Aperture Coupled Wideband Dielectric Resonator Antenna Array with Polarization Reconfiguration

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***Abstract*— Four elements aperture coupled cylindrical shaped Dielectric Resonator Antenna (DRA) circular array is proposed for generating reconfigurable polarization radiation patterns. In this array, all the elements are sequentially fed to generate circular polarization. The linear and circular polarizations of the DRA array are achieved by exciting the elements in different arrangements. The antenna provides wideband impedance matching ($S_{11} \leq$ -10 dB) of 39% (2.7 to 4 GHz) which covers RADAR band (2.7-2.9 GHz) and LTE bands (FDD 22 (3.41-3.59 GHz), TDD 42(3.4-3.6 GHz), TDD 43 (3.6-3.8 GHz)) for both linear and circular polarization radiation patterns. A feed network to accommodate these polarization reconfigurable patterns is under investigation and will be presented during the conference.**

Keywords—Dielectric Resonator Antenna; reconfigurble polarization; aperture coupling.

I. Introduction

In recent years, polarization reconfigurable antennas have proven to be of very importance in wireless communications applications such as base station antennas. In addition to other necessary requirements, a compact size, antenna design with low conductor loss and high power handling capability is required**.** The Dielectric Resonator Antennas (DRAs) provide wide bandwidth with low dissipation loss compared to other microstrip antennas [1]. Among the different shapes of DRA, cylindrical shaped DRA offers enhanced design flexibility [2-3]. There are numerous feeding methods to excite the DRAs. In [4], the authors have presented Circular Polarization (CP) and Linear Polarization (LP) Reconfigurable Antenna with impedance bandwidth 22.9% for LP and 28.43% for CP.

In this paper, an aperture-coupled feeding method is used to provide sufficient isolation between the dielectric resonator (DR) and the feed circuits [5]. Further, since the DRA is directly placed on the ground plane, there is no source of surface wave which contributes to losses. All the DRs are excited in sequential rotation to generate circular polarization [6].

In this proposed array design, individually each element gives 39% of impedance bandwidth. A feed network to accommodate the proposed polarization reconfigurable patterns is under investigation.

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II. Antenna Design

The proposed array antenna design, as shown in Fig.1, 2(a), and 2(b), consists of four cylindrical shaped DRAs using Rogers TMM10 material with dielectric constant ε_r = 9.2 and tan δ =0.0022. The radius of the DR is 20 mm with 10 mm of height (H). All the DRAs are having an air gap in center, of radius r = 4 mm and height h=5mm. The array is excited using aperture coupled feeding method where the substrate is on the back side of ground plane. All the DRs are placed on the ground plane and 50Ω of feed line is on 1.6 mm thick substrate (Rogers RO4003, dielectric constant (ε_s) = 3.55, tan δ = 0.002). The dimension of the ground plane is 160×160 mm^2 (L×W), with rectangular slots (apertures) of dimension 14×5 mm^2 (S_L× S_W). In this present design, the stub length (L_{sb}) is 3.5 mm as shown in Fig. 2(a). The DRAs are operating $TM_{11\delta}$ mode.

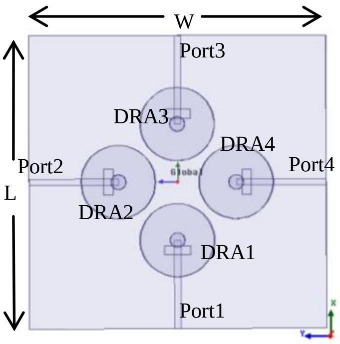
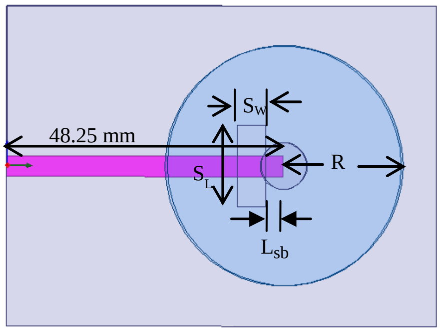
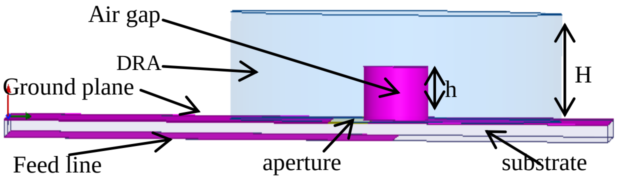


Fig. 1. Geometry of Aperture coupled DRA array.



(a)



(b)

Fig. 2. Geometric configuration of single element DRA of an aperture coupled DRA array: (a) Top view, and (b) Side-view.

III. Simulation Results and Discussion

The simulation study of the DRA array has been carried out using Ansys High Frequency structure simulator (HFSS) version 15.0 available in Antenna and Microwave Lab (AML) at San Diego State University. The S-parameter performance is shown in Fig. 3. From the figure, the impedance bandwidth for $S_{11} \leq$ -10 dB criteria is 39% which covers the frequency range from 2.7 to 4 GHz. The far field patterns at different frequencies and polarizations were obtained. In Fig. 4 (a-d), gain radiation patterns at 3.3 GHz are shown for both linear and circular polarization generations. The DRA array offers linear horizontal polarization with the excitation of DRA1 with 0^0 input phase and DRA 3 with 180^0 input phase. Similarly, the array provides vertical linear polarization, with the DRA2 excitation with 90^0 phase and DRA4 with 270^0 phase. All the DRAs excited in sequential rotation with $\pm$ 90^0 phase increments offer right hand circular polarization (RHCP) and left hand circular polarization (LHCP), respectively. In case of the linear horizontal and vertical polarizations, the minimum value of gain is 7 dBi with cross pol levels less than -45 dB. The axial ratio (AR) for circular polarizations is less than 0.1 dB. The realized gain is better than 4 dBic in left hand (LH) and right hand (RH) circular polarizations. The cross pol levels for circular polarization are also low at 3.3 GHz but these levels increase towards the low and high frequency ends of the matching band.

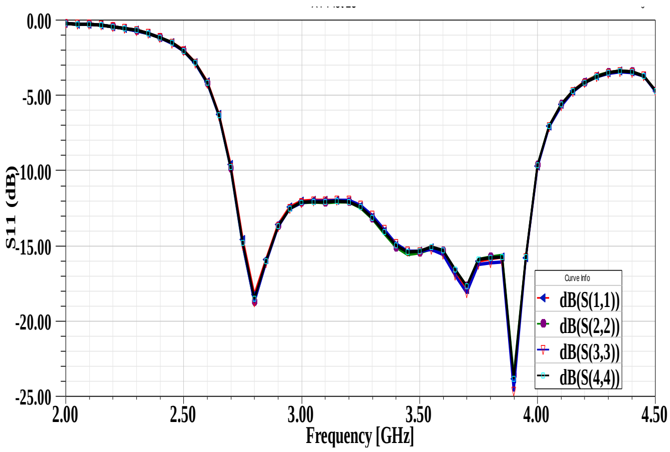


Fig. 3. S-parameter vs Frequency curve of Aperture coupled DRA array.

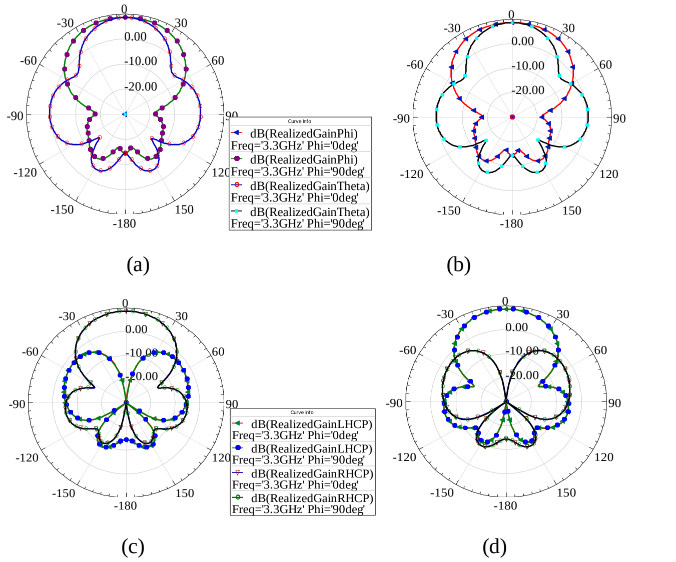


Fig. 4. Radiation patterns of Aperture coupled DRA array at 3.3 GHz. (a) Horizontal polarization, (b) Vertical Polarization, (c) Right hand circular polarization, and (d) Left hand circular polarization.

IV. Conclusion

In this design, a DRA array with sequentially rotated four dielectric resonators is presented for polarization reconfiguration. The DRA array offers linear horizontal, linear vertical, right hand circular and left hand circular polarization with different value of magnitude and phase at each port. The realized gain of the antenna is better than 4 dBi for each polarization. A feed network is under investigation and will be presented during the conference.

Acknowledgments

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