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Aperture-Coupled Symmetric Dielectric Resonators Antenna for X-band Applications

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ABSTRACT

A dielectric resonator (DRA) for X-Band application is designed and a parametric study of its bandwidth is done by varying its design parameters. In this project design, two cylindrical dielectric resonators are placed symmetrical with respect to the centre of rectangular aperture fed through its aperture coupling. By optimizing the design parameters the bandwidth of 3.24dB can be achieved. This DRA is designed to provide bandwidth in X Band frequencies from 9.62 to 12.9GHz and provide a gain of 7.5 dBi. The geometry of antenna design and its specifications is provided in this project. The parametric study, by varying different dimensions and parameters,is done and the simulated resultant plots like reflection coefficient, VSWR, radiation pattern and gain are also plotted.

Keywords: Aperture coupling, symmetric shape, dielectric resonator antenna, micro strip, patch

I. INTRODUCTION

In the present scenario of communications, there is a phenomenal growth in the wireless communications. This led to the development of various types of antennas [1]. This led to the development of various types of antennas. As micro strip antennas have high conductive losses at X-band frequencies, since the advancement of dielectric resonator antenna in 1980, it has been investigated for high band applications at high frequencies [2]. The dielectric resonator antenna has been a remarkable advancement in the antenna design. The dielectric resonator (DR) has been widely used as an energy storage for many years [3]. DRAs have received raising interest for their attractive features, such as high impedance bandwidth, smaller size, the freedom to design their shape and usage of their feeding structure. The shape of a dielectric resonator antennas may vary from rectangular, cylindrical, hemispherical, etc [4]. It may also have non geometrical shapes such as truncated tetrahedron shape, split cone shape and half-hemispherical shape DRAs for bandwidth enhancement [3]. There are different feeding mechanism coaxial probes, slots, micro strip lines, coplanar waveguides [4] used based on the bandwidth requirement.

With an increased demand of bandwidth for voice and data applications demand for wideband and multiband antennas increased over single band antennas [5]. One of the major drawback of DRA is its limited bandwidth. To overcome this limitation, numbers of bandwidth enhancement techniques have evolved over the last few decades. They include stacking two DRAs with two different materials[2], multi layered resonators[3], fractal shaped antennas[4], fractal geometry on a CPW fed slot loop antenna[5], UWB planar monopole antenna integrated with an NB cylindrical DRA[6].

A single cylindrical dielectric resonator can be designed to be excited by two crossed slots[7]. The centers of the two slots are set at definite positions and due to the partial independence of the slot modes from the DRA, a wider bandwidth is achieved.

A novel wideband slot-fed symmetric dielectric resonator antenna is presented. This project aims at producing a new technology for increasing bandwidth by using two cylindrical dielectric resonators. Thus as the title of the project suggests, the two resonators are located on either side of aperture at same distance, thus fed by a single slot. The feed used in this project is rectangular microstrip type which is positioned between the two dielectric resonators. The usage of two dielectric resonators coupled through a single aperture slot from the micro strip feed results in a wider bandwidth.

II. ANTENNA GEOMETRY

The geometry of the suggested antenna is shown in the figure above. The prototype antenna consists of a substrate on which ground is mounted. The rectangular micro strip is placed below the substrate while a rectangular stub is etched on the ground plane. On either side of the stub two DRAs are mounted placed symmetrical to the micro strip fed through the rectangular feed.

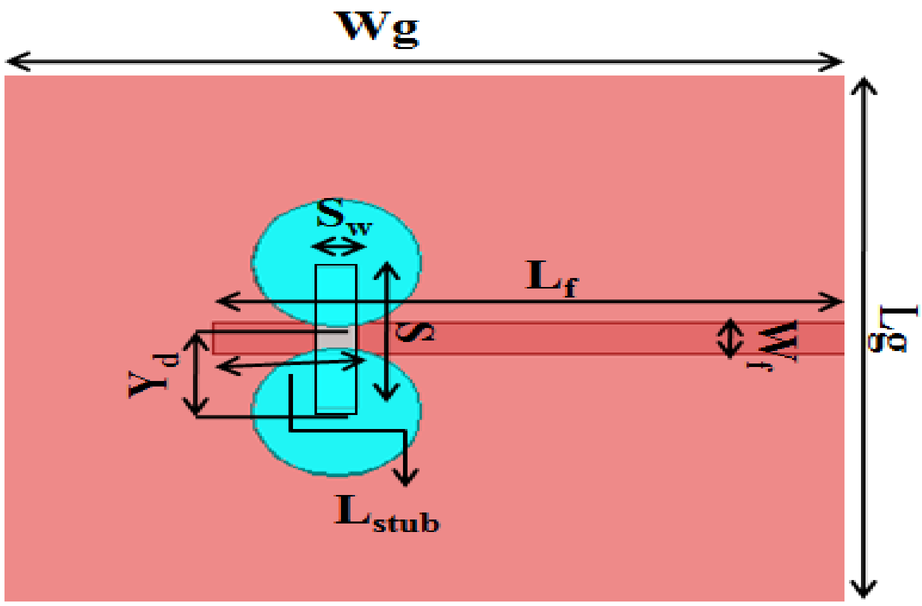

Fig 1 showing the top view of DRA

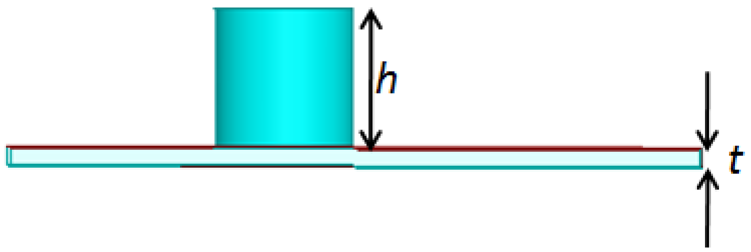

Fig.2 showing the side view of DRA

In the design, FR4 of dielectric constant (ε_r) 4.4 is used as the primary material of the substrate. The dimensions of substrate are 30×25mm^2 with thickness of 0.8mm, having a loss tangent of 0.017. The rectangular micro strip

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of 22.5mm long (L_f) and 1.5mm (W_f) wide is used which excites the DRA. The dimensions of the aperture impact the resonant frequency of the structure and the amount of the undesired radiation in the form of back lobe in the radiation pattern of the antenna. These dimensions also affect the coupling between the radiating resonators and the micro strip line. The dimensions of the stub of length (S) 4mm and width (S_w) 1.2mm is ejected from ground plate are depicted in the figure. The dielectric material used is alumina-96pct of dielectric constant (ε_r) of 9.4.

The diameter *D* of the cylinder and its height *h* is depicted as 6mm and 9mm respectively. The two DRs are offset from the center of the slot at Y_d of 3mm.

III. PARAMETRIC STUDY

In this section, the changes in the resultant response is studied by varing its various parameters. The antenna design is analyzed and optimized using High Frequency Structural Simulator which is based on Finite Element Method (FEM) which is more accurate for designing antennas as compared to other antenna software.

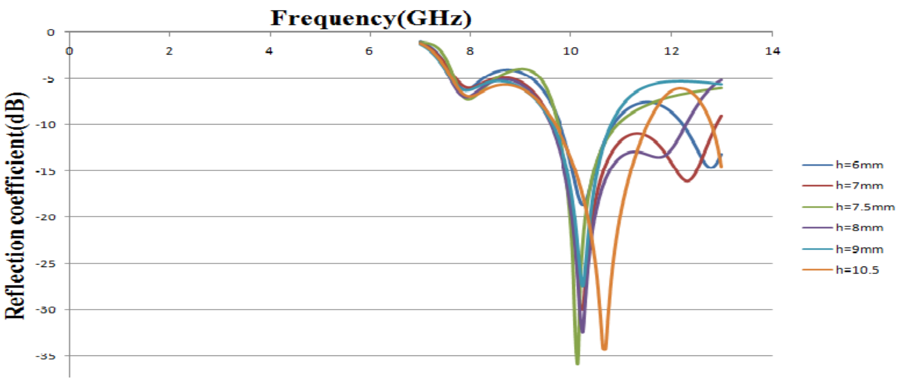

Fig-3: Plot of reflection coefficient with respect to variations in height with S_w=1.5mm,Y_d=3.5mm

The figure 3 below shows the simulated graphs of impedance bandwidth of the DRA by varying the height(h) of antenna. The changes of impedance bandwidth and radiation pattern is also studied by varying the height of the DRA(*h*). It indicates the changes in the resultant plot of DRA are varied from 6mm to 10.5mm. Figure 4 shows the plot of VSWR of DRA when height is varied from 6 to 10.5mm.

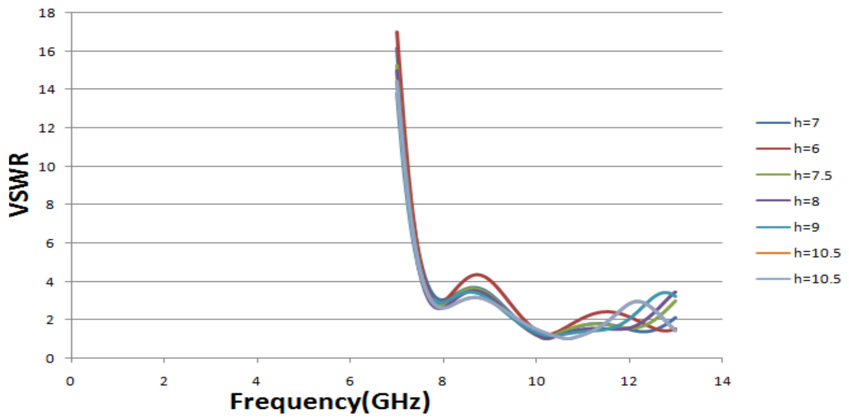

Fig-4: Plot of VSWR with respect to variations in height with S_w=1.5mm,Y_d=3.5mm

The figure 5 below shows the simulated graphs of impedance of the DRA by varying the stub width (S_w) of antenna. It is observed that the bandwidth changes as the thickness of the stub is varied from 0.5mm to 1.5mm. Thus stub thickness (S_w) is a function of antenna bandwidth.

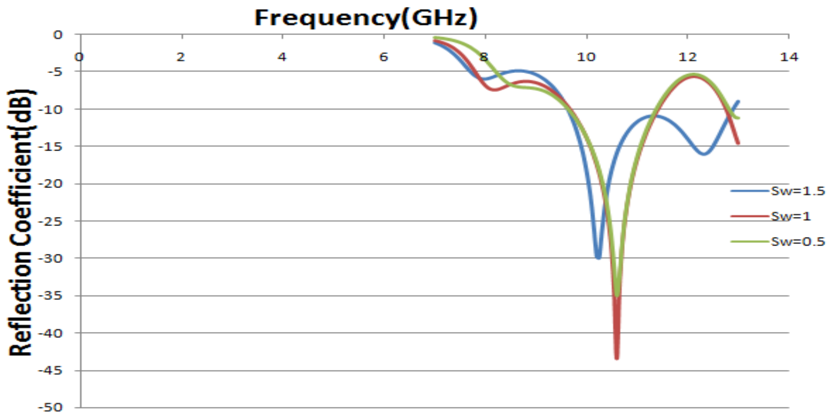

Fig-5: Plot of reflection coefficient with respect to variations in S_w with h=7mm,Y_d=3.5mm

It is noted that optimum bandwidth is obtained when stub thickness is 1.5mm.The figure 6 shows the VSWR plot of the DRA which identifies the operating frequency of the DRA by varying the Sw of the design.

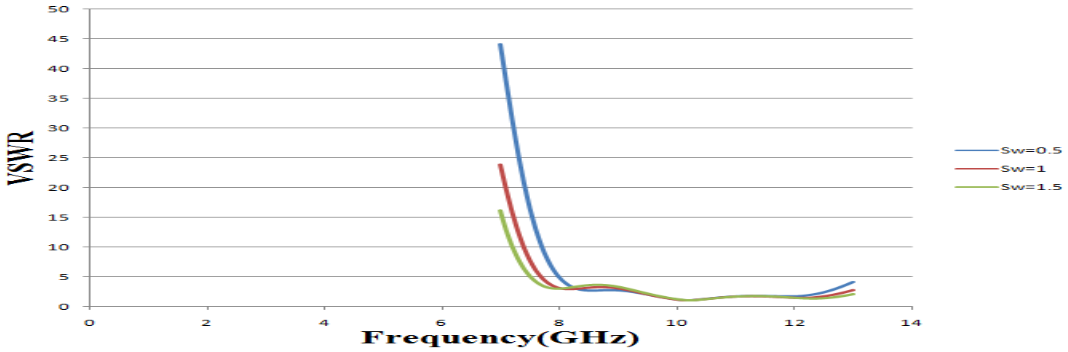

Fig-6: Plot of VSWR with respect to variations in height with S_w=1.5mm,Y_d=3.5mm

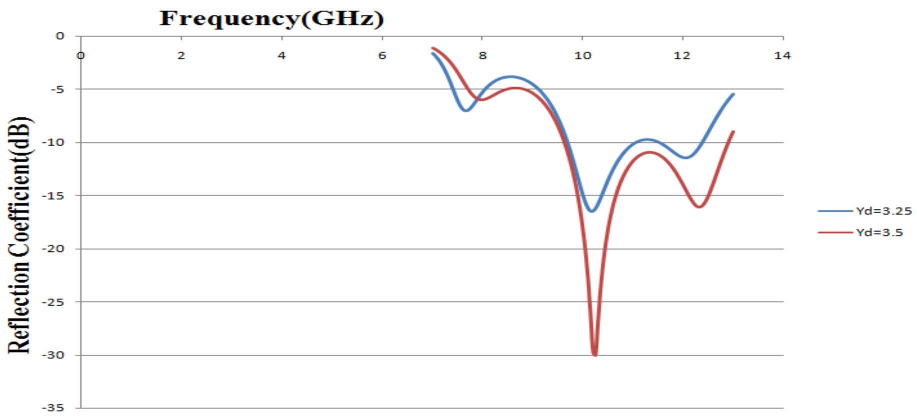

Fig-7: Plot of reflection coefficient with respect to variations in Y_d with S_w=1.5mm,*h*=7mm

The changes of impedance bandwidth and VSWR are also studied by varying the distance between the two DRs. It is observed that the bandwidth increases when the distance (Y_d) increases from3.25 to 3.75. However this is possible only till the distance doesn't exceed the width of the micro strip. The figure 7 is used to indicate these plots. Figure 8 gives the plots of VSWR with varying Y_d.

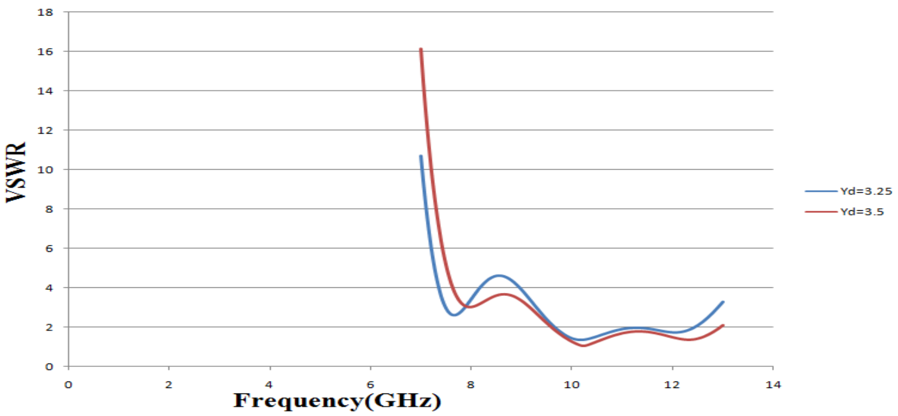

Fig-8: Plot of VSWR with respect to variations in Y_d with h=7mm,S_w=1.5mm

IV. OPTIMIZED DESIGN

On the basis of the detailed study of the plots and other results obtained in the parametric study, the optimized dimensions for the antenna design is decided and experimentally validated and verified. The design parameters are optimized such that they provide maximum bandwidth and gain.

The details of the optimized parameters are as described below. Based on the detailed parametric studies, the optimum dimensions obtained for the antenna are L_g=30mm, W_g=25mm, L_f=22.5mm, W_f=1.5mm, D=6mm, h=7mm, S=6.6mm, S_w=1.5mm, L_{stub}=4mm, Y_d=3.5mm. The figures above show the plots of optimized antenna.

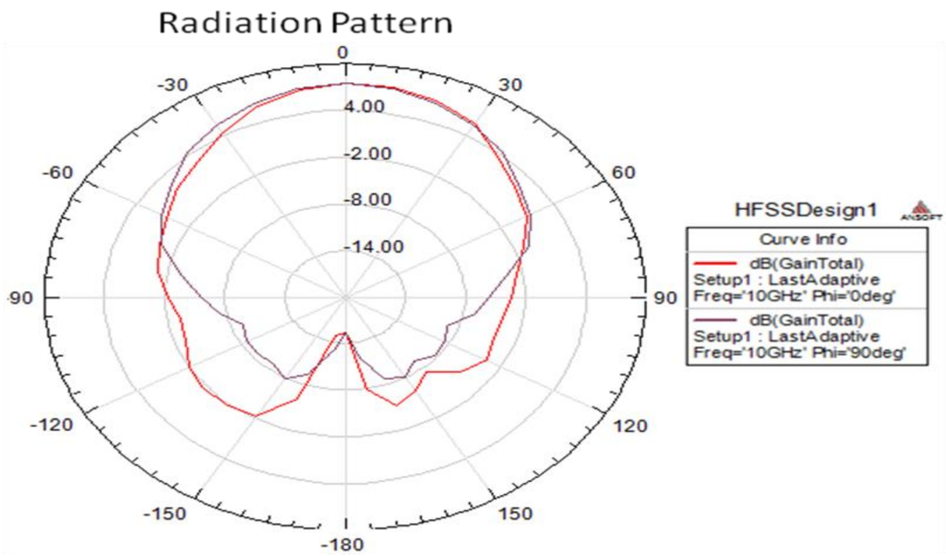

Fig-9: 2-D Radiation pattern of directivity of an optimized antenna in E-plane and H-Plane

Fig. 9 shows the radiation pattern of proposed optimized antenna. Fig. 10 shows the 3- dimensional radiation pattern of the proposed optimized antenna design. It is observed that the antenna gives a bandwidth of 3.24dB in the X-band range of frequencies. It covers X-band frequencies ranging from 9.62GHz to 12.9GHz shows the radiation pattern of the proposed antenna and 7.5dB gives the gain obtained from the optimized design.

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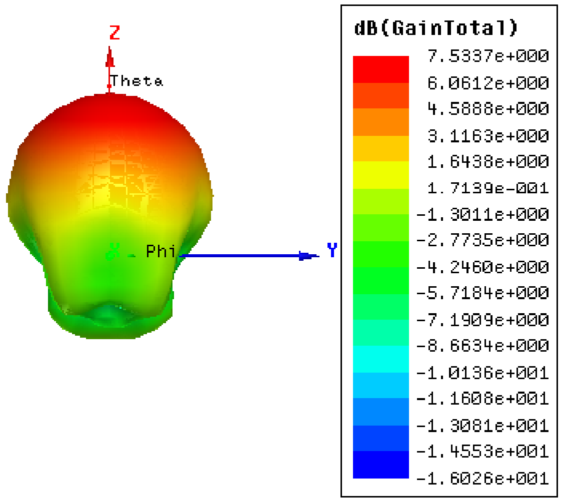

Fig-10: 3-D Polar plot of radiation pattern of optimized antenna

V. CONCLUSIONS

A compact dielectric resonator antenna for wideband applications has been demonstrated. The use of a pair of dielectric resonators enhances the characteristics and performance of the antenna. The symmetric positioning of the two resonators introduces a novel technique of enhancing bandwidth. From the antenna design, an impedance bandwidth 3.24dB is obtained in the X-band frequencies ranging from 9.62GHz to 12.9GHz and a gain of 7.5dB is obtained.

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