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► **To cite this version:**

Yacouba Coulibaly, Tayeb Denidni, Halim Boutayeb, Larbi Talbi. Design of a New Broadband Dielectric Resonator Antenna. The European Conference on Antennas and Propagation: EuCAP 2006, 2006, Nice, France. p.442.1. hal-00166633

HAL Id: hal-00166633

<https://hal.science/hal-00166633>

Submitted on 8 Aug 2007

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DESIGN OF A NEW BROADBAND DIELECTRIC RESONATOR ANTENNA

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ABSTRACT

In this paper, a new microstrip broadband antenna is proposed. This antenna was numerically designed using Ansoft HFSS simulation software package. The investigated antenna uses a dielectric resonator, a microstrip fed stepped patch, and an intermediate substrate to widen the bandwidth. A parametric study was performed to optimize the proposed design. Then, based on the optimised design, an antenna prototype was fabricated and measured. Simulations and measurements were carried out, and the comparison between them shows a good agreement. Using this approach, a fractional bandwidth of 42 % at the center frequency of 9.64 GHz was achieved.

1. INTRODUCTION

Over the last years, there has been a substantial growth of multi-band and broadband applications, which leads designers to develop new antennas configuration. Dielectric Resonator Antennas (DRAs) have shown to be an attractive alternative for applications at microwave and millimeter wave-bands. DRAs have some key features for the design of planar antennas: low loss, low profile, high radiation efficiency, high density integration, and reduced size.

However, the bandwidth of a DRA is generally below 10% [1] and this narrow bandwidth is not enough for modern applications. Therefore, different approaches have been proposed to increase the bandwidth. In respect to this issue, different shapes of DRAs such as, conical [2], tetrahedron and triangular [3] have been proposed. Another method for bandwidth enhancement is based on stacking two or more elements of different sizes with the same or different dielectric material to improve the coupling between the feedline and the antenna [4]. Coplanar parasitic DRAs can also be used to increase the bandwidth [5]. These methods are little difficult to be fabricated. For this, a new alternative approach based on a hybrid structure has been proposed recently [6-8]. This method uses the combination of different types of resonant of different structures to design a wideband hybrid structure. Furthermore, a low profile DRA fed by a microstrip has been investigated in [9]. This antenna uses a stepped microstrip to achieve

an efficient coupling, and a bandwidth of 17% has been obtained.

In this paper, a new DRA is proposed. This antenna uses three parts: a dielectric resonator (DR), an intermediate substrate and a microstrip fed stepped patch. Based on the simulation results, a prototype of the antenna was fabricated and measured. The simulation results including the return loss, the radiation pattern as well as the measured return loss are presented. In Section 2, the antenna design is described, and in Section 3, the simulated and measured results are compared and discussed. Finally, conclusions are made in Section 4.

2. ANTENNA DESIGN

The topology of the proposed hybrid antenna is shown in Fig 1. The antenna consists of a Dielectric Resonator (DR), an intermediate substrate and a microstrip fed patch. The DR has a height $2d$, width b , length a , and relative permittivity ϵ_{dra} . The intermediate substrate of thickness h_2 and permittivity ϵ_2 is inserted between the dielectric resonator and the microstrip feed as shown in Fig.1. The intermediate substrate is a square of width W_i . The feeding circuit is composed of a microstrip feed line of width W connected to a stepped patch as illustrated in Fig 1.b. The patch consists of three strips and their geometric dimensions are shown in Fig.1. The distance from the edge of the DRA to the edge of the patch is d .

To simulate this design, HFSS was used [10]. This antenna has the advantages of having different parameters which can be adjust to have a good impedance matching. Several prototypes are simulated to investigate the effects of some parameters.

In this design, the fundamental mode of the DRA TE_{111}^y which is a hybrid mode is excited. For the DRA, the resonant frequency, the permittivity, the width, the length and the height are 11 GHz, 10.2, 10.4 mm, 10.4 mm and 2.54 mm, respectively. Fig.2 shows the return loss coefficients for various thickness of the in intermediate substrate while the others design parameters are held constant. The intermediate substrate is used to lower the permittivity of the DR; therefore the bandwidth can be increased. From the parametric study shown in Fig.2, it can be concluded that the optimized value of $h_2 = 0.8$ mm. Referring to

Fig.2, the return loss indicates that when h_2 increases, the DRA resonance frequency shifts down.

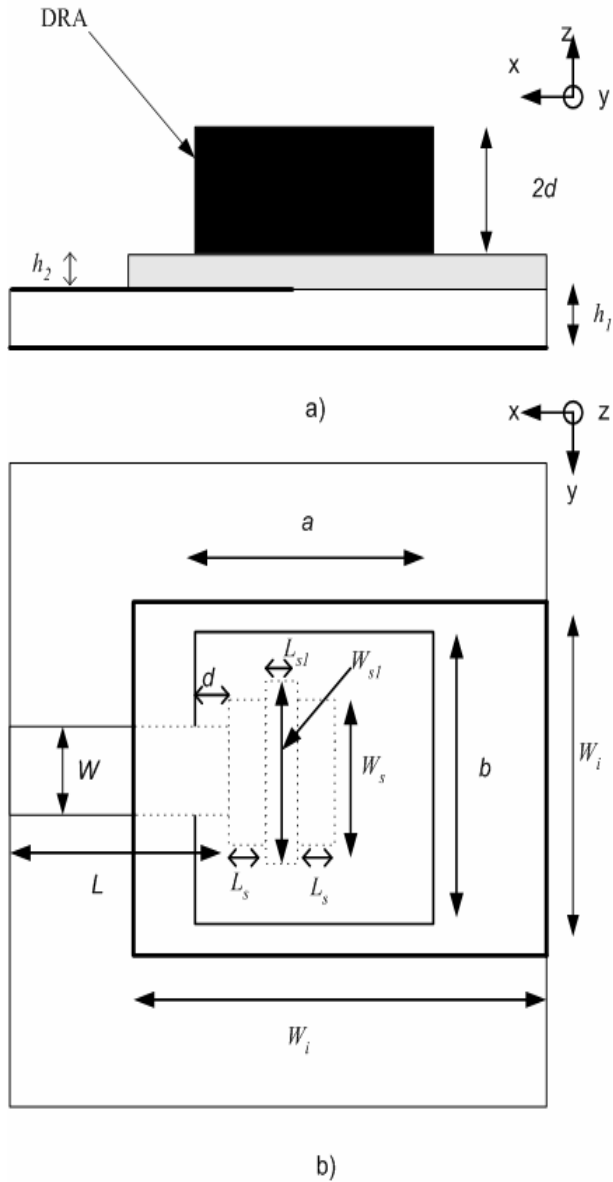


Figure 1. Geometric configuration of the proposed antenna. a) Side view; b) top view.

The next parameter to be analyzed is the distance between the edge of the DRA and the edge of the patch. Fig. 3 shows that the choice of d affects the bandwidth of the DRA. The choice of this parameter is critical to have an efficient coupling

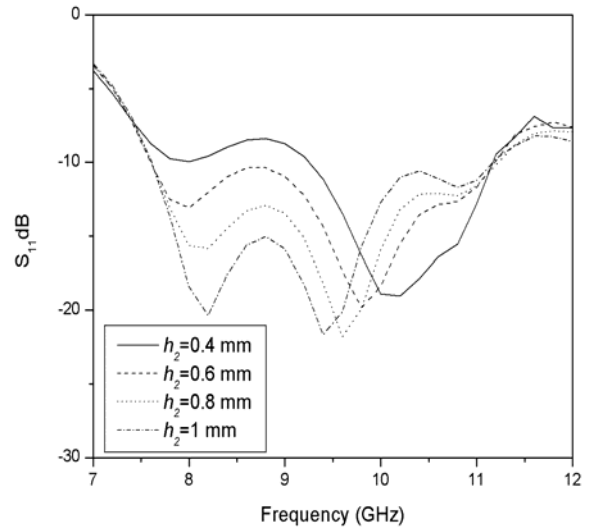


Figure 2. Return loss for different values of h_2 .

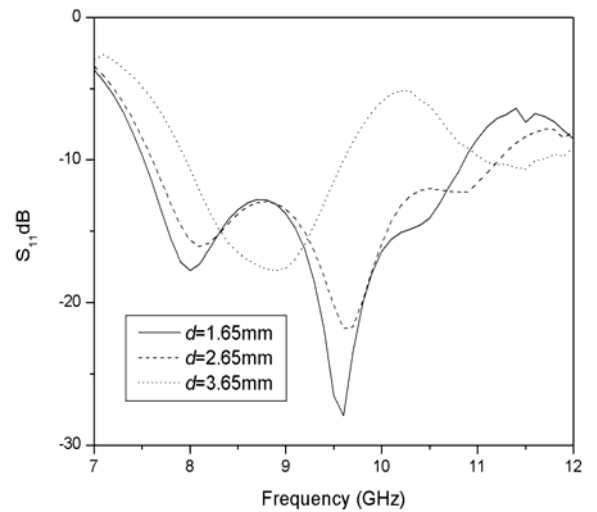


Figure 3. Return loss for different values of d .

3. EXPERIMENTAL RESULTS

To validate the proposed design, an antenna prototype was fabricated based on the optimized values. In order to make measurements of the S parameters, a coaxial connector is soldered to the microstrip line of the antenna. The DRA is made of a RT/Duroid 6010 of permittivity $\epsilon_{dra} = 10.2$. A standard substrate of thickness of 2.54 mm of is used. The microstrip line and the patch are printed on the same substrate but with a standard thickness $h_1 = 1.27$ mm. The intermediate circuit is fabricated out of a substrate RT/Duroid 3060 of permittivity $\epsilon_1 = 2.2$ and thickness $h_2 = 0.8$ mm. Using a

network analyzer, experimental measurements on the fabricated prototype were carried out. The measured and simulated S parameters are shown in Fig. 4. From these curves, it can be observed that there is a good agreement between the measured and simulated results. However, there is a shift between the measured and simulated frequencies. The corresponding bandwidth of 40 % and 42 % (for return loss < -10 dB) at the center frequency of 9.35 GHz and 9.64 GHz is achieved for the simulation and the experimental results.

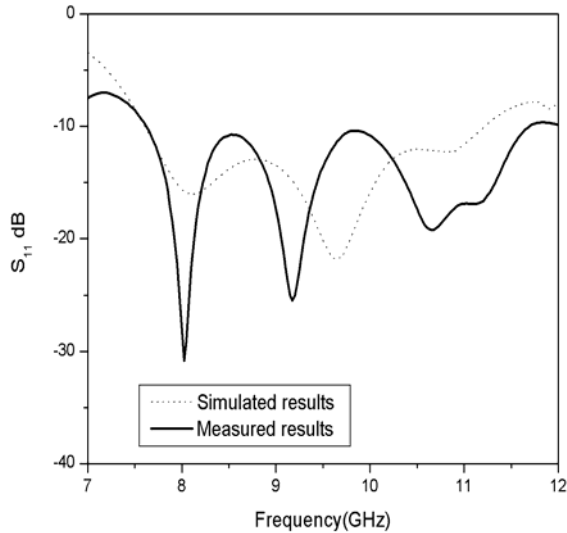


Figure 4 Simulated and measured return loss of the proposed antenna. The dimensions of the antenna: $a = b = 10.4 \text{ mm}$, $2d = 2.54 \text{ mm}$, $\epsilon_1 = \epsilon_{\text{dura}} = 10.2$, $\epsilon_2 = 2.2$, $W = 1.2 \text{ mm}$, $L = 27 \text{ mm}$, $L_s = 2 \text{ mm}$, $W_s = 5 \text{ mm}$, $L_{s1} = 1 \text{ mm}$, $W_{s1} = 7.5 \text{ mm}$, $h_2 = 0.8 \text{ mm}$, $W_1 = 30 \text{ mm}$.

To examine the antenna radiation performance, experimental measurements were carried out in an anechoic chamber located at INRS-EMT, Montréal. The radiation patterns were measured at the frequencies of 8, 9, and 10 GHz. The measured co-polarization in the E- and H-planes are shown in Figs. 5, 6 and 7. From these results, it appears that the patterns are stable across the operating bandwidth. The H-plane asymmetry is due to the radiation of the microstrip line and the patch. The ripples in the measured pattern are caused by the diffractions from the edge of the ground plane.

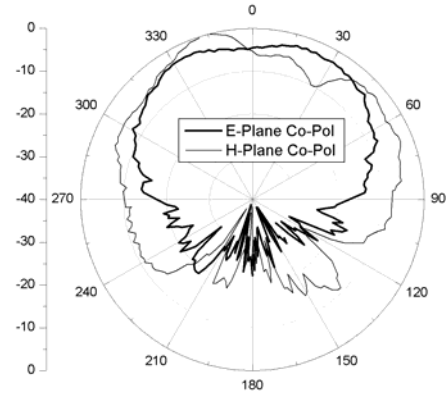


Figure 4. Measured radiation patterns at 8 GHz.

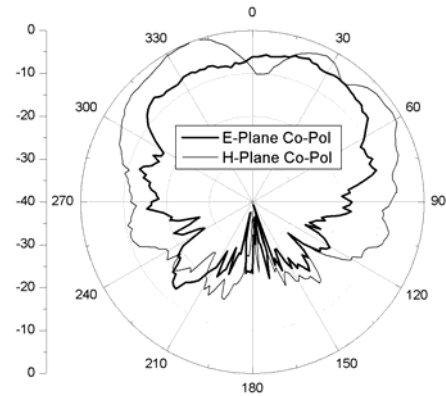


Figure 4. Measured radiation patterns at 9 GHz.

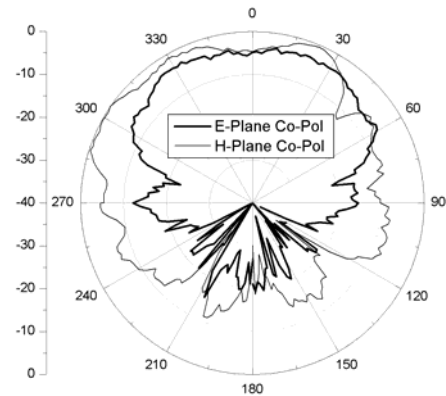


Figure 6. Measured radiation patterns at 10 GHz.

4. CONCLUSION

In this paper, a design of a new low profile broadband dielectric resonator antenna has been investigated numerically and experimentally. The bandwidth is enhanced by adding an intermediate substrate and using a stepped patch for efficient coupling. A parametric investigation of different variables has been presented. A bandwidth of 42 % with return loss less than -10 dB at 9.64 GHz is achieved and verified with experimental results. The radiation patterns of the proposed antenna have the same properties over the operating bandwidth. With the obtained features, this antenna can be suitable for broadband wireless communication systems at X-Band.

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