Dual-Frequency Half Split Cylindrical Dielectric Resonator Antenna

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***Abstract*—In this paper, a simple aperture coupled half split cylindrical dielectric resonator antenna is proposed for dual-frequency operation. The dual-frequency is achieved by exciting higher order $TE_{02\delta}$ mode along with the fundamental $TE_{01\delta}$ mode. A prototype of antenna is made using commercially available Rogers RT duroid 6010 of dielectric constant 10.2. The measured gain of proposed antenna is 5.4 dBi and 5.1 dBi, respectively at first and second frequency. The proposed antenna exhibits broadside radiation and the measured cross polarized levels are below -18 dB. A fair agreement between the measured and simulated result is observed.**

I. Introduction

Investigation of dielectric resonators (DRs) as an antenna element was first carried out by Long *et. al.* [1] and since then they are widely used due to their attractive features such as small size, low loss, relative larger bandwidth, ease of excitation etc. [2]. In conventional cylindrical dielectric resonator antenna (CDRA), the modes widely used for radiation purpose are (i) $HE_{11\delta}$ which provides broadside radiation and (ii) $TM_{01\delta}$ which provides omnidirectional radiation pattern [3]. Recently in [4], $EH_{11\delta}$ mode is realized as a new broadside radiating mode. In the case half split CDRA, $TE_{01\delta}$ is used to obtain broadside radiation pattern [5].

In recent years, due to the rapid development of wireless communications, uses of dual-band dielectric resonator antennas (DRAs) are more extensive than ever. Various approaches have been utilized to get the dual-band/dual-frequency operation [6]-[9].

In this paper, a simple aperture coupled half split DRA is proposed for dual-frequency operation. The dual-frequency is achieved by exciting higher order $TE_{02\delta}$ along with the fundamental $TE_{01\delta}$ mode.

II. Antenna Design

Fig. 1 shows the isometric and top view of the proposed antenna. The half-split cylindrical DR is placed at the center of $40mm \times 40mm$ grounded substrate of thickness 0.787mm and made form Rogers RT Duroid 5880 (ϵ_{rs}=2.2). The prototype of DRA under investigation is fabricated using Rogers RT Duroid 6010 (ϵ_r=10.2, $tan\delta$=0.0023). The proposed antenna is fed through an aperture on the ground plane of microstrip line. To achieve the dual-frequency response, excitation of higher order mode design approach is utilized which has inherent advantage of compactness since no additional DRA is required. By properly adjusting the stub length s, it is possible to excite higher order $TE_{02\delta}$ mode along with the fundamental $TE_{01\delta}$ mode.

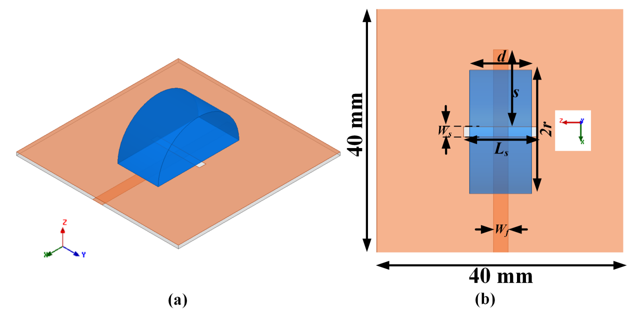

Fig. 1. Proposed antenna (a) Isometric View (b) Top view: *2r=20mm, d=10mm, s=12.5mm, W_f=2.35mm, W_s=1.6mm, L_s=12mm*

III. Results and Discussion

The resonant frequency of an isolated CDRA excited in $TE_{01\delta}$ mode is 4.61 GHz which is determined by the following equation [2]

$$f_r = \frac{2.327}{\sqrt{\epsilon_r + 1}} \left(1 + 0.2123\frac{r}{h} - 0.00898\left(\frac{r}{h}\right)^2\right)\frac{4.7713}{r} \quad (1)$$

A small shift in resonant frequency is observed between the theoretical (4.61 GHz) and simulated one (4.45 GHz) which is due to the aperture and finite ground plane. The second resonant frequency (6.72 GHz) corresponds to higher order $TE_{02\delta}$ mode. Fig. 2 shows the parametric analysis for different stub length. It is observed from the figure that, on changing the length of the stub, s, the second band starts appearing because of higher order mode excitation. This confirms that on properly adjusting the stub length s, one can excite the $TE_{01\delta}$ and simultaneously $TE_{02\delta}$ mode which results in dual-frequency response. Fig. 3 shows the electric field distribution in half split CDRA. It is clear from the field distribution that at 4.45 GHz mode excited is $TE_{01\delta}$ while at 6.72 GHz the mode is $TE_{02\delta}$.

The simulated and measured response of proposed antenna along with the antenna prototype is depicted in Fig. 4. It is observed from the figure that, there is a shift in simulated and measured resonant frequency which can be attributed to the misalignment od DRA with the feeding aperture. Also, a commercially available adhesive is used to stick the DRAs together and to the ground plane and this might also disturbs

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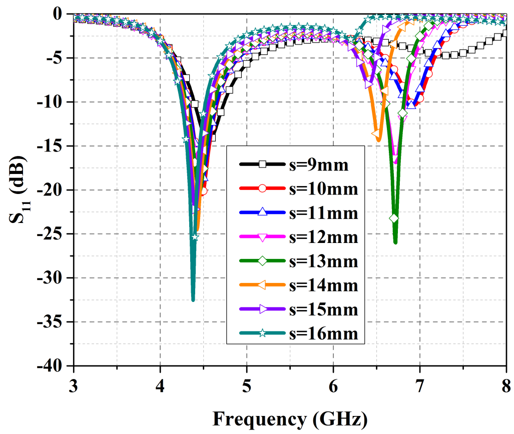

Fig. 2. Parametric variation of stub length

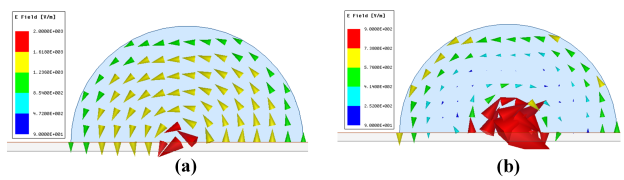

Fig. 3. Electric field distribution at (a) 4.45 GHz (b) 6.72 GHz

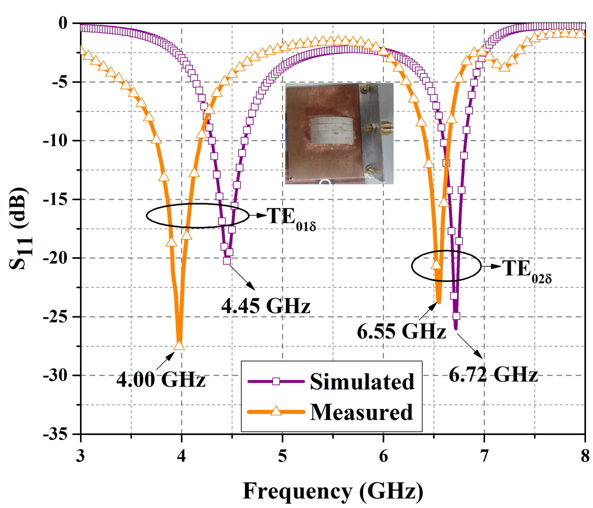

Fig. 4. Measured and simulated S_{11} (dB)

the matching due to which resonant frequency got deviated from the simulated one.

The simulated and measured radiation pattern in yz- and xz-plane is shown in Fig. 5 and Fig. 6, respectively. Both the modes incur broadside radiation pattern. The simulated and measured gain of proposed antenna is 5.6 dBi and 5.4 dBi at first frequency and 5.47 dBi and 5.1 dBi at second frequency, respectively. The proposed antenna can be scaled to any frequency (by changing DR dimensions and its dielectric constant) to realized it for more practical applications.

IV. Conclusion

An aperture coupled half split cylindrical dielectric resonator antenna for dual frequency operation has been proposed.

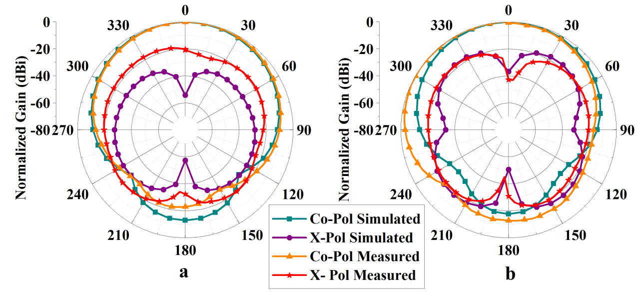

Fig. 5. Radiation Pattern in yz-plane at (a) 4.00 GHz (b) 6.55 GHz

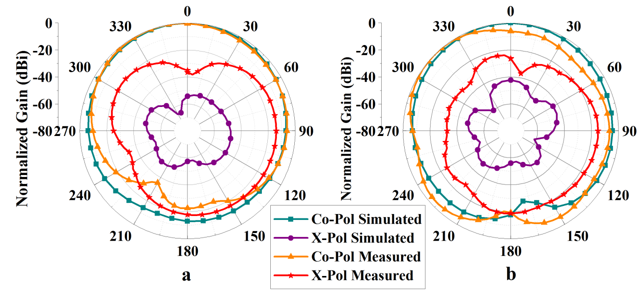

Fig. 6. Radiation Pattern in xz-plane at (a) 4.00 GHz (b) 6.55 GHz

The dual-frequency is achieved by simultaneously exciting $TE_{01\delta}$ and $TE_{02\delta}$ modes of half split CDRA. The proposed antenna exhibits broadside radiation with measured cross polarized level below -18 dB. The measured gain of proposed antenna is 5.4 dBi and 5.1 dBi, respectively at first and second frequency.

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