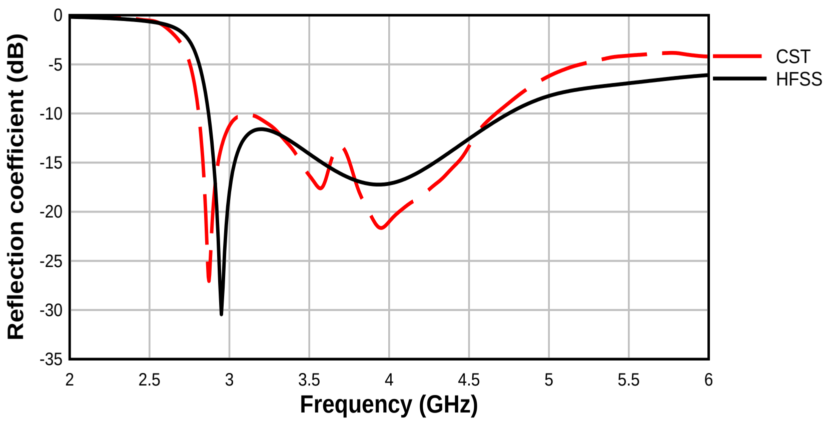


Fig 4: CST and HFSS simulated reflection coefficient.

So, we can notice that the result is verified for the two simulators which are based on two different methods (HFSS on finite element method and CST on finite integration method). The simulated matching frequency band of the proposed antenna for -10 dB reflection coefficient is from 2.807 GHz to 4.668 GHz with an impedance matching bandwidth of around 49.79%.The obtained gains are 9.33 dBi at 2.872 GHz, 8.55 dBi at 3.566 GHz and 7.04 dBi at 3.946 GHz.

Fig. 5 shows the effect of the height of the rectangular gaps (H_{gap}). We note that the impedance matching bandwidth and the reflection coefficient is sensitive to the height gap variation and we have the best impedance matching bandwidth (49.79%) for H_{gap} = 11 mm.

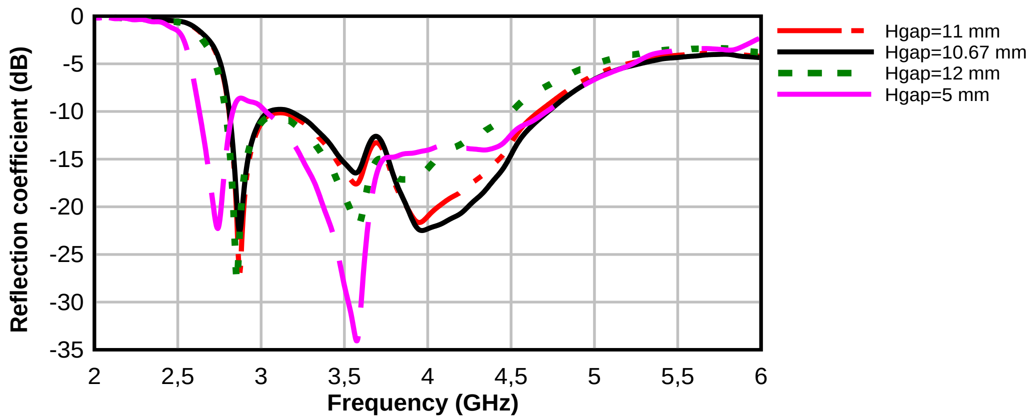


Fig 5: Reflection coefficient for various gap height

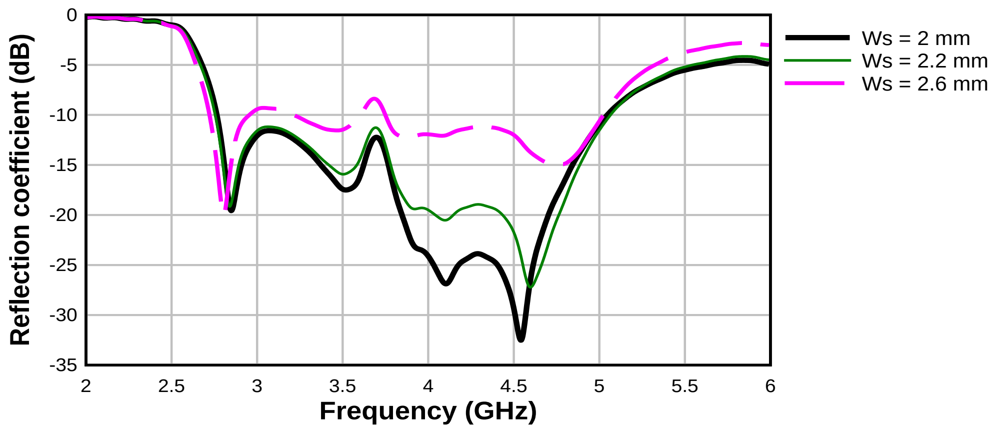


Fig 6: Simulated reflection coefficient for various conducting strip widths

Fig.6 shows the effect of the width Ws. We can observe that the impedance match is sensitive to the conducting strip widths. The best result is obtained for Ws = 2 mm, for this width value the operating band is from 2.765 GHz to 5.047 GHz corresponding to an impedance matching bandwidth of around 58.43%. The maximum obtained gains are 9.84 dBi at 2.85 GHz, 8.47 dBi at 3.5 GHz and 8.96 dBi at 4.54 GHz.

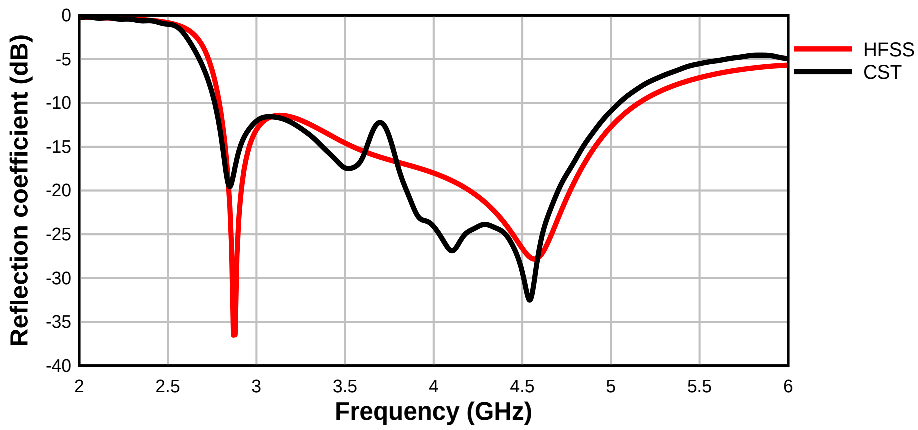
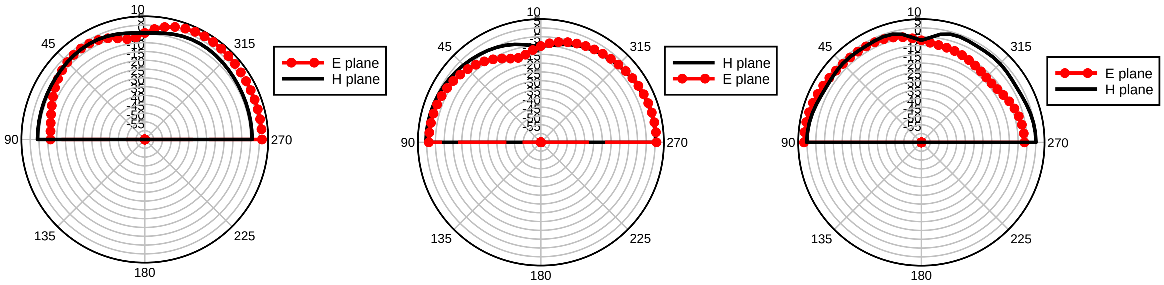


Fig 7: CST and HFSS reflection coefficient for Ws = 2 mm.

Fig.7 illustrates the comparison of the reflection coefficient simulated on CST and HFSS simulators. A good agreement between the two simulators is obtained.



a- 2.85 GHz b- 3.5 GHz c- 4,54 GHz

Fig 8: Simulated radiation patterns of the proposed antenna at 2.85 GHz, 3.5 GHz and 4.54 GHz.

Fig.8 represents the radiation patterns of the modified antenna in the E and H planes at 2.85 GHz, 3.5 GHz and 4.54 GHz respectively. The figure above shows that the radiation patterns for the three frequencies at the H-plane are symmetrical, but asymmetrical at the E-plane.

CONCLUSION

A rectangular DRA with two lateral air gaps and exited by a simple feeding network, named the strip-fed method was presented. The structure provided height bandwidth as compared to the simple rectangular DRA (29, 76% better). A parametric study was carried out using “Ansoft HFSS” and “CST Microwave”. A good agreement is obtained between the two commercial simulators. The return losses coefficient and the radiation patterns of the proposed antenna structure were presented. As a result, this antenna has a very wide band, from 2.765 GHz to 5.047 GHz having an impedance matching bandwidth of 58.43%. The maximum obtained gains are 9.84 dBi at 2.85 GHz, 8.47 dBi at 3.5 GHz and 8.96 dBi at 4.54 GHz.

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