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Design of Dielectric Resonator Antenna with Plus Shaped Dielectric for Satellite Communication

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Abstract: DRAs are basically radiating resonators that can transform the guided waves into unguided waves (RF signals). The dielectric resonator antennas have been used the material of ceramic which has property of high permittivity and high Q factor (between 20 and 2000) in the past[4].This paper presents a wideband dielectric resonator antenna for satellite communication. The FR4 glass epoxy substrate is used to design the antenna with relative permittivity 4.4 and thickness 1.6mm. The proposed antenna has a compact size of 45 * 50 * 1.6 mm^3 and is fed by circular feed network. The -10 dB impedance bandwidth of proposed antenna is simulated for the 1 GHz to 10 GHz. The antenna has the resonant frequency at 4.18 GHz and 7.8GHz. The antenna is designed and simulated by using HFSS (High Frequency Structure Simulator) version 13 software.
Keywords: Microstrip Antenna, Dielectric resonator antenna, wideband antenna, satellites applications

I. INTRODUCTION

Dielectric resonator antennas (DRAs) have various advantages so that it can replace traditional radiating elements which were operated at very high frequencies, especially for millimeters wave applications and also for high frequency applications. There are some characteristic than make DRA a promising candidate in the field of antenna structure these are as follows. There are no conduction losses in the dielectric resonator antenna and the DRA's have high radiation efficiency when they are excited properly. The basic principle of operation of the cavity resonator and dielectric resonator antenna are almost same. DRAs are similar to the radiating resonators that can transform guided waves into unguided waves (RF signals).

Aftab Ahmad Khan et al. in [17] presented a novel dual-band multiple-input multiple-output (MIMO) rectangular dielectric resonator antenna (DRA) for Worldwide interoperability for microwave access (WiMAX) (3.4–3.7) GHz and wireless local area network (WLAN) (5.15–5.35) GHz applications is proposed and investigated. The design operates at fundamental $TE_{\delta 11}$ x , $TE_{1\delta 1}$ y and higher order $TE_{\delta 21}$ x , $TE_{2\delta 1}$ y modes, excited through two coaxial probes, symmetrically placed adjacent to the DRA. A compact design is achieved by stacking a high permittivity material. The obtained impedance bandwidth at 3.6 GHz is 9.97% and at 5.2 GHz is 8.88%. Measured antenna gain through both ports at 3.6 GHz is 5.7 dBi and at 5.2 GHz is 6.61 dBi, respectively. Isolation achieved at 3.6 GHz is −13 dB and at 5.2 GHz is −16 dB, respectively. Co- and cross-polarisation, radiation efficiency, diversity gain, envelope correlation and mean effective gain of the proposed design are measured. Results show that the proposed design is suitable for use in MIMO WiMAX/WLAN applications

In this paper, the proposed antenna consists of DRA design with plus shaped dielectric material having dielectric constant 30 by circular feed network. The design was simulated at high frequency structure simulator. The antenna, which has compact dimensions of 45 * 50 mm^2, is printed on the top of Substrate FR4_epoxy of thickness 1.6 mm, relative permittivity 4.4 and tangent loss is 0.02. The dimension of the ground plane is same as the substrate dimension. The excitation of 50 ohms through co-axial probe feed is given to the patch. The design dimensions of the proposed antenna are obtained using HFSS (High Frequency Structural Simulator). The HFSS is based on the Finite Element Method (FEM) to simulate the proposed antenna.

II. PROPOSED WORK

The research will start with comprehensive literature review and will be carried theoretically and through simulations using software simulation package like High Frequency structure simulator (HFSS). HFSS software will be used for selection of design parameters and simulation to analyze and optimize the antenna's characteristics and performance.

First of all antenna design parameters are to be selected such as antenna size, length and breadth of DRA structure over the ground plane, resonant frequencies, feed point location, shorting plate size and location.

A. Selection of design parameters like size of antenna, substrate material, feed technique etc.
B. Designing and modeling the antenna structure in the software.
C. Simulating and optimizing the antenna structure to achieve desired frequency bands.

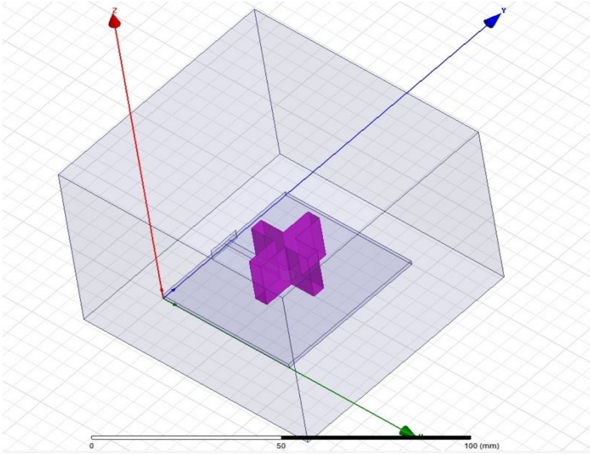

Figure 1. Proposed Design

III. RESULTS

Figure 2 shows S_{11} parameters (return loss) for the dielectric resonator antenna that resonates at 4.18 GHz and 7.09GHz having value of -26.74 and -17.89 dB. The bandwidth of the antenna can be said to be those range of frequencies over which the return loss is less than -10 dB (corresponds to a VSWR of 2). The overall bandwidth coverage is 2 GHz which covers the satellite communication bands. Thus, the bandwidth of antenna is the difference between the maximum frequency and minimum frequency that can be calculated from return loss versus frequency plot. A rectangular high dielectric material is used placed on the top of circular feed design. The return loss is considered good when it shows the deep peak which means there is very less signal power return to the input side.

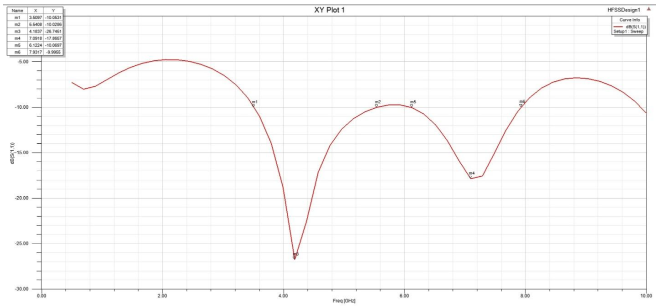

Figure 2 Return Loss

Fig. 3 indicates the voltage standing wave ratio (VSWR) of the proposed DRA antenna. The assessment of VSWR is below 3 that can be observed from the graph clearly. It shows 0.8 dB VSWR at resonant frequencies respectively. These values are below the acceptable level of 2 dB.

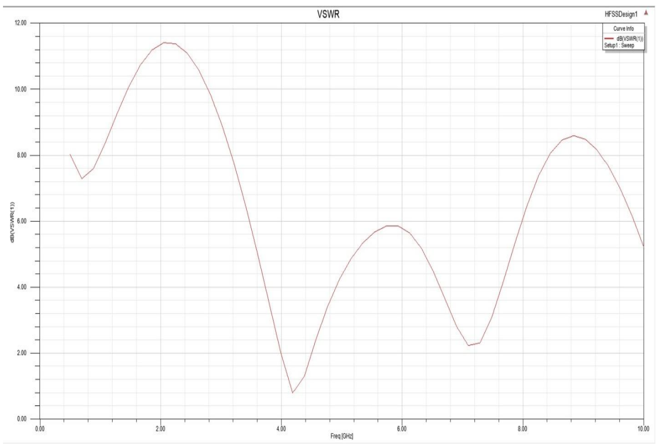

Figure 3 VSWR plot

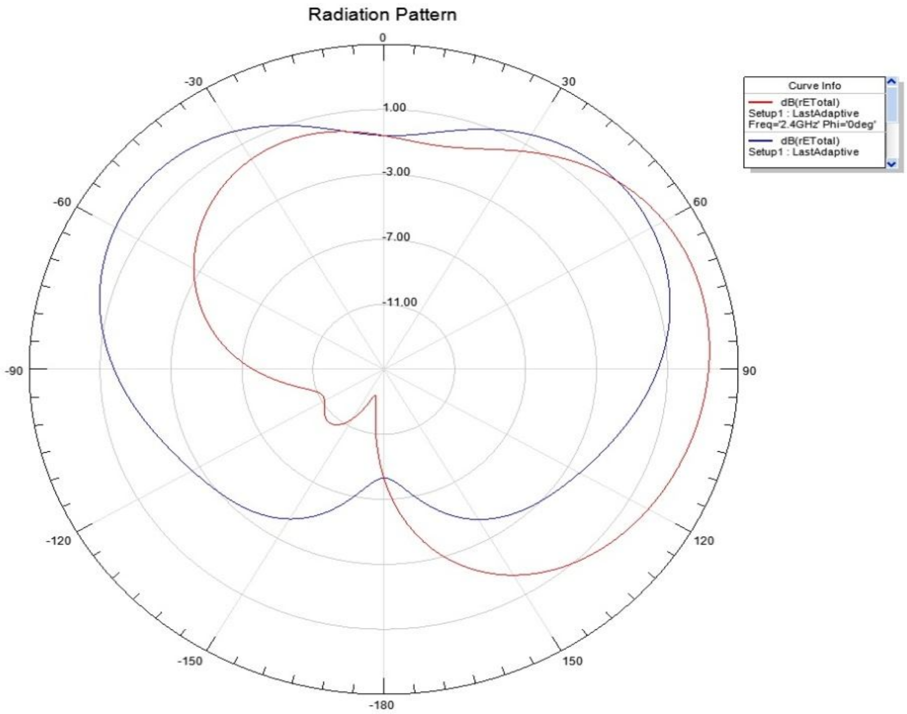

Figure 4 Radiation Pattern.

IV. CONCLUSION

In this paper, a compact DRA antenna for 4G LTE band with enhanced bandwidth is studied and analyzed. Overall dimensions of the proposed antenna are 50 mm × 45 mm. The simulated return loss of the proposed antenna is shown in Figure 4.3. Return loss of -26.74 dB is obtained at resonant frequency of 4.18GHz. Simulation results show that the proposed antenna covers impedance bandwidth of 2 GHz in satellite communication frequency range. There is considerable reduction in overall size, improvement in bandwidth and gain using the proposed DRA antenna with novel circular feed structure. The physical parameters examined in this study include the substrates and their dielectric constants; feed line and dielectric material dimensions. The antenna parameters like operating frequency, VSWR, Bandwidth, Return loss, radiation pattern and gain are determined.

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