International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

# Realization of Rectangular Dielectric Resonator Antenna for Broadband Applications

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**Abstract**

***Due to the fast growth of technology, the demand for wireless mobile communications has led to the development of antennas that are low profile and small in size. Therefore, in this presentation, a novel broadband, low-profile dielectric resonator antenna using relatively low dielectric constant substrate material has been presented. A broadband low profile dielectric resonator antenna that uses a relatively low dielectric constant substrate has been proposed. A stepped microstrip feeding mechanism has been analyzed to achieve efficient coupling over a wide bandwidth. The DRA has been made from inexpensive widely available substrate material. Furthermore, methods for size reduction of the proposed antenna using metallic patches have been investigated. Simulations as well as experimental results are also presented using Comsol software.***

*Key-words: Dielectric Resonator Antennas (DRAs), Comsol softwares. & Bandwidth*

## Introduction

In the last two decades, microstrip antennas [1–4] and dielectric resonator antennas (DRAs) [5–7] have been extensively investigated as suitable antennas for wireless applications. The DRA offers attractive features such as low ohmic loss, low profile, small size, wide impedance bandwidth as compared to the microstrip antenna. The DRA can be used at millimeter frequency bands and is compatible with existing excitation methods such as the coaxial probe, microstrip transmission line, co-planar waveguide feed or aperture coupling. DRAs are available in basic shapes such as rectangular, cylindrical, spherical and hemispherical geometries. Rectangular DRAs offer more design flexibility since two of the three of its dimensions can be varied independently for a fixed resonant frequency and known dielectric constant of the material [8]. Hence, we have chosen the rectangular DRAs for investigation.

Section 1 of this paper presents the proposed geometry for the broadband, low-profile rectangular DRA. Section 2 presents the proposed geometry of the compact DRAs. In the second section, the low profile DRA is made compact by covering the top surface of the DRA with a square metallic sheet.

## 2. Antenna Configuration

In order to make the antenna more compact laterally, in addition to being low profile, we investigated the use of metallic sheet on the top surface of the DRA. The design parameters and the feed mechanism for the compact DRA configuration are the same as the low profile DRA. For the compact DRA configuration as shown in Fig. 1, the area of square metallic sheet ($a$mm$^2$) controls the level of miniaturization with a corresponding trade-off in bandwidth, a bigger sheet results in

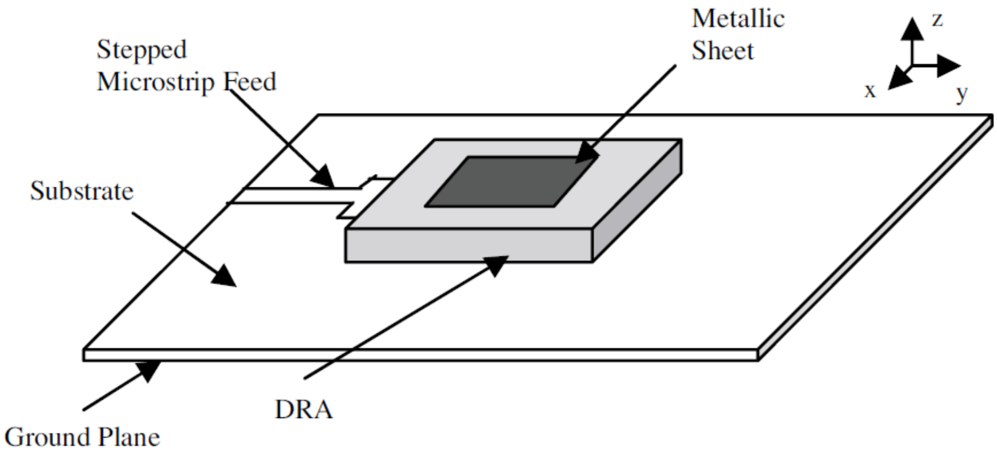


Figure 1. Geometry of compact DRA with small metallic sheet.

a more compact antenna with a narrower bandwidth than a smaller sheet. Section 3 presents the results for two cases: a small sheet covering a portion of the top surface of the DRA and a sheet that covers the entire top surface of the DRA as shown in Fig. 2.

## 3. Numerical and Experimental Results

### 3.1 Low Profile DRA

The low profile DRA is analyzed first. The dimensions of the low profile DRA are $l = w$ = 10mm and $h$ = 2.5 mm. The prototype DRA is made of widely available Rogers RT®/Duroid 3010 substrates that have dielectric constant $\varepsilon_r$ = 10.2. The same substrate material is used

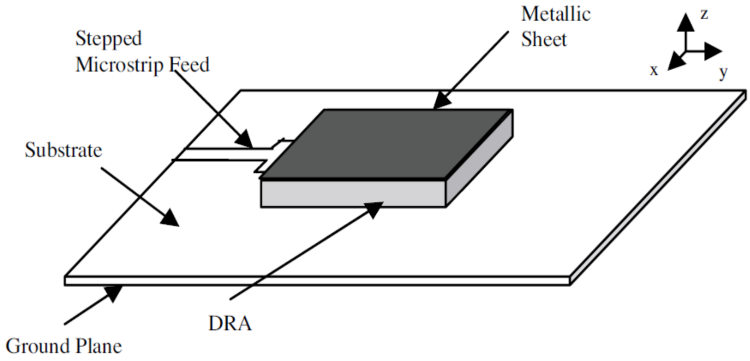


Figure 2. Compact DRA with metallic sheet covering the entire top surface. for both the feed line substrate as well as the DRA. The thickness of the substrate used is $t$ = 1.27 mm. The width of the feed microstrip line is $w1$ = 1.2mm (resulting in 50Ω characteristic impedance) and the width and length of wide strip are $w_2$ = 3mm and $l_2$ = 11 mm. In the simulations, a finite substrate was used (finite ground plane) with dimensions 90mm × 90 mm. The DRA is placed on the substrate such that the wider edge of the microstrip line coincides with the DRA's center. Theoretical results for the antenna were obtained using Comsol softwares.

***Input impedance and return loss***

The computed input impedance versus frequency is shown in Fig. 3. The figure shows good impedance matching is achieved using the stepped microstrip line feed. The computed and measured results of return loss versus frequency of the low profile DRA are shown in Fig. 4. The computed return loss is less than −10 dB over a frequency bandwidth of 13% whereas the measured −10 dB returns loss bandwidth is even better, at about 17%. The prototype was constructed using a milling machine that is not very precise resulting in the difference between simulation and measurement.

***Radiation patterns***

The radiation patterns are computed at 8.3 GHz, 8.8 GHz and 9.1 GHz respectively as shown in the Fig. 5, to verify the stability of the radiation pattern over the entire bandwidth. It is seen from the radiation patterns that the antenna is linearly polarized with broadside radiation. The radiation patterns show the there is some scalloping due to the diffraction from the edges of the finite ground plane. The cross polarization levels are less than at least −20 dB at 8.3 GHz, 8.8 GHz and 9.1 GHz.

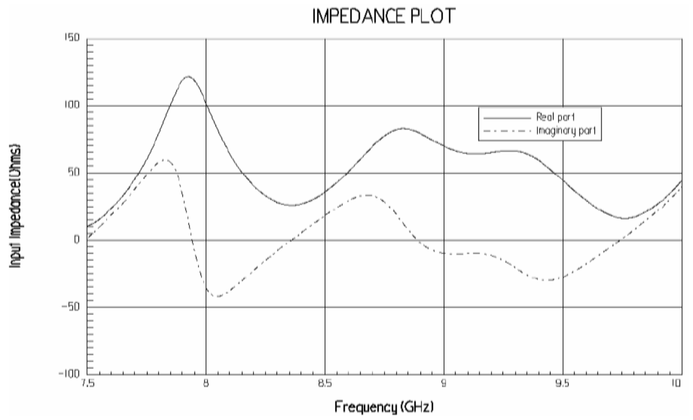


Figure 3. Computed input impedance, real and imaginary parts, vs. frequency.

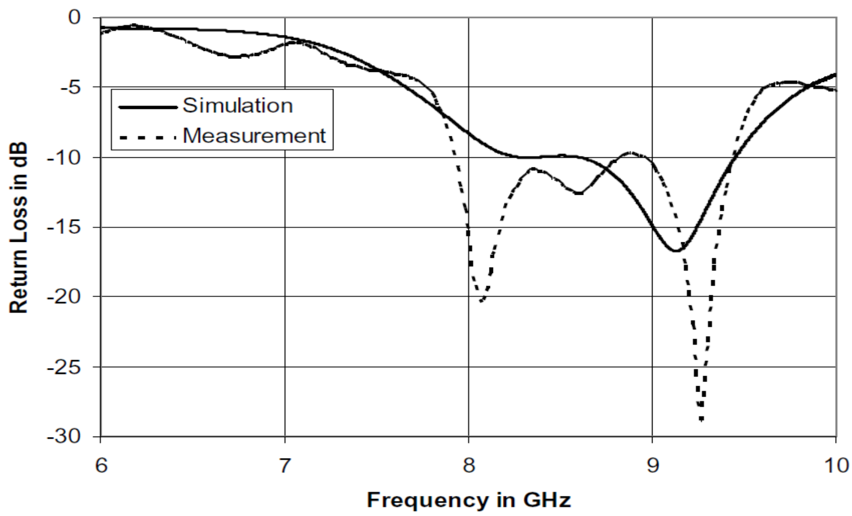


Figure 4. Computed and measured return loss vs. frequency for low profile DRA.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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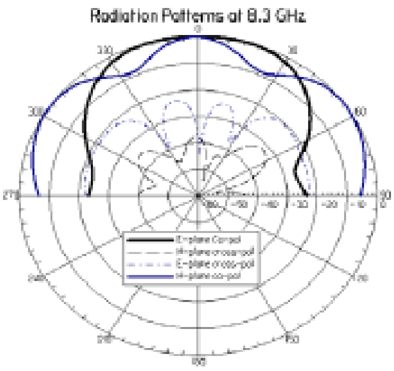
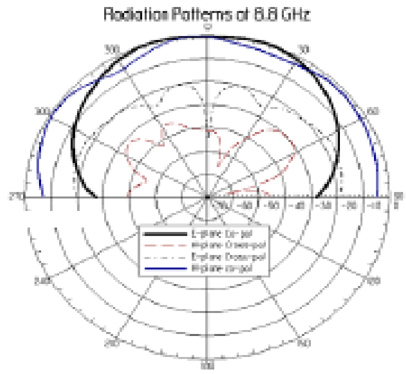
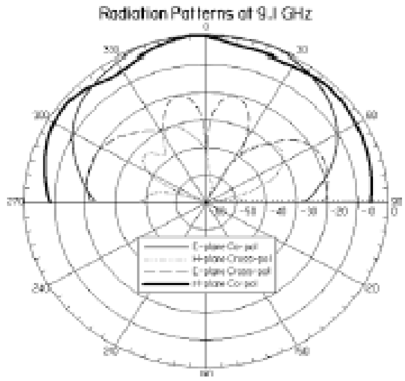



(a)




(b)




(c)

Figure 5. Computed radiation patterns at (a) 8.3 GHz, (b) 8.8 GHz and (c) 9.1 GHz for low profile DRA.

**3.2 Compact DRA**

The placement of a metallic sheet or patch on the top surface of the DRA lowers the center frequency of operation. The magnitude of this shift is an indication of the compactness or size reduction that can be obtained. Our investigations concluded that the bigger the metallic sheet (the more surface area of the DRA it covers), the larger is the shift, and hence the bigger is the size reduction that can be obtained. However, there is also a corresponding reduction in bandwidth. We present two examples in this paper, a small patch partially covering the surface of the DRA and a larger patch covering the surface of DRA entirely. The area of the small patch is 32.5mm2 and the area of the larger patch is 100mm2. The following presents results for the return loss, bandwidth, and radiation patterns of both cases.

***Return loss/bandwidth***

The computed and experimental return loss versus frequency is shown in Fig. 6 for the DRA with the small metallic patch. This antenna achieves a computed return loss of −28 dB at a frequency of 6.3 GHz and gives a 10-dB return loss bandwidth of 4%. Experimentally, the measured return loss as shown in Fig. 6 is −25 dB at a frequency of 7 GHz and the 10-dB return loss

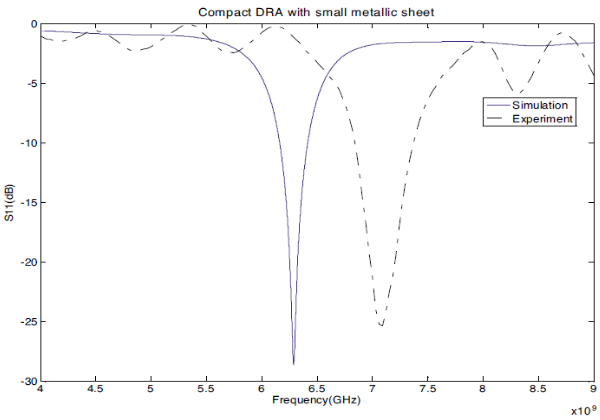



Figure 6. Computed and measured return loss vs. frequency for compact DRA with small metallic sheet.

bandwidth is nearly 7.8%. The addition of the small patch resulted in 22% downward shift in the center frequency.

The computed and measured return losses for the DRA with larger metallic patch are shown in Fig. 7, which shows center frequencies of 5.15 GHz and 5.5 GHz, respectively. The downward percentage shift in the measured center frequencies, relative to the uncovered low profile DRA is 39%. The 10-dB measured return loss bandwidth was 5%. Even this bandwidth is still much better than that of a standard microstrip patch antenna built on an identical substrate, which is no more than 1–2%.

***Radiation patterns***

The radiation patterns, computed at 6.3 GHz for the DRA with the small metallic patch, and at 5.1 GHz for the DRA with the large metallic patch, are shown in Fig.8 and Fig. 9, respectively. The figures show linear polarization with cross polarization levels below −30 dB in the *E* and *H* planes, for both antennas.

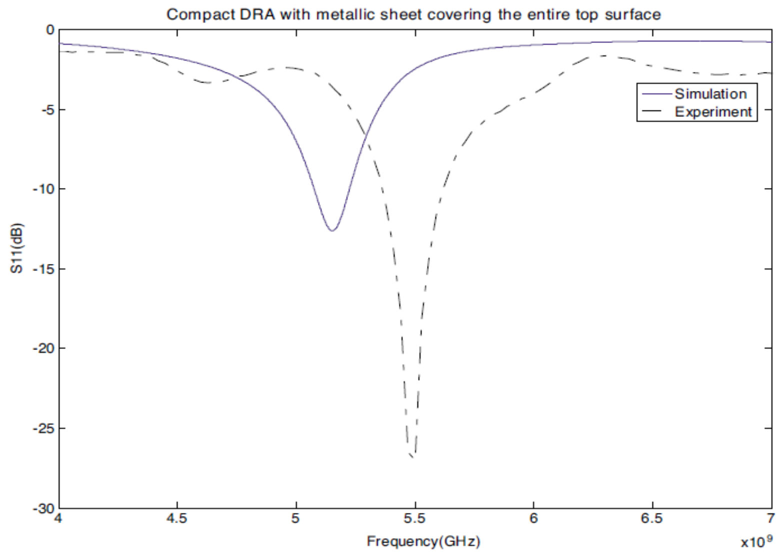



Figure 7. Computed and measured return loss vs. frequency for compact DRA with large metallic sheet.

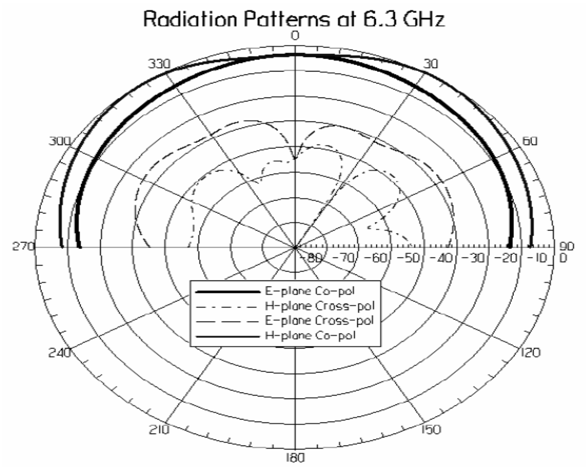



Figure 8. Computed radiation pattern at 6.3 GHz for compact DRA with small metallic sheet.

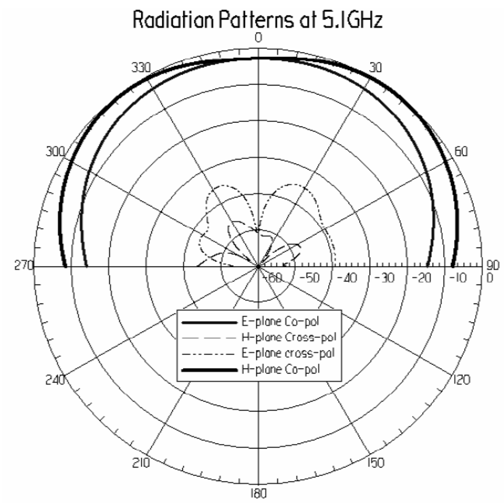


Figure 9. Computed radiation pattern at 5.1 GHz for compact DRA with large metallic sheet.

## Conclusion

The rectangular DRA has been fed with a stepped microstrip feed to ensure efficient coupling. Bandwidths in excess of 19% are obtained. In addition, the paper also describes the method to miniaturize the antenna size using metallic strips or patches. Substantial size reduction is demonstrated while maintaining a reasonable bandwidth.

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