STACKED ELLIPTICAL DIELECTRIC RESONATOR ANTENNAS FOR WIDEBAND APPLICATIONS

Mohamed Al Sharkawy, Atef Z. Elsherbeni and Charles E. Smith
Center of Applied Electromagnetic Systems Research (CAESR)
Department of Electrical Engineering,
The University of Mississippi
University, MS 38677, USA
atef@olemiss.edu

Abstract: This paper presents an improvement in the bandwidth of the dielectric resonator antenna (DRA) using a stacked elliptical DRA configuration placed above an infinite ground plane. The feed is a coaxial probe, providing proper wideband matching. The input impedance, the return loss and the radiation pattern were computed using the software package WIPL-D. Parametric studies were investigated for assessment of the antenna performance, resulting in an improved bandwidth of 61.5% (8 GHz) based on a –10 dB return loss for a 50 Ω transmission line.

Introduction:

Dielectric resonator antennas (DRAs) have been studied by many researchers because of their small size, low cost and high radiation due to the fact of having low conduction losses, as they lack any metallic parts. They are also characterized by their light weight and ease of excitation with different excitation mechanisms such as probes, slots, microstrip lines, and coplanar lines [1]. Dielectric resonator antennas are considered a better alternative to microstrip patch antennas, because they provide different radiation patterns based on various modes of operation [2-3]. Furthermore, DRAs exhibit large bandwidth, with flexibility in design due to their various geometrical shapes provided with a large scale of permittivities. Thus, dielectric resonator antennas are considered as a functional antenna element for applications in the microwave frequency range and above.

Presented in this work is a parametric study of two stacked elliptical DRAs placed on an infinite ground plane and excited by a coaxial probe penetrating the lower DRA. The antenna configuration is mainly composed of two elliptical DRAs with different permittivities and radii placed over each other, however, they both rotate around the same axis of symmetry as shown in Fig. 1. A similar DRA configuration, but with circular cross-section, was previously introduced in [4], where the maximum achieved bandwidth was 35 %. The single element of elliptical DRA was previously investigated for circular polarization applications in [5]. In Fig. 1 the height of the two DRAs is defined by the variable $h$ with the assigned indices $b$ and $t$ for bottom and top, respectively. The same index is used in defining the elliptical cross-section for both the top and bottom DRAs, as the elliptical cross-section is defined by a major and minor axes $a$ and $b$. 

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The probe position is defined from the axis of rotation by the two variables $s_x$ and $s_y$ along the $x$ and $y$ axis, respectively, having a length of $L_w$. The same parameters as those introduced in [4] are used, but for an elliptical configuration having the ratio of $b/a = 0.5$. The return loss is computed using the software package WIPL-D [6] and verified using a finite difference time domain (FDTD) code, where a bandwidth of 46 % is achieved, as shown in Fig. 2. Figure 3 shows the bandwidth improvement of the elliptical relative to the stacked circular DRA configurations.

![Fig. 1. Geometry of the stacked elliptical DRA excited by a coaxial probe.](image)

![Fig. 2. Return loss for stacked elliptical DRA excited by a coaxial probe.](image)

The stacked elliptical DRA is investigated first by changing the values of the relative permittivity for both the top and bottom DRAs, with the parameters defined in Fig. 2, and the results are shown in Fig. 4. From the computed data presented in Fig. 4 it is obvious that the best bandwidth for this particular case occurs at $\varepsilon_{rb} = 2.5$ and $\varepsilon_{rt} = 15$, where the achieved bandwidth for these values of permittivity is 61.5 %, which covers 8 GHz from 9 to 17 GHz. Studies were also made to see the effect of changing the excitation position $s_x$ and $s_y$ for the case where $\varepsilon_{rb} = 2.5$ and $\varepsilon_{rt} = 15$. Figure 5 shows the return loss of the stacked elliptical DRA for different values of $s_x$ and $s_y$, with $a_{bx} = 7$ mm, $a_{by} = 3.5$ mm, $a_{tx} = 4.25$ mm, and $a_{ty} = 2.25$ mm.
mm, $a_y = 2.25$, $h_b = 4.75$ mm, $h_t = 2.5$ mm, $L_w = 4.5$ mm. It was found that the best position for the probe, for this case, occurs at $s_x = 2.25$ and $s_y = 0$ along the major axis. The effect of changing the minor to major axes ratio ($b/a$) on the bandwidth is addressed in Fig. 6. As seen from Fig. 6, the best case for this design occurs when the ratio of $b/a$ is 0.5.

Figure 7 presents the input impedance and the return loss for the best case for this configuration with $\varepsilon_b = 2.5$, $\varepsilon_t = 15$, $s_x = 2.25$ mm and $s_y = 0$. The remaining configuration parameters are listed in the table of Fig. 2. The normalized radiation pattern is computed for this DRA design at 10.33 GHz, which can be seen in Fig. 8. The radiation characteristic of the elliptical DRA does not show significant variations relative to the corresponding circular DRA in terms of cross-polarization levels.
Fig. 7. Input impedance and return loss for the stacked elliptical DRA.

Fig. 8. Computed radiation patterns for the designed stacked elliptical DRA.

Conclusions:
A single element stacked elliptical DRA excited by a coaxial probe is proposed and a new design is presented which provides wide bandwidth (61.5% or 8 GHz). One and two dimensional arrays of this new stacked elliptical DRA are currently under investigation for applications in the X-band.

References: