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Compact Dual Band Cylindrical Resonator Antenna Using a Conformal Feed

Engineering

KEYWORDS : Ceramic dielectric material, dielectric resonator antenna (DRA), dual band, fundamental mode

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ABSTRACT

A dual band dielectric resonator antenna (DRA) which is compact in size using a conformal feed by a microstrip line is proposed. In this configuration, the dielectric resonator shows the functions of an effective antenna and the feeding through a conformal metal strip is used in the structure to excite a cylindrical DRA with HEM11δ and HEM12δ. By optimizing the proposed structure parameters, the structure resonates at two different frequencies. One is from the DRA and the other from the conformal metal strip. In order to determine the performance of varying design parameters on bandwidth and resonant frequency, the parametric study is carried out using finite element method based simulation software Ansys High Frequency Structure Simulator. The antenna has bandwidth and peak gain of 3.5%, 5dBi and 8.2%, 7dBi at the resonant frequencies of 3.9 GHz and 8.6 GHz, respectively and it finds suitable applications in communication system.

I. INTRODUCTION

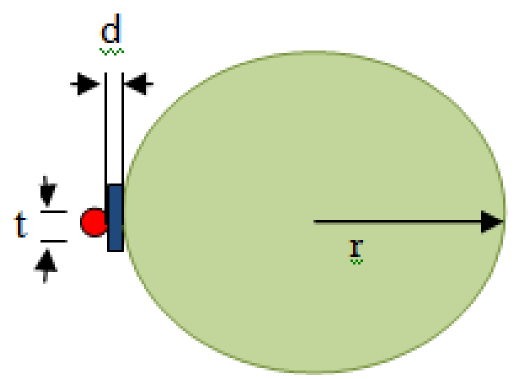
Dielectric resonators Antenna (DRA) is very much suitable for radiation. It radiates through its whole surface unlike the microstrip patch, which radiates through slot or edges only. Also they have low loss, high permittivity, light weight, high efficiency and generally called as compact radiators for microwave and higher frequencies [1-2]. Other advantages are wide bandwidth, low dissipation loss at high frequency and high radiation efficiency as there is no conductor and no surface wave losses. A DRA along with a resonator in the feeding structure can be called as hybrid dielectric resonator. The other radiator is a metal in any shape can be placed much closed to the DRA. Such hybrid antenna offer, dual-band and wide band operation without increasing antenna volume.

In this paper the same cylindrical DRA with modified feeding technique i.e. conformal metal strip with probe is used. Good resonance at 3.9 GHz (S- band) for blue tooth, Wi-Fi , cellular phone applications and at 8.6 GHz(X- band) for RADAR applications was noticed.

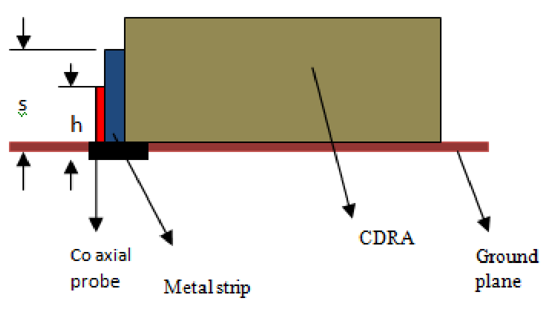
The CDRA reported in [2] was covering single band with a percentage bandwidth of 1.6%. In this paper, an attempt of modified feeding technique is taken to be fit for dual band application. Further the antenna (Fig. 1-a) offers two resonating bands with centre frequencies, one at 3.9GHz (%bandwidth = 3.5) and other at 8.6GHz (% bandwidth = 8.1) without sacrificing the dimension. The optimum height of probe and relative permittivity is determined through systematic study of return losses at the two bands. It is observed that the lower resonant frequency 3.9 GHz can be excited with fundamental mode HEM11δ and higher resonant frequency 8.6 GHz is excited with higher mode HEM12δ..

II. ANTENNA CONFIGURATION

The geometry of proposed antenna is shown in Fig. 1.The dielectric Arlon AR1000(tm) of permittivity10.2 is given a shape of cylinder. A conformal metal strip is attached to the cylinder surface and the strip is connected to SMA probe. As the excitation is conformal so the disturbance due to penetration is avoided. The proposed model is simulated using Ansys HFSS. The optimized dimensions are: εr = 10.2, cylinder radius r =10mm, Probe height h = 6.5mm, strip height s =8mm.



(a) Top view



(b)Side view

Fig. 1 (a) Top and (b) side view of proposed model

III. RESULTS AND DISCUSSIONS

The simulation of the antenna was carried out one by one. The parametric studies of different probe heights, air gap height-radius, permittivity and height of the DRA is done.

III. A. Optimization of probe heights: Table I shows the operating frequencies and % band width of proposed model. The % bandwidth seen in this study does not show any remarkable value but the matching is good. For several heights of probe, dual band coverage with good return loss at both the frequencies is seen. The best matching is for 6.5 mm of probe height.

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Table 1 Parametric study of probe heights (h) keeping strip height(s) constant = 8mm

Sl no	Probe height h (mm)	Resonant frequency f (GHz)	%BW	S11 (in dB)
1	6.5	3.9,8.6	3.5,8.2	-12,-34
2	6.0	3.9,8.4	3.5,8.1	-12,-32
3	7.0	3.9,8.6	3.5,7.0	-13,-24
4	7.5	3.9,8.6	3.5,7.0	-14,-26

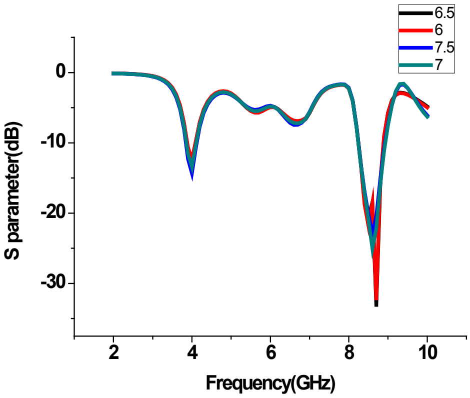


Fig.2 Simulated input reflection coefficient with varying probe heights (h)

III.B. Optimization of relative permittivity:

The matching of antenna is studied for different materials of different relative permittivity. The matching is best for relative permittivity 10. However the parametric study of different relative permittivity to get the matching is shown in the result and the return loss values are summarized in table II. This study opened an idea for material selection to get optimum matching.

Table-II Parametric Study of Different Relative Permittivity keeping probe height (h) = 6.5 mm and strip height (s) = 8 mm.

Sl no	Relative permittivity	Resonant frequency(in GHz)	S_{11} (in dB)
1	3.5	6.4	-16
2	4.5	5.8,9.2	-13,-24
3	6.15	5,8.2	-12,-16
4	10	3.9,8.6	-12,-34

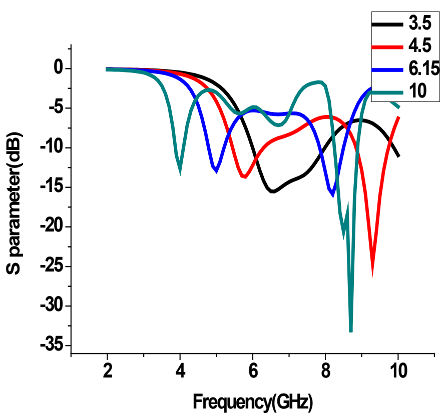
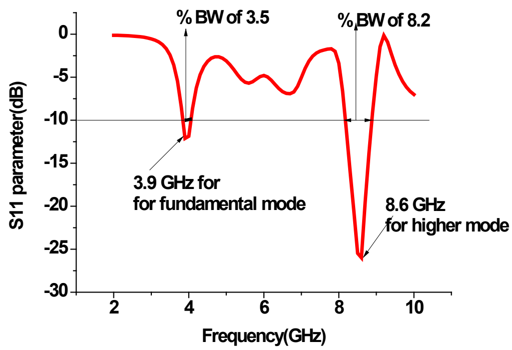


Fig. 3 Simulated input reflection coefficients with varying relative permittivity

Fig. 4 Simulated input reflection coefficient for refined data after parametric study



III C. Modes of operation: From simulation based study optimized probe height, air gap dimension and relative permittivity were determined. Setting the parameters at optimized level the structure was subjected to excitation. The electric field distribution on the surface is found out as shown in figure (6). Very strong electric field exists near the probe and spreads on the surface of DRA. The spreading of electric field shows that t he antenna operates in HEM 12δ mode for operating frequency 8.6GHz (fig 5 - i) and HEM11δ for 3.9 GHz (fig 5 –ii).

Fig. 5(i) Electric field at 8.6 GHz (HEM12δ mode) in CDRA

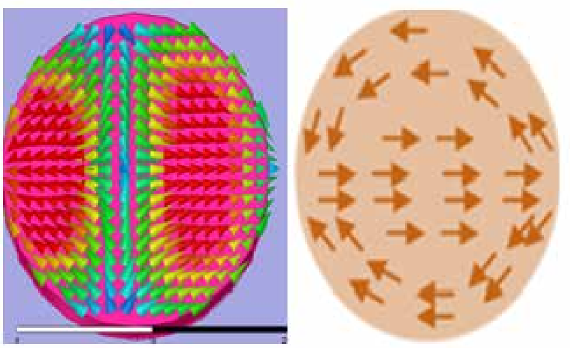
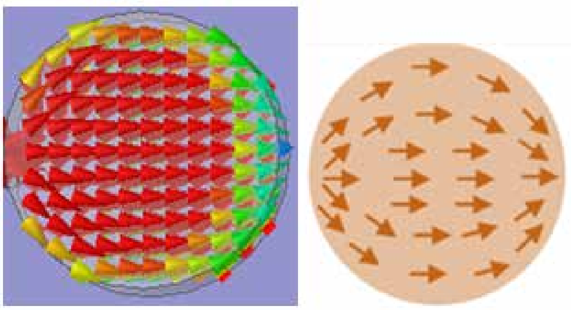


Fig. 5(ii) Electric field distribution at 3.9GHz (HEM11δ mode)



III D. Radiation Pattern: The far field radiation patterns for both the resonating frequencies 3.9 GHz and 8.6 GHz in E plane (YZ-plane) and H plane (XZ- plane) are plotted. It is observed the H plane is broader and Omni directional in nature. The E plane pattern has two nulls in cross polarization.

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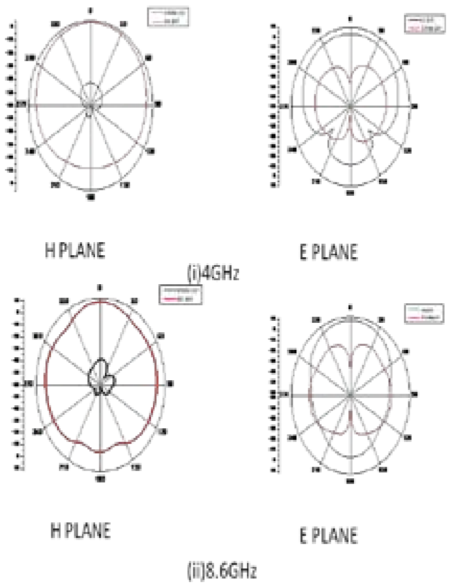

Fig 6. Simulated E plane and H plane radiation patterns of proposed DRA at 3.9 GHz and 8.6GHz

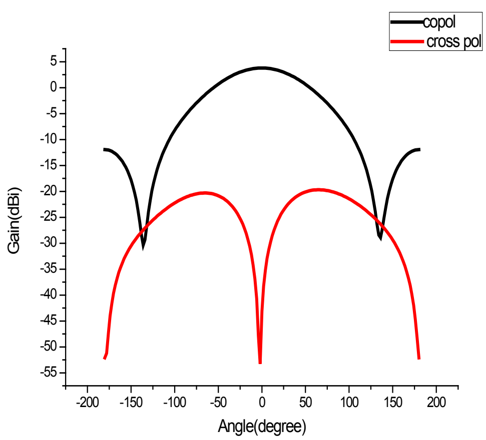

Fig7 (i). Simulated radiation pattern plot for 3.9 GHz(E plane)

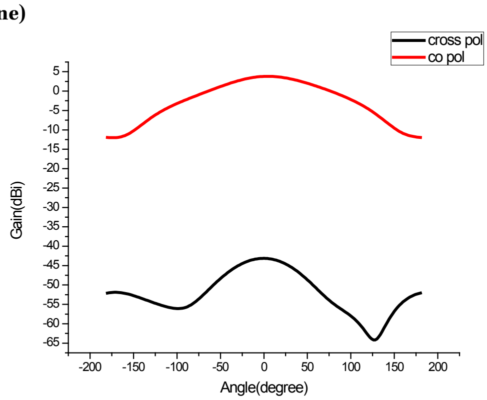

Fig7 (ii). Simulated radiation pattern plot for 3.9 GHz (H plane)

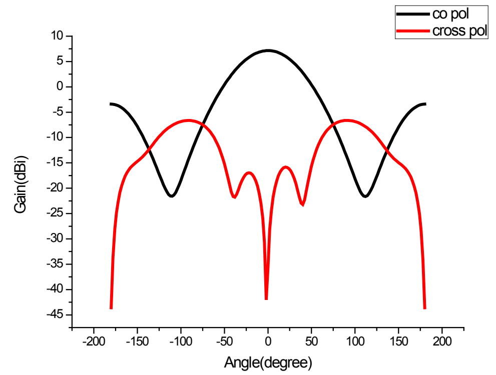

Fig8 (i). Simulated radiation pattern plot for 8.6 GHz (E plane)

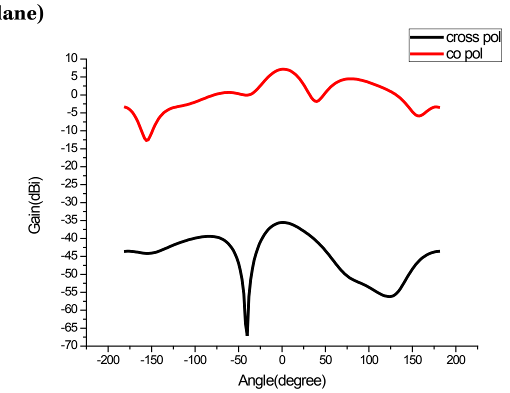

Fig8 (ii). Simulated radiation pattern for 8.6 GHz (H plane)

Table-III Radiation characteristics for different frequency

Sl no	Freq (GHz)	Mode	Co-pol Gain(in dB)	Cross-pol Gain(in dB) H - Plane	Half power Beam width in degrees	
					E plane	H Plane
1	3.9	$HEM_{11\delta}$	5.0	-42	54	70
2	8.6	$HEM_{12\delta}$	7.0	-33	52	44

The co polarization and cross polarization gains are reported in table III for 3.9 GHz and 8.6 GHz. From the figure 7 (i) and (ii) also from figure 8 (i) and (ii) it is observed that the gain is 2 dB higher for 8.6 GHz where the return loss is around -28 dB as compared to other lower resonance frequency 3.9 GHz having return loss of -12dB and co polarization gain of 5 dB.

II E. 3D Radiation Pattern

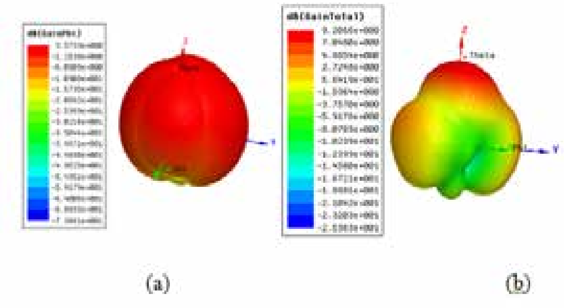

Fig 9. Simulated 3D radiation pattern at (a) 3.9 GHz and at (b) 8.6GHz

The above figure shows the 3D visualization of the far field intensity. It gives the relative distribution of fields. The shape of the radiation pattern is like an apple and the gain is around 3.57 dB at lower resonant frequency and 9.2 dB at higher resonant frequency of operation.

IV. CONCLUSION

A dual-band dielectric resonator antenna (DRA) using a conformal feed by a micros trip line is proposed .With conformal feeding through metal strip, the structural complications is avoided. The design parameters are investigated through parametric study. The electric field distribution shows the higher mode operation in HEM 12δ which is found for one resonating frequency 8.6 GHz. The field strength is very strong on the surface of DRA as compared to the edges. The antenna is found to have a bandwidth as well as antenna peak gain of 3.5%, 5dBi and 8.2%, 7dBi at the resonant frequencies of 3.9 GHz and 8.6 GHz, respectively and the antenna may find suitability to be used in different communication applications.

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