Cylindrical Dielectric Resonator for 1x2 and 2x2 Antenna Array for C Band Application

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Abstract— A dielectric resonator (DR) is made of a dielectric material which is non conductive in nature. The design for the resonator is made such that it generally functions in the millimeter and microwave bands. The waves bounce back and forth inside the resonator due to change in the permittivity at the surface.
This paper discusses the use of dielectric resonator on a circular microstrip patch antenna(CMPA) and the effects of it on different configurations of cylindrical antenna. The key parameters which are observed in this paper are VSWR, S-11, Directivity and Gain. By observing these parameters, we show that with the addition of a dielectric resonator the gain of an antenna increases by a significant value and are more suitable for C-band applications.

Keywords—Dielectric Resonator (DR), Circular microstrip patch antenna(CMPA), Gain, Directivity, S-11, VSWR, C-band.

I. INTRODUCTION

Dielectric Resonator antenna (DRA) is mostly used at microwave frequency and higher, which consists of the chosen material of DR of various shapes and sizes which are then mounted on a metal surface which is an MPA shaped according to the requirement.

The DRA's do not have any metal parts which acts as an advantage since they no longer dissipate energy and do not become lossy at high frequencies. Hence these antennas are more efficient and has very less loss as compared to that of metal antenna's at millimeter wave and microwave frequencies. DRA's also has the capability to avoid surface waves which is lacking in case of a patch antenna.

DRA's are preferred for a lot of research work due to its attractive features of not suffering from metallic losses due to absence of metal which results in high efficiency, large bandwidth and increased gain. The small size of the DRA's also make a suitable option for construction of array of antennas.

II. DESIGN THEORY:

DESIGN OF CMPA:

A single microstrip patch antenna was first designed using RT-Duroid($\epsilon r = 2.2$) as the substrate material at a frequency of 6.17GHz..
The radius of the patch was calculated using the equations in fig-1 and was obtained as 0.879cm.

$$\text{Fringing Field}\Rightarrow F = \frac{8.791 * 10^9}{fr\sqrt{\epsilon r}}$$

$$r = \frac{F}{\left[1 + \frac{2h}{\Pi \epsilon r F}\left(ln\left(\frac{\Pi F}{2h}\right) + 1.7726\right)\right]^{1/2}}$$

Fig-1: radius of patch

The width of the patch was calculated from the equations in fig-2 as was obtained as 0.492cm.

$$B = \frac{377\Pi}{2Zo\sqrt{\epsilon r}}$$

$$\frac{w}{d} = \frac{2}{\Pi}\left[b - 1 - ln(2B - 1) + \frac{\epsilon r - 1}{2\epsilon r}\left\{ln(B - 1) + 0.39 - \frac{0.61}{\epsilon r}\right\}\right]$$

Fig-2: width of the patch

The length of the feedline was calculated from the equations in fig-3 and was obtained as 2.45cm.

$$\epsilon reff = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}\left[1 + 12 * \frac{h}{w}\right]^{-\frac{1}{2}}$$

$$ko = \frac{2\Pi f}{c}$$

$$L = \frac{270^{0}\left(\frac{\Pi}{180}\right)}{\sqrt{\epsilon reff * ko}}$$

Fig-3: length of the feedline

A single circular microstrip patch antenna (CMPA) was designed, simulated and optimized using the obtained values from Fig-1, Fig-2 and Fig-3 and the S-11,VSWR,GAIN and directivity parameters were observed and noted.

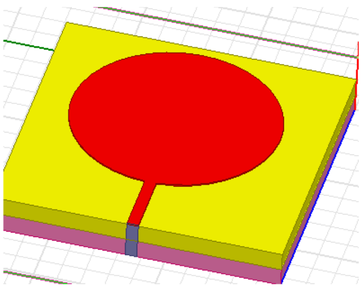

Fig-4:Model of a single CMPA.

Similarly, the arrays of the antenna are constructed keeping the distance of separation between $\boldsymbol{\lambda}/2$ to $\boldsymbol{\lambda}$ as shown in Fig-5 and Fig-6.

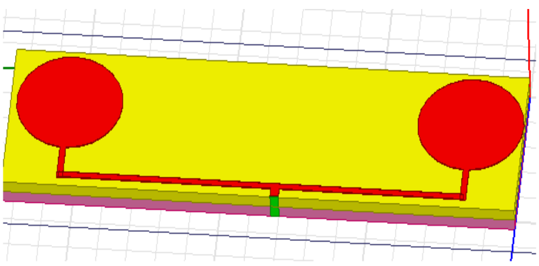

Fig-5: Model of a 1x2 array

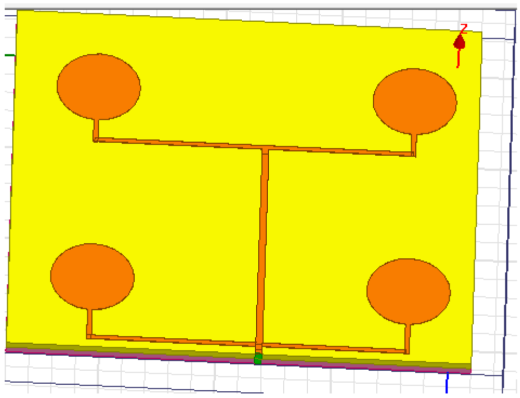

Fig-6:Model of a 2x2 array.

The values of S-11,VSWR, Gain and Directivity are observed and noted for each of these configurations for further comparisons with the CDRA and CDRA arrays.

DESIGN OF CDRA:

To calculate the height of the Dielectric resonator we use the equation shown in Fig-7.

$$h = \frac{\lambda}{\sqrt{\epsilon r}}$$

Fig-7:height of Dielectric resonator

Three materials were considered to design the Dielectric resonator so that the best suitable material for the designed patch antenna is obtained after placing it on the single patch.The three materials considered were tantalum,pentoxide ($\epsilon r = 27.7$), porcelain$\epsilon r = (6.5)$, and teflon ($\epsilon r = (2.1)$.

Material of DR	S-11	VSWR	GAIN	DIRECTIVITY
Tantalum Pentoxide	**-16.05**	**1.928**	**4.9926**	**5.097**
Porcelein	-12.74	1.87	3.12	4.98
Teflon	-13.39	1.765	2.31	3.98

Table-1: summary of the obtained values of the respective DR material.

From table-1 it is observed that after placing each material of the resonator individually on the single patch, tantalum pentoxide has the highest value of gain and directivity. The return loss(S-11) and the VSWR are in the feasible region(between 1 and 2).

Hence tantalum pentoxide is the suitable material for the construction of the DRA.

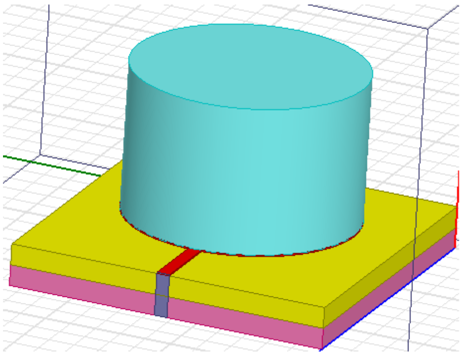

Fig-7-Model of a single DRA

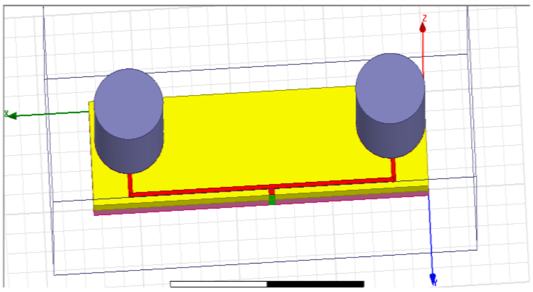

Fig-8a: Model of a 1x2 CDRA array

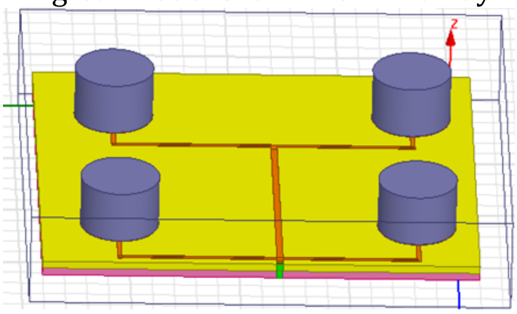

Fig-8b-Model of 2x2 CDRA array

The simulations were performed in the HFSS software again after placing the DR on the patch of microstrip antenna's designed and the VSWR, S-11, Gain and Directivity parameters were observed.

III. RESULTS AND ANALYSIS

In this research work, the simulation results indicate that there was an increase of 2dB gain and directivity in the single CMPA and a similar increase of 2dB was observed in gain and directivity for a 1x2 array configuration after placing the dielectric resonator on the top of the CMPA antenna's. However there was a significantly large increase in gain and directivity by a margin of 6dB in 2x2 array configuration when the dielectric resonator was placed on the antenna elements which is also shown in the table-2 below.

IV. CONCLUSION

The different antenna configurations were designed as a microstrip patch antenna and the VSWR, S-11, Gain and Directivity parameters were noted for each configuration. A suitable dielectric resonator was designed, compared and the best suitable material was chosen to place the resonator on top of the CMPA designed and the parameters were noted again. It was observed that with the addition of a dielectric resonator there was a significant increase in gain and directivity which infers that the losses have reduced to a great extent.

V. REFERENCES

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