# Mechanically Stable No Adhesive Approach for Rectangular Dielectric Resonator Antenna: A Commercially Viable Design for Practical Applications

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## Abstract

This work demonstrates for the first time the possibility of realizing a mechanically stable no-adhesive rectangular DRA, which has been a long standing demand for practical implementation. A simple ground plane with vertical metallic pins positioned strategically have been explored as clipping devise to ensure robust fixation of DRA without any glue. The study is based on the dominant $TE_{11\delta}$ mode and the proposed design maintains unperturbed modal and the radiation characteristics throughout the band. The design has been executed for a 3.6 GHz antenna indicating its stability in maintaining the said characteristics. As much as 6 dBi gain with about 30 dB co to cross polar isolation has been demonstrated.

## 1. Introduction

The last few decadeshaveseen extensive investigation and research [1] on Dielectric Resonator Antennas (DRAs). It finds high suitability in modern day communications and gained popularity for microwave and millimetre wave applications. However, practical issues regarding bonding and fixing them remains a challenge. The crude technique of aligning individual units and fixing using non-conducting glue [2], is a hazardous approach and hinders DRA usage in mass scale industrial purposes and especially in space-borne technologies [3].

Some recent investigations [4, 5] have established some glueless approaches for cylindrical DRA structures. This work for the first time introduces yet another kind of glue-less technology for the rectangular DRA (RDRA). The study has been conducted and established using a simple grounded substrate, unlike [4], where 2-unit compound ground plane (GP) or [5], where engineered thick grooved GP has been used. A simplified approach of adhesive-free design, comprising a single unit metal plate and vertical pin holders has been proposed. They confirm unperturbed modal configuration with 6 dBi broadside gain. The design is commercially viable and suitable for easy mass-scale implementation.

## 2. Antenna Design

A schematic representation of the design concept is shown in Fig. 1. A rectangular DRA of dimension

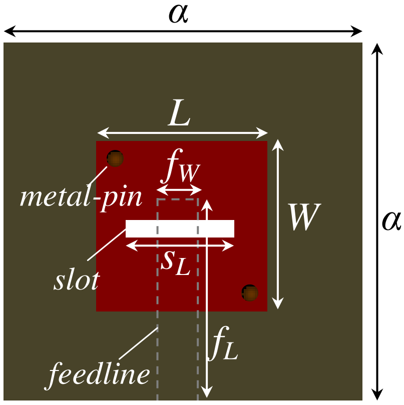



**Figure 1**.Schematic representation of the proposed RDRA

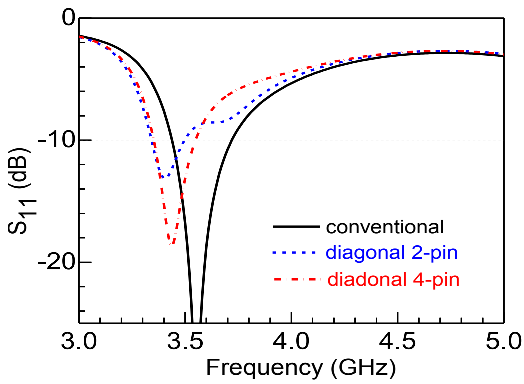



**Figure 2.** Comparison of the reflection co-efficient characteristics of the RDRA with pins positioned diagonally along with the conventional case. Parameters: α=60, $L=W=2h=20$, $\varepsilon_r$=10, $s_L$=12, $s_W$=2, $f_L$=38, $f_W$=3.1 (all dimensions in mm)

$L=W=2h$ and relative permittivity, $\varepsilon_r$ has been primarily investigated. A grounded RT duroid 5870 substrate bearing a rectangular aperture ($s_L \times s_W$) and a microstrip line ($f_L \times f_W$) has been used for feeding the antenna. Its resonant frequency for the dominant $TE_{11\delta}$ mode is estimated as:

$$f_{GHz} = \frac{15F}{W_{cm}\pi\sqrt{\varepsilon_r}} \quad (1)$$

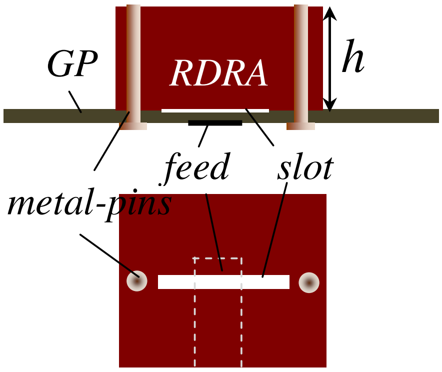



**Figure 4.** Proposed design with vertical pins positioned centrally

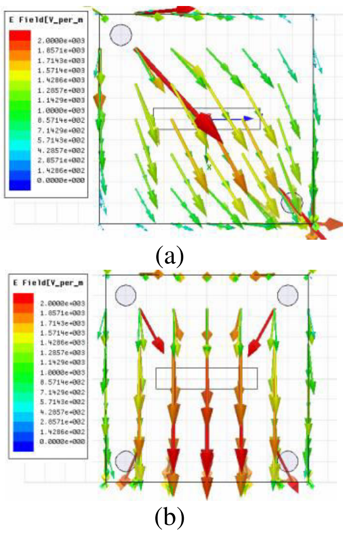



**Figure 3**. E-field characteristics at resonance (a) 2-pins placed at two opposite diagonals; (b) 4-pins placed at the 4 diagonals.

where, *F* is the normalized frequency to be estimated from the universal design curves [6]. For, $L=W=2h=20$ mm and $\varepsilon_r=10$, $f$ comes to be 3.6 GHz.

## 2.1 Vertical Pins as DRA Holder: Positioned at Diagonal Corners

Initially, 2 metallic pins of radius 1mm have been positioned at two opposite diagonals as shown in figure 1. The pins have been inserted through the grounded substrate into the DRA, which will help in holding the DRA without glue. Simultaneously, another design with 4 pins positioned diagonally, has been explored. The antenna characteristics have been studied using an EM simulator [7]. Figure 2(a) compares the reflection co-efficient characteristics of the proposed DRA with the conventional cases. It is interesting indeed to note that when the 2 pins are placed diagonally, the matching is lost. However, when the all diagonals are balanced with the 4 pins the matching is improved. This can be further understood from figure 3. The E-field pattern clearly

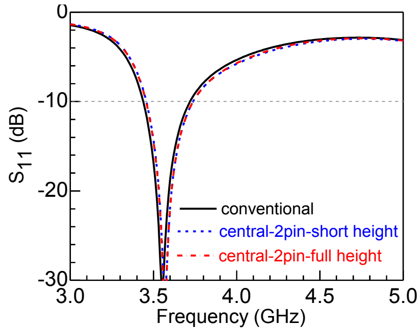



**Figure 5.** $S_{11}$ characteristics of the different configurations. Parameters as in figure 2.

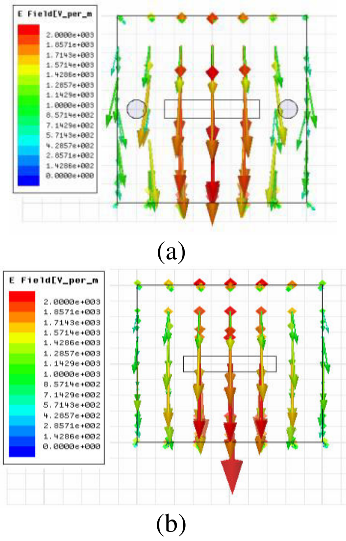



**Figure 6.** E-field characteristics at resonance (a) 2-pins placed centrally; (b) conventional

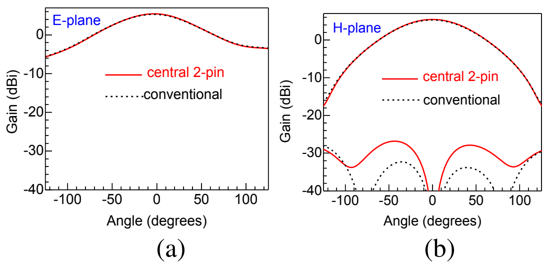



**Figure 7.** Radiation characteristics at resonance (a) E-plane; (b) H-plane. Parameters as in figure 2.

reveals that when 2-pins are used the situation is unbalanced and leads to excitation of a spurious mode. However, the 4-pins give rise to a more balanced situation and the DRA resonates in its dominant mode as revealed from the E-field configurations.

## 2.2 Vertical Pins as DRA Holder: Positioned centrally over H-plane

Since, we intend to minimize the pin numbers, subsequently; we have explored introducing the two

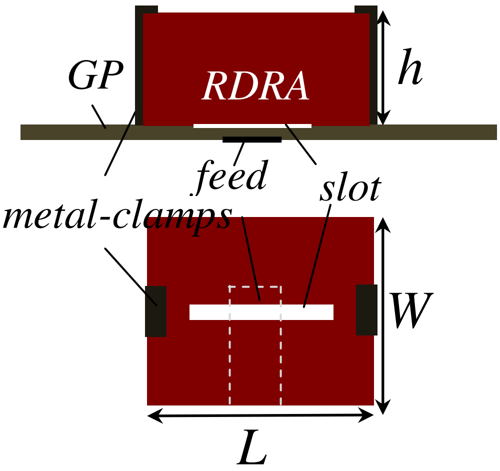



**Figure 8.** Proposed design with vertical pins positioned centrally

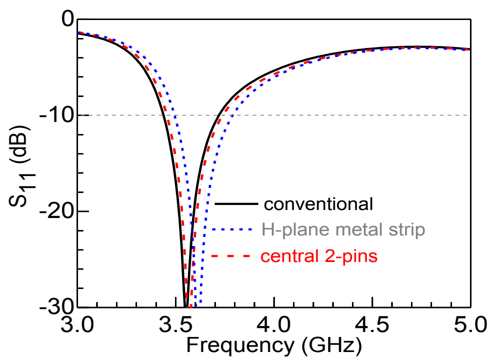



**Figure 9.** Comparison of the $S_{11}$ characteristics of the proposed configurations. Parameters as in figure 2.

vertical pin holders centrally along H-Plane of the DRA. This is shown in figure 4. This location should have minimal effect on the basic modal fields. Initially pins of short heights have been used to verify the conjecture, while subsequently we moved to full height pins perforated through the DRA. Figure 5 shows the resulting reflection co-efficient, and as conjectured it shows absolutely no deviation from the conventional case. The full pins can be screwed to the ground plane at the bottom and with the DRA at the top. The E-field characteristics as shown in figure 7 further strengthen our conjecture. It reveals a clean dominant mode pattern.

The radiation characteristics are shown in figure 7. Both the E-plane and H–plane co-polar characteristics remain unperturbed with a gain of about 6 dBi. The H-plane cross-polar (XP) peak increases by 4 dBi. However the co-to-cross polar isolation remains more than 35 dBi and hence is not of much concern.

## 2.3 A Variant Using a Pair of Metal Clamps

The central pins perforating through the RDRA may be at times a bit difficult to use practically and is not suitable if

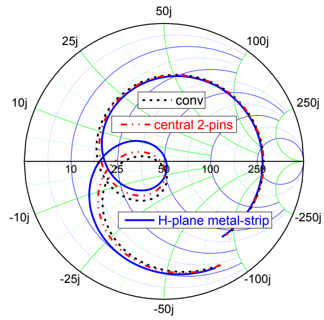
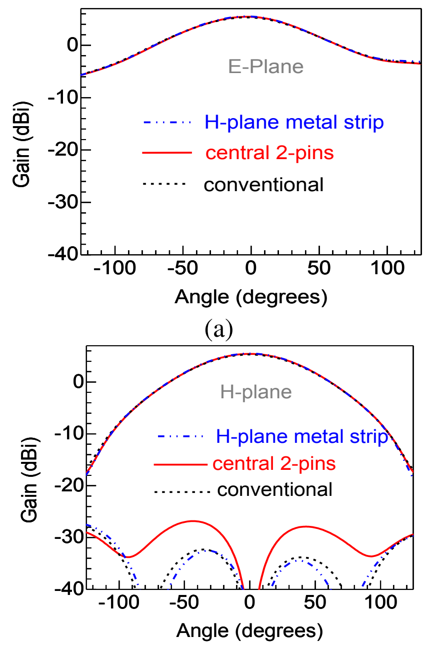



**Figure 10.** Comparison of the impedance characteristics of the proposed designs




(a)

(b)

**Figure 11.** Radiation characteristics at resonance of the proposed RDRA with H-plane metal clamps compared with the other designs; (a) E-plane; and (b) H-plane. Parameters as in figure 2.

the DRA is a brittle material. Instead, we explored using two metal strips as clamps across the H-plane of the DRA. A schematic representation of the proposed design is shown in figure 8. The metal strips can be soldered or clamped with the GP at the base.

The reflection co-efficient plots depicted in figure 9 prove that the characteristics remain unchanged and the antenna resonates absolutely at the same frequency. The smith chart in figure 10 further reveals that the impedance characteristics remain unperturbed.

The radiation characteristics are shown in figure 11. Here too the co-polar characteristics both for E-plane and H-plane remain unchanged with a peak gain of 6 dBi. It is interesting to note here, the H-plane XP peak reduces. The mild increase in XP peak noted with the vertical pins perforating through the DRA, here reduces to its

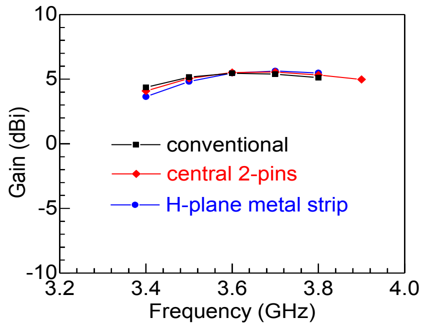



**Figure 12.** Peak gain variation over the operating band of the proposed designs compared with the conventional case.

conventional value. This design is practically more viable and best suited for rectangular DRA. The peak gain over the full operating band of the DRA for all the cases is shown in figure 12. The gain value over the band varies between 5 dBi to 6 dBi and shows not much variation with the traditional case.

## 3. Experiments

A home-made prototype comprising a grounded substrate using RT duroid 5870 and a rectangular DRA is shown in figure 12. Agilent's N9926A network analyzer has been used to measure the reflection co-efficient values as shown and compared with the simulated predictions in figure 13. The measured results closely corroborate the simulated values. The radiation measurements are awaiting preparation of the anechoic chamber, and to be available soon.

## 4. Conclusion

This investigation ensures the feasibility of implementing the no-adhesive simple designforaperture-feed rectangular DRA. Two individual cases have their respective advantages. One may choose pin-shaped holders perforated through the DRA body which is suitable to be accommodated in any shapes of the DRA. The metallic strip is more suitable for the rectangular structure. This should find potential applications to avoid chemical adhesive and achieving mechanically robust DRA.


## 5. Acknowledgements

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## 6. References


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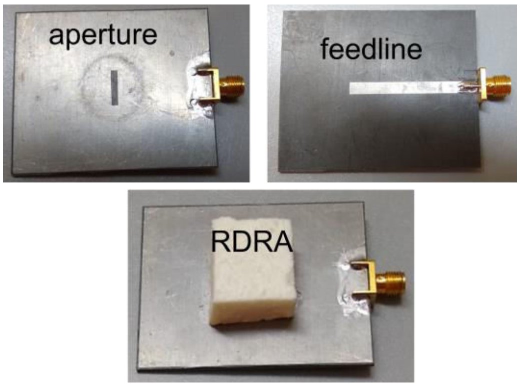


**Figure 13.** Photographs of the fabricated aperture fed RDRA

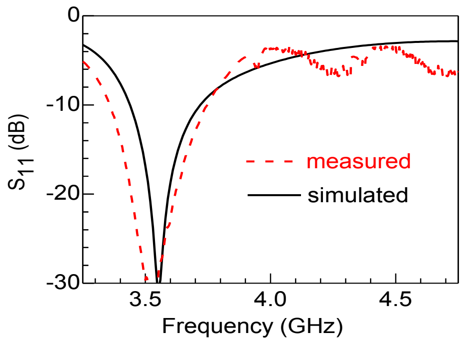


**Figure 14.** Measured reflection co-efficient characteristics compared with its simulated values.


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