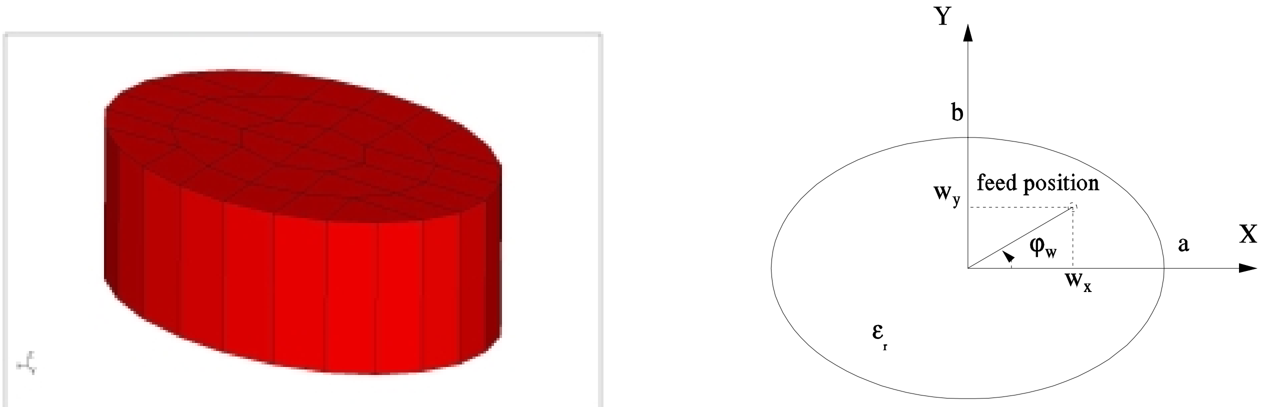
SINGLE-FED CIRCULARLY POLARIZED DIELECTRIC RESONATOR ANTENNA

Ahmed A. Kishk
Department of Electrical Engineering
University of Mississippi, University, MS 38677
ahmed@olemiss.edu

Introduction: Attention to dielectric resonator antennas (DRA) has been increasing because of their small size, bandwidth, high radiation efficiency [1] and ease of excitation. Attention was also toward linearly polarized DRA [2-3] and wideband antennas [4-5]. Circularly polarized DRA has been studied experimentally in a sub-array environment. The circular polarization is excited by a cross-slot excitation [6-8] or by designing a crossed-shape dielectric resonator [7]. All these studies have been performed experimentally to excite two orthogonal modes with 90^o phase shift between them. If single feed is required, a perturbation for the geometry can be used to achieve that. However, always such technique provides very small circular polarization bandwidth. If such antenna is used in a sub-array with a sequential feeding mechanism of each two elements or four elements sub-array a much wider bandwidth for the circular polarization can be achieved.

Here, we design a circularly polarized elliptic dielectric resonator with single probe feeding. The probe position and parameters are used to match the antenna and to excite the circular polarizations. The analysis is performed numerically using WIPL-D [9].

Results and Discussion: The elliptic dielectric resonator antenna with height, h, dielectric constant εr, major axis a and minor axis b located above an infinite ground plane is excited by a coaxial probe of length ℓ_w and is located at (w_x, w_y) as shown in the cross section Fig. 1. The elliptic cross section with major axis *a*=5.25mm, and minor axis *b*=3.5 mm, the dielectric height, *h*=3.5mm and the dielectric constant ε_r=12.0. In microstrip antennas, to excite circularly polarized fields the axial ratio of the patch is close to one and the probe should be located at (w_x, w_x), which is corresponding to an angular position of 45^o with the major axis. In the DRA, when the elliptic ratio is close to one, the antenna produces highly elliptic polarization. Therefore, an elliptic resonator with axial ratio of a/b=1.5. In addition, we considered three different probe positions (2mm, 2mm), (2mm, 3mm), and (2.5mm, 2mm), which are corresponding to the angular positions 45^o, 36^o, and 65^o, respectively. These are referred to as case1, case2, case3, respectively. The axial ratios of the far field in the broadside direction are computed versus frequency as shown in Fig. 2 for the above three cases. It can be seen that the widest bandwidth of a 3dB axial ratio (AR) is about 3.5%, which is achieved by case 2. The angular position of the probe in this case is equal tan^{-1} (b/a). The input impedance is shown in Fig. 3 for the above three cases indicating comparable performance. The input impedance clearly indicates that two modes are excited, but their coupling changes with the probe position. In case 2, one can see that the coupling strength for both modes is about the same level. This is reflected in a better axial ratio for this case. The reflection coefficients are plotted in Fig. 4 showing that case 2 provides the widest band of about 14% compared to 11% for case1, and case 3. Finally, the radiation patterns are given in Fig. 5 for the three cases. In this Figure, the envelope of the circular polarization radiation pattern is plotted at the frequency that has the smallest axial ratio in the direction normal to the antenna. Each case is normalized to its own peak, and each pattered is displaced by 10dB below the other case. As the angular position increases as the axial ratio increases.



(a) DRA Geometry (b) Cross-section

Fig. 1 Geometry of the elliptic dielectric resonator antenna excited by a probe.

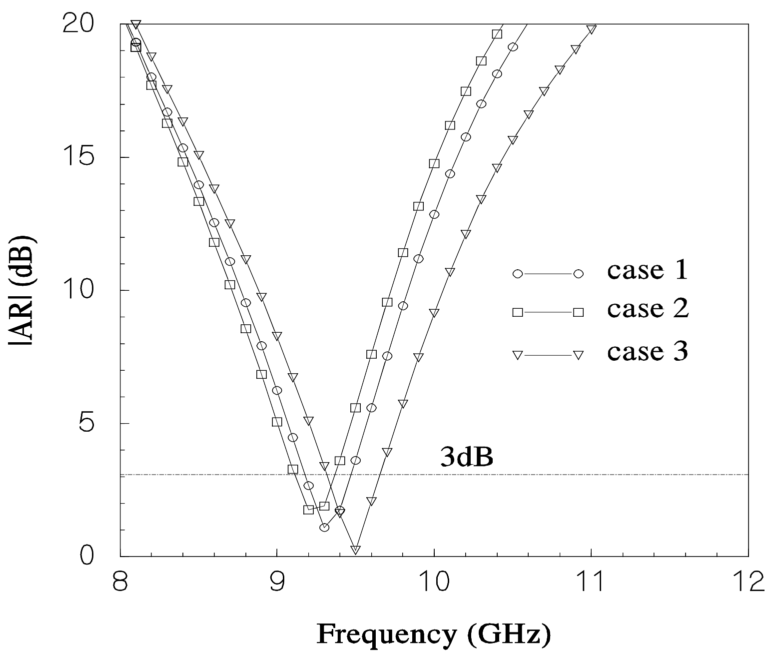


Fig. 2. The axial ration versus frequency for elliptic DRAs with major axis a=5.25mm, b=3.5 mm, h=3.5mm, ε_r=12.0, $\ell_w = 3.0mm$, wire radius 0.25mm, and different probe locations, case1, (2mm, 2mm), case2, (2nmm, 3mm), and case 3, (2.5mm, 2mm).

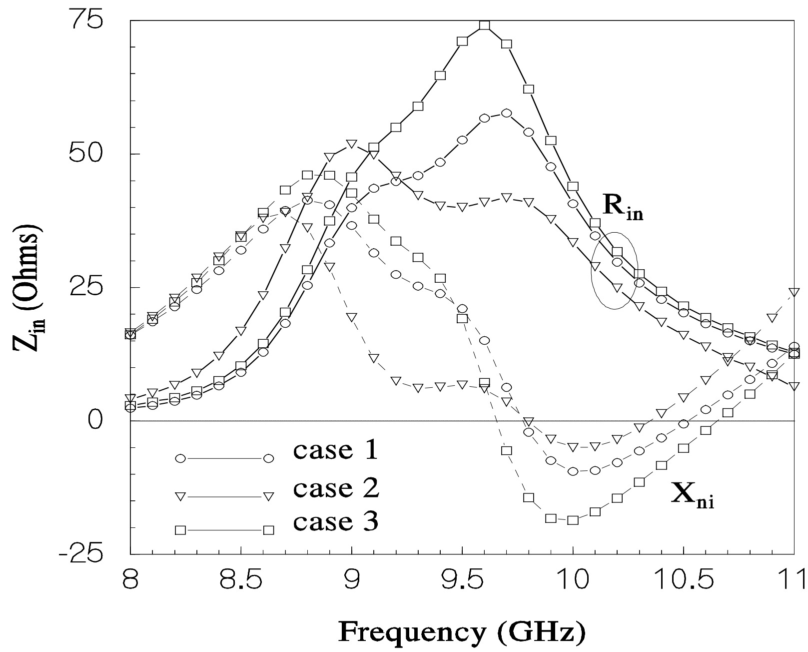


Fig. 3. Input impedances elliptic DRAs with major axis *a*=5.25mm, *b*=3.5 mm, *h*=3.5mm, ε_r=12.0, $\ell_w = 3.0mm$, wire radius 0.25mm, and different probe locations, case1, (2mm, 2mm), case2, (2nmm, 3mm), and case 3, (2.5mm, 2mm).

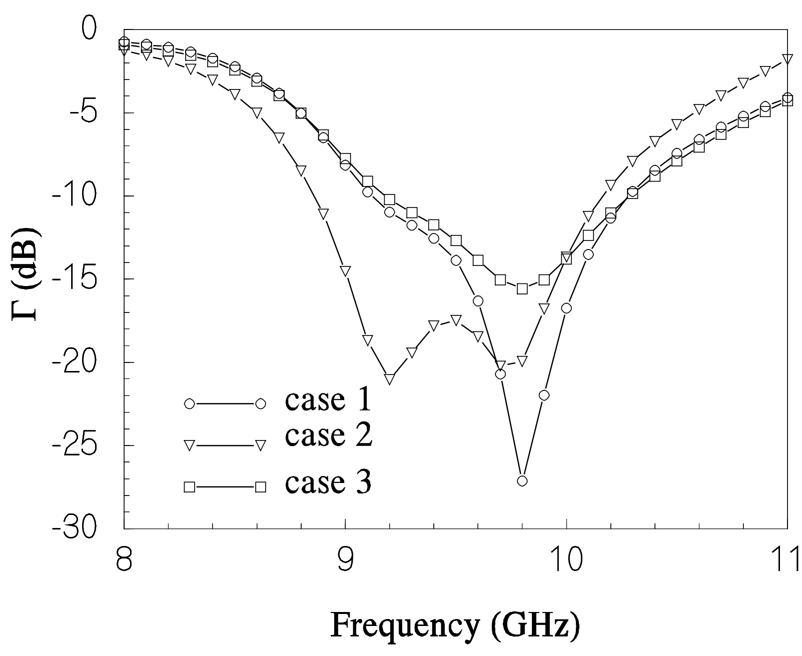


Fig. 4. The reflection coefficients showing the effect of probe position elliptic DRAs with major axis *a*=5.25mm, *b*=3.5 mm, *h*=3.5mm, ε_r=12.0, $\ell_w = 3.0mm$, wire radius 0.25mm, and different probe locations, case1, (2mm, 2mm), case2, (2nmm, 3mm), and case 3, (2.5mm, 2mm).

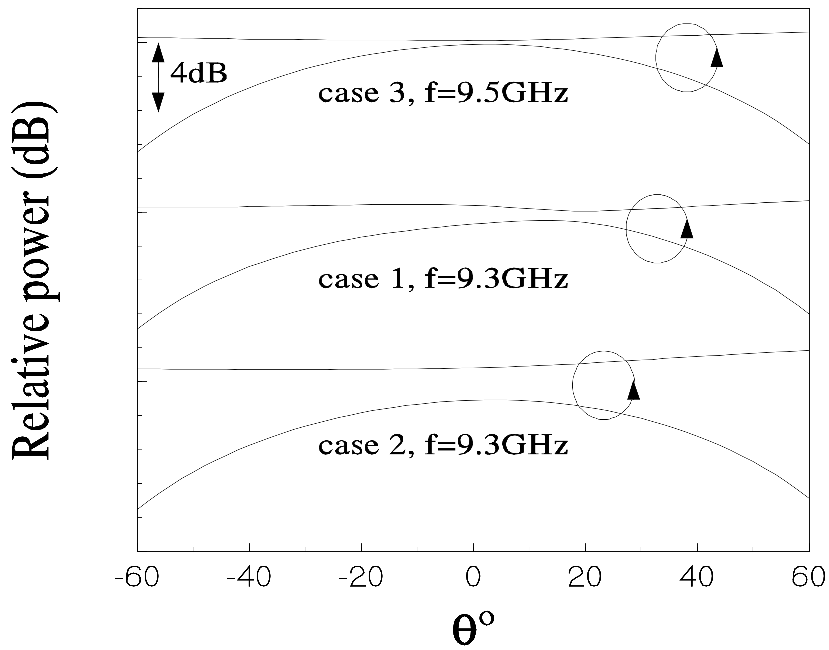


Fig. 5. Radiation patterns envelop of the circular polarization at the frequency that has best axial ratio elliptic DRAs with major axis *a*=5.25mm, *b*=3.5 mm, *h*=3.5mm, ε_r=12.0, $\ell_w = 3.0mm$, wire radius 0.25mm, and different probe locations, case1, (2mm, 2mm), case2, (2nmm, 3mm), and case 3, (2.5mm, 2mm).

Acknowledgement: This work was partially supported by The Army Research Office under grant No. DAAD19-02-1-0074.

References:

[1] R.K. Mongia, A. Ittipiboon, and M. Cuhaci, "Measurement of radiation efficiency of dielectric resonator antennas," *IEEE Microwave and Guided Letters*, Vol. 4, No. 3, pp. 80-82, 1994.

[2] A. A. Kishk, M. R. Zunoubi, and D. Kajfez, "A numerical study of a dielectric disk antenna above grounded dielectric substrate," *IEEE Trans. Antennas Propagat,* vol. 41, pp. 813-821, 1993.

[3] G. P. Junker, A. A. Kishk, and A. W. Glisson, "Input impedance of dielectric resonator antennas excited by a coaxial probe," *IEEE Trans. Antennas Propagat*, vol. 42, pp. 960-966, 1994.

[4] A. A. Kishk, Yan Yin, and A. W. Glisson, "Conical Dielectric Resonator Antennas For Wideband Applications," *IEEE Transactions on Antennas and Propagation*, vol. 50, pp. 469-474, April 2002.

[5] A. A. Kishk, "Tetrahedron and Triangular Dielectric Resonator Antenna with Wideband Performance," *2002 IEEE Antennas and Propagation Int. Symposium*, vol. 4, pp. 462-465, June 2002.

[6] A. A. Kishk, A. W. Glisson and G.P. Junker, "Bandwidth enhancement for split cylindrical dielectric resonator antennas," *Journal of Progress in Electromagnetics Research*, vol. 33, pp. 97-118, 2001.

[7] K.K. Pang, H.Y. Lo, K.W. Leung, K.M. Luk, and E.K.N. Yung,"Circularly polarized dielectric resonator antenna subarrays," Microwave and optical Technology Letters, vol. 27, no. 6, pp. 377-379, December 2000.

[8] A. Petosa, A. Ittipiboon, and M. Cuhaci, " Array of circular-polarized cross dielectric resonator antennas, " Electronics Letters, vol 32, pp. 1742-1743, 1999.

[9] B. M. Kolundzija, J. S. Ognjanovic, and T. K. Sarkar, "WIPL-D: Electromagnetic modeling of composite metallic and dielectric structures, Software and User's Manual," Artech House, Inc., 2000.