Parametric Analysis of Composite Structure Dielectric Resonator Antenna for 5G Applications

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Abstract

With the advanced researches in the field of communication , the wired communication mediums are shifting towards becoming wireless. Therefore, for achieving high efficieny, low loss & affordability in wireless technology, efficient & compact radiators are required. DRA is One of those efficient radiators. Here in this paper, a compact & combined (DRA) Dielectric Resonator Antenna Structure has been investigated. The Proposed DRA is made by combinning 2 QHDRAs & 1 CDRA & operates at a frequency of 27.176GHz. In this project, different parametric studies of Gain, Directivity, Return Loss & Radiation Patterns, for future 5G Uses (millimeter frequency).For enhancement of the bandwidth, Micro-strip line & DRA are used . Various aspects of return loss improvement, bandwidth enhancement, Gain Enhancement have been Studied & explained. Results for Bandwidth, radiation pattern, gain and reflection coefficient are analyzed using CST Studio (2019).In this Project Gain of the designed Antenna is 6.2 dbi. The radiation efficiency of 80.2%& impedance (IBW) bandwidth value is more than 15%. The designed antenna structure with mentioned materials and their values respectively is a good design for future 5G applications.

Keywords 1

Cylindrical DRA (CDRA, Micro-strip, Quarter Hemispherical DRA (QHDRA), Dielectric Resonator Antenna (DRA)

1. Introduction

Nowadays, Wireless Technology is evolving with fast speed [1]. Mostly many of the present communication instruments & device operates in a spectrum, less than 3GHz (cellular spectrum) [2]. The frequency spectrum being used presently, is heavily crowded due to increase in the quantity of devices. This problem is resolved by using milli-meter wave frequency because it is minimally used &.therefore it is a better choice for future 5G Technology[2].

Milli-meter-wave bands includes:- 26, 27, 28, 38 & 60 GHz [3]. The most suitable band for the 5G communication systems are 27, 28 & 38 GHz because they have least atmospheric absorption [4].Here Dielectric Resonator is choosed because it does not have metallic parts,which becomes lossy higher frequencies [5].DRAs Various aspects like:- merging, bandwidth enhancement techniques, optimization & modelling technique for constructing DRAs are studied extensively before starting the designing & simulation[6]. DRA is made of a dielectric structure which is not conducting & offers very low loss and excited with a Micro-strip feeding line.

From the Past researches,different shapes of Dielectric Resonator are provided in the literature[7] like:- cone, cylinder, rectangle, hemisphere etc. &designing methods forabove mentioned shapes are explained[7].

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In the literature,different composite designs of DRA are explained well[8].The composite cylindrical DRAs have also been studied [9].The hemi-sphere structure perfectly radiates uniform radiations.This composite structure produces larger bandwidth, enhanced gain and improved radiation pattern. Here, DRA is excited by using micro-strip excitation technique[10]. The number of researches in past is very less in field of Q-HDRA. This paper target is to explore the capability of the proposed structure at 27.176GHzfrequency& also to attract Antenna designers for making more progress in the composite design field of DRA. In this Research paper, one small size structure of antenna is proposed that consists of 2 QHDRAs & 1CDRA [11] which operates at frequency of 27.13 GHz. Micro-strip slot aperture feeding technique was used for feeding the DRA .

2. Antenna Configuration

The Proposed structure of Antenna Comprises of Composite Dielectric Resonator Antenna which Consists of 2 QHDRA & 1CDRA,placed on a silver Ground Plane. The Ground Plane has length (a) = 10 mm, breadth (b) = 9 mm and height (c) = 0.254 mm. Substrate of Rogers RT 5880 (dielectric constant =2.2) is used with length and breadth equal to that of ground, and height(d) is 2.74 mm. The Substrate contains a slot of dimension e=4 mm, f=0.30 mm and the height of slot is same as height of substrate. The antenna is coupled with a Micro-strip having dimensions p=5.01 mm, q=1 mm and r= 0.05 mm. Copper (annealed) is used as the material for micro-strip feed line. The bottom of micro-strip is 2.55 mm above to the bottom of substrate. A QHDRA is obtained by Cutting a sphere whose radius is 2 mm. A CDRA having height of 2.3mm & radius about 0.5 mm is kept at the centre of substrate Rogers RT 6010 M with Epsilon 10.7 is used for both QHDRA and Rogers RT 5880 is used for CDRA. Dielectric Resonator Antennas are kept on the top of substrate.

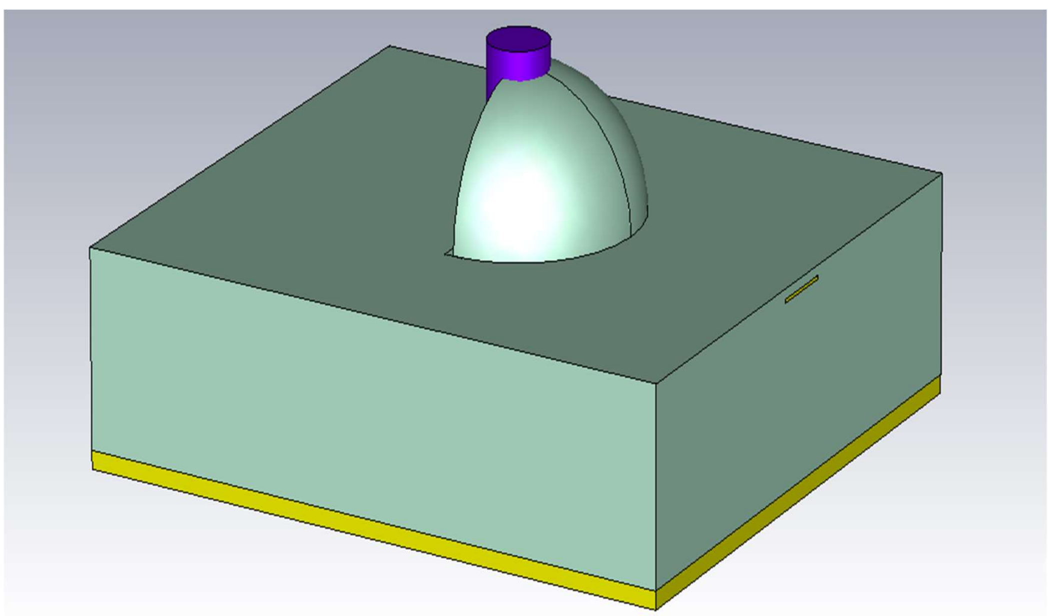

Figure 1: Perspective view of the Proposed Composite Dielectric Resonator Antenna

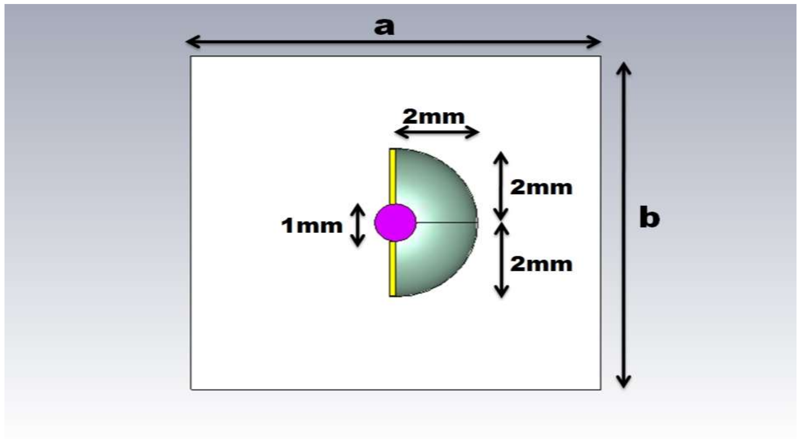

Figure 2: Top view of Proposed Composite Dielectric Resonator Antenna

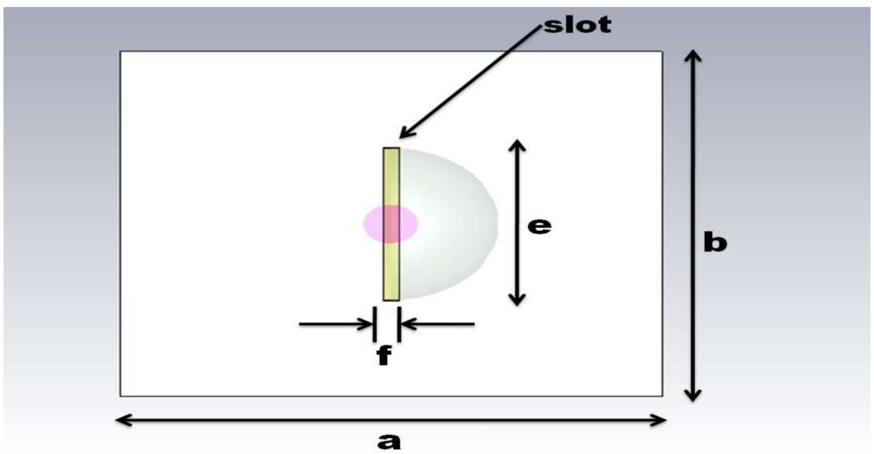

Figure 3: Bottom plane view of Composite Dielectric Resonator Antenna

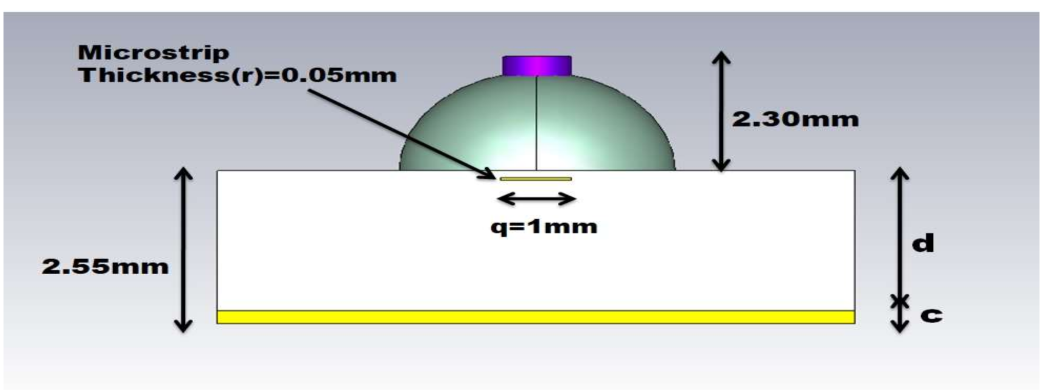

Figure 4: Right Side view of Composite Dielectric Resonator Antenna

3. Results

In this paper, the QHDRA one was prepared by cutting ¼ part from a whole complete sphere. The sphere radius was about 2 mm. Similarly the second QHDRA has been designed with the equal radius but QHDRA 2 was cut in a way that it was smaller than QHDRA 1.The ¼ parts cut from the Sphere are placed side by side thereby forming combined QHDRA structure. A CDRA was also attached to the Combined QHDRA structure, thereby forming the proposed design.The Antenna structure shown in figure 1 is feeded by MSA feedingtechnique.The Return Loss graph is shown in figure 5. The designed Antenna shows a dip of -62 db (approx). The designed antenna resonate at 27.176 GHzfrequency. The Gain of the designed antenna is 6.2 dbi at 27.176 GHz frequency as shown in figure 10. Figure 6 & 7 shows radiation pattern Corresponding to S 11 minima frequency in principal planes.

The radiation pattern indicates that the proposed structure has a broadside radiation pattern in all the bands.Figure 8 shows the proposed antenna structure efficiency. The Efficiency is 0.802(80.2%)which was observed at 27.176 GHz frequency. Impedence (Z-Parameter) matching with 50 ohm connector is very good and is shown in figure 9. The admittence (Y parameter) is shown in figure 12.The Proposed Antenna Structure has a very good VSWR i.e. 1 at the resonance frequency (27.176GHz) shown in figure 11. Here the VSWR value denotes that voltage has a constant magnitude along the transmission line.

4. Conclusion

A Composite Antenna design which consist 1 CDRA & 2 QHDRAs is proposed which can be used for future 5G uses. The operating bandwidth of 2.8GHz & Gain of 6.2 dbi is achieved.The Proposed Antenna Structure provides sufficient bandwidth at 27.176 GHz which is quite suitable for intended 5G applications.

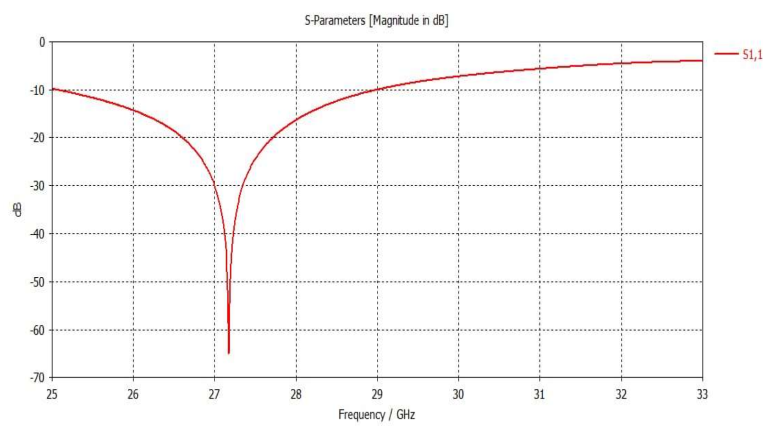

Figure 5: Return loss characteristics (S-parameter vs. Frequency)

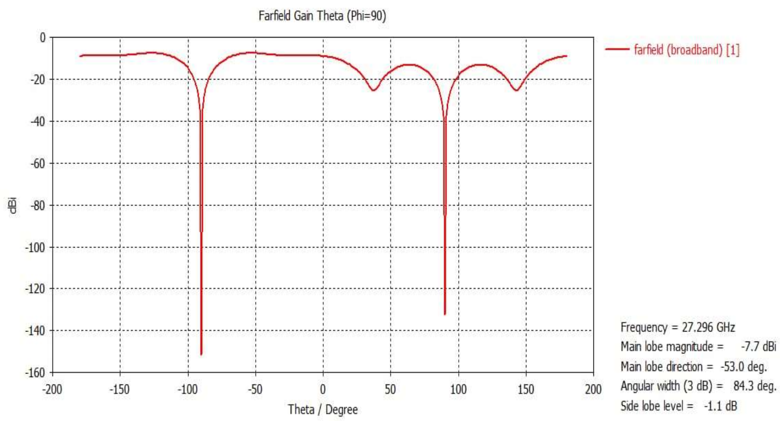

Figure 6: Radiation Pattern Graph (Variation of gain theta when phi =90)

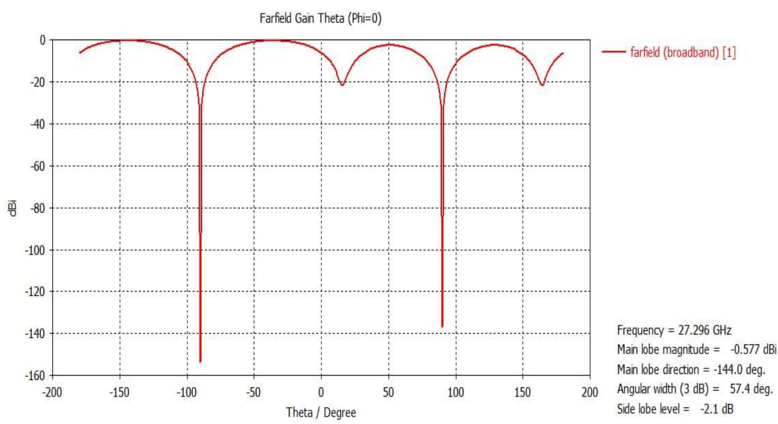

Figure 7: Radiation Pattern Graph (Variation of gain theta when phi = 0)

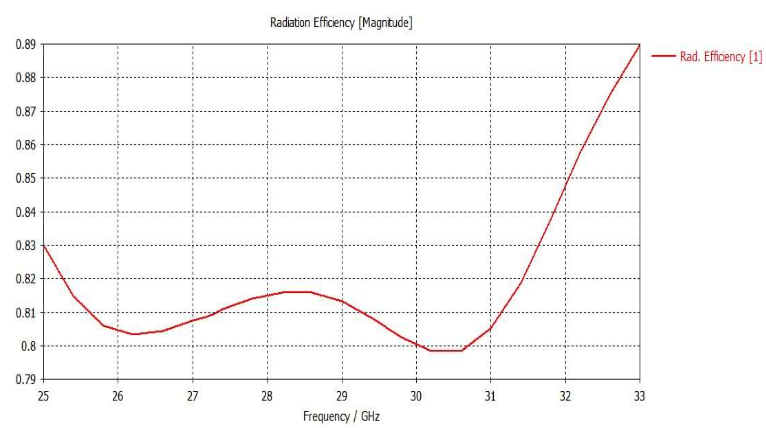

Figure 8: Variation of Radiation Efficiency over frequency Graph at 27.176 GHz Frequency (Efficiency of antenna)

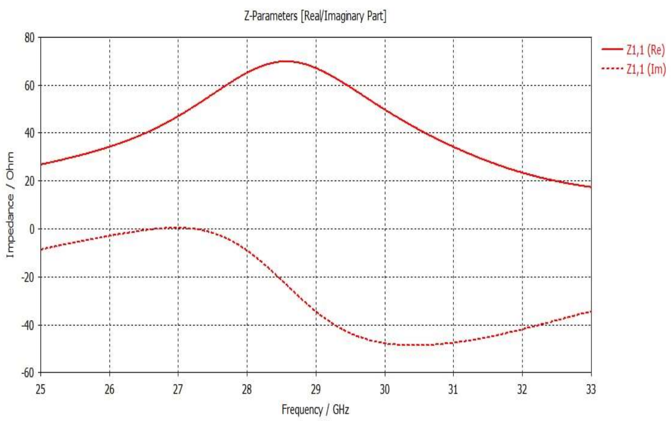

Figure 9: Impedance Graph at 27.176 GHz Frequency (Variation of Z – Parameter over frequency)

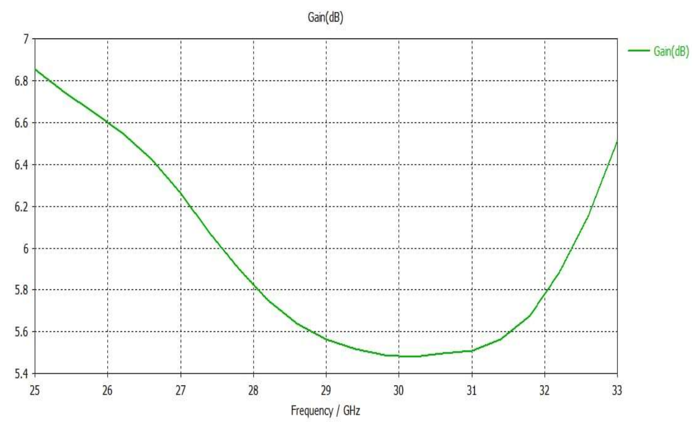

Figure 10: Variation of Gain over Frequency Graph (at 27.176 GHz Frequency)

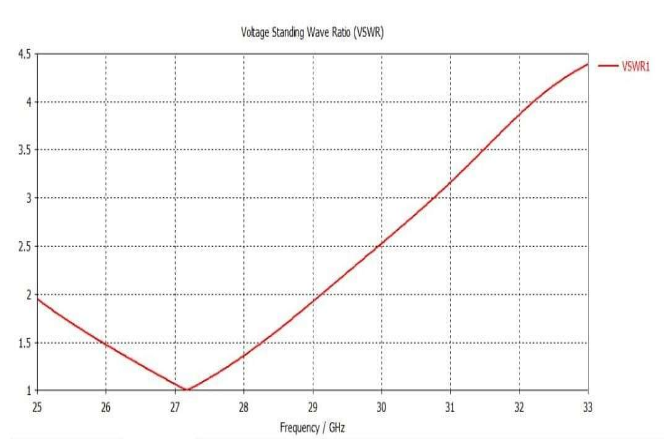

Figure 11: Variation of VSWR over Frequency (at 27.176 GHz Frequency)

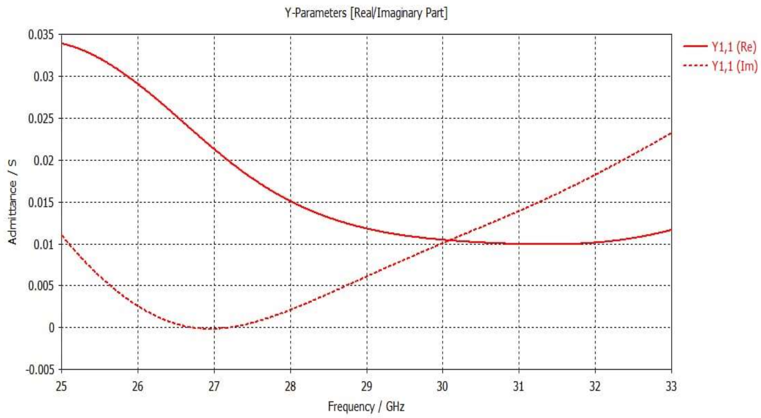

Figure 12: Variation of Y Parameter over frequency (at 27.176 GHz Frequency)

The radiation parameter of the designed Antenna is satisfactory & can be accepted. Also, the design of the proposed antenna is compact & easy to construct & it can be mounted in any portable hand-hold communication device for shorter distance, loss free & high-speed data communication links. Therefore, the proposed Antenna Structure has every desired characteristics required for 5G Communication.The Future scope would include designing of a MIMO Multiband High Gain wider bandwidth Antenna by the help of design explained in this paper.

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