International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-10 Issue-2, December 2020

# Design and Analysis of Cylindrical Dielectric Resonator Antenna for 5G Application

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***Abstract:** DRA's are used for 5G communications of large bandwidth at sub 6GHz and millimeter to Terahertz. The channel capacity can achieve a very high data rate i.e. C=Blog2(1+SNR) where C is the channel capacity and B is the bandwidth of the channel. The cylindrical resonator antenna operating in hybrid $HEM_{11\delta}$ mode. In this paper a cylindrical dielectric resonator antenna(CDRA) with frequency range (2-6GHz).The cylindrical dielectric resonator with radius r=10mm and height h=10mm. the CDRA material is alumina ceramic with a permittivity of $\varepsilon_{DRA}$ is 9.9 and the resonant frequency is $f_r$=4GHz. The substrate will be is Rogers RT 5880 with $\varepsilon_r$=2.2 and tan$\delta$=0.0009, the thickness is 1.52mm. The CDRA is excited about the microstrip line. so the cdra is coupled electromagnetically by this microstrip line and below the substrate, we have a ground plane with annealed alumina so we have no radiation or low below the substrate all the radiation is top of the CDRA. The proposed antenna is simulated using CST microwave studio software and the designed antenna will operate for 5G applications and we can consider massive MIMO antenna array configurations. This design analyses the parameters of CDRA.*

***Keywords—**CDRA, MASSIVE MIMO, 5G, DRA, Microstrip line*

## I. INTRODUCTION

The growth of wireless communication technologies demands advancements in antenna technology. The essential need for efficient and low-profile antennas are required for 5G technologies. The development of antenna structures with performances considerably enhanced over traditional antenna structures and methodologies. The development of the dielectric resonator antenna technologies has taken significant strides in overcoming fundamental limitations in the design of broadband and efficient antenna structures. The antenna structures like the microstrip patch suffer from reduced efficiency due to the stratified nature of the design resulting in surface wave loss together with the presence of a conducting patch contributing to conductor loss in the antenna structure. The dielectric resonator antenna is suited for low-loss applications due to the absence of conductors or surface wave loss. It is observed that the frequency range of interest for many systems had gradually progressed upward to the millimeter and near millimeter range. At these frequencies the conductor loss of metallic antennas becomes severe and the efficiency of the antenna.

Revised Manuscript Received on December 15, 2020.
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## II. ANTENNA DESIGN

There are different kinds of 3d structures are available for DRA. The DRA makes use of the radiating mode of the dielectric resonator. The resonant frequency is determined by its dimension and dielectric constant. The CDRA is a short form of cylindrical dielectric resonator antenna that can be excited by using microstrip, aperture, probe so different excitation types would generate different modes inside these resonators and will have different resonant frequencies. The cylindrical dielectric resonator antenna using alumina ceramic with permittivity of 9.9 and the dimensions of cdra is in the order of its radius r=10mm and height h=10mm, the microstrip feed is used with a resonant frequencyof cdra is 4GHz.

**Table I: Design parameters of a CDRA**

| Parameter | Value(mm) | Parameter | Value(mm) |
|---|---|---|---|
| x | 60 | R(radius) | 10 |
| y | 60 | H(height) | 10 |
| L | 40 | T(thickness) | 4.65 |

### *A. Advantages of DRA*

- The size of DRA depends on the resonant frequency and dielectric constant of the materials($\lambda_0$/Γ€$_r$).
- DRA will give high radiation efficiency and a high degree of freedom and versatility, it uses several feeding mechanisms

### *B. Disadvantages of DRA*

- DRA has a high fabrication cost due to high permittivity material.
- It is difficult to design a modified shape due to material rigidity, difficult to get specific dielectric.

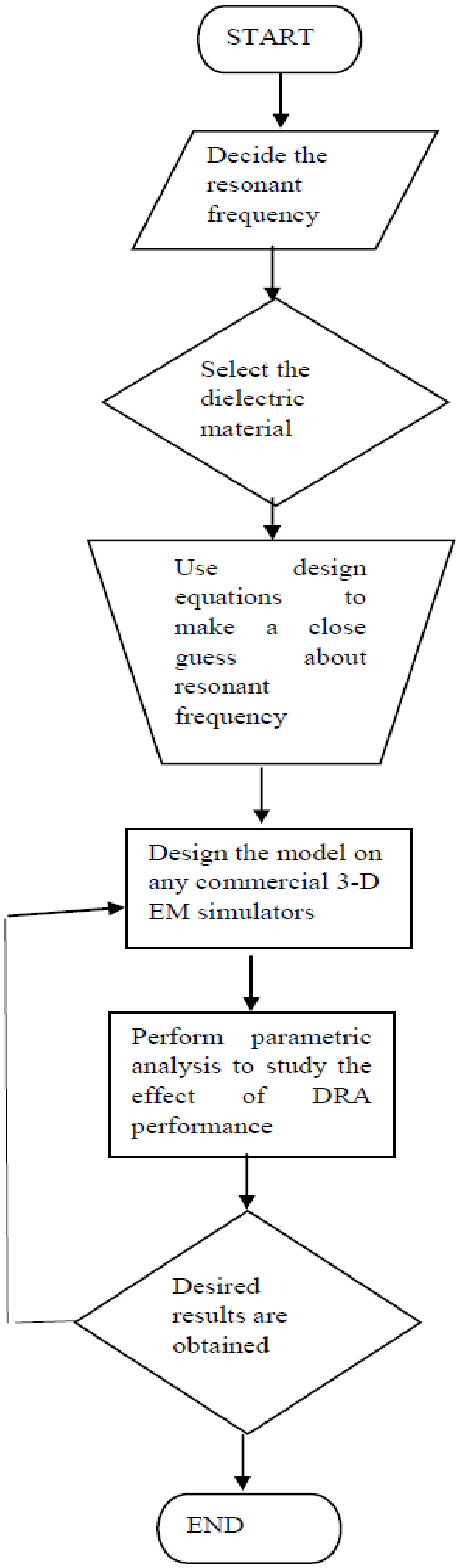


**Fig: 1 Flowchart of CDRA**

The formula to calculate the resonant frequency of a CDRA is

$$f_r = \frac{c}{2\pi r\sqrt{\epsilon_{DRA}}}\left[1.71t\frac{r}{h} + 0.1578\left(\frac{r^2}{h}\right)\right] \quad (1)$$

The above expression is only valid for hybrid mode and the same dielectric resonator antenna can be excited by using different modes i.e TE and TM modes then the resonant frequency expressions are different for these modes.

## III. DESIGN OF CDRA IN CST

By using CST Studio designed cdra initially considered substrate Rogers RT5880(lossy), then placed on that substrate CDR with alumina ceramic in a cylindrical shape and created ground plane with copper annealed and this CDRA is excited with microstrip line.

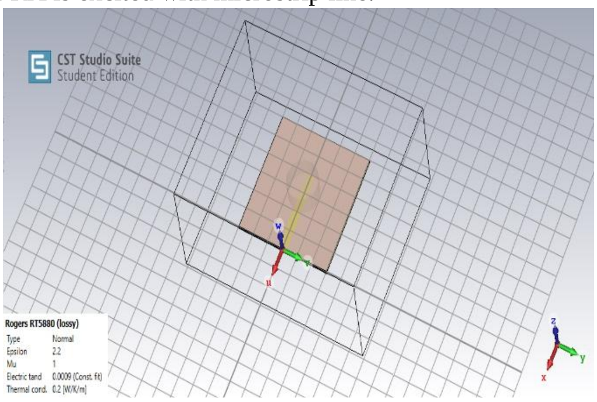


**Fig 2:Substrate Rogers RT5880(lossy) in CST**

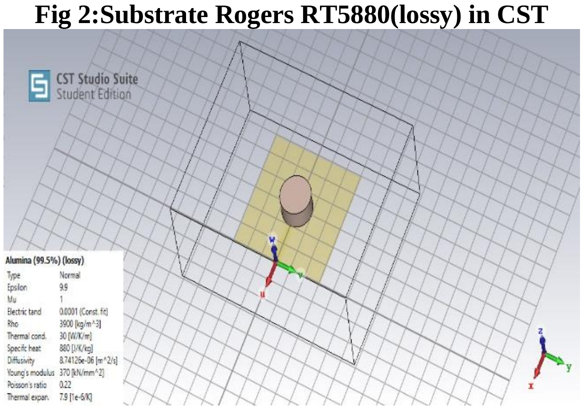


**Fig 3: DRA in Cylindrical shape in CST**

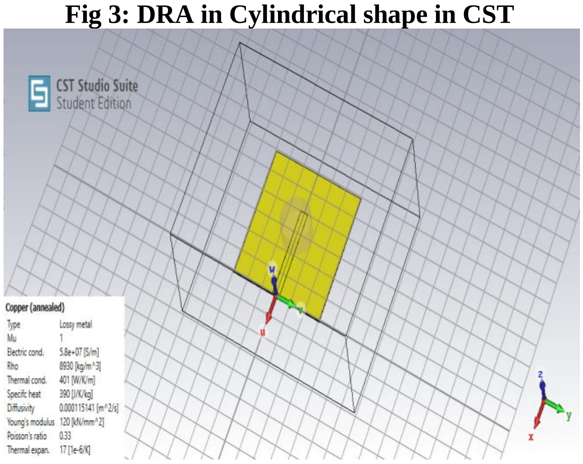


**Fig 4: Ground plane created below the substrate**

*Retrieval Number: 100.1/ijeat.B20421210220*
*DOI:10.35940/ijeat.B2042.1210220*
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## IV. RESULTS AND DISCUSSION

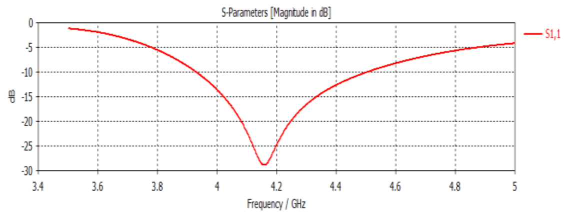


**Fig 5:S parameter vs frequency**

The CDRA is resonating at 4.16 GHz and as per calculation it needs to resonate at 4GHz but nearly the same.

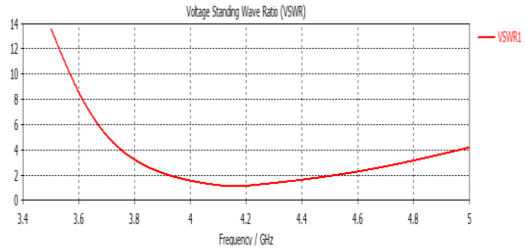


**Fig 6:Vswr vs Frequency**

The VSWR of the proposed antenna from the figure we can observe that the VSWR of the proposed antenna in the sub 6GHz is at the resonant frequency of the antenna is 1 which shows the antenna has proper impedance matching at the resonant frequency.

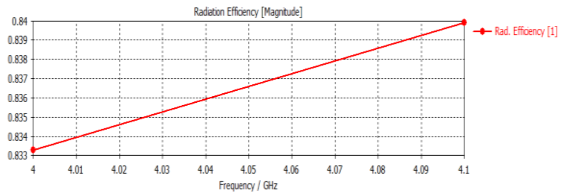


**Fig 7:Radiation efficiency vs frequency**

The radiation efficiency of the proposed antenna is maximum at the resonant frequency.

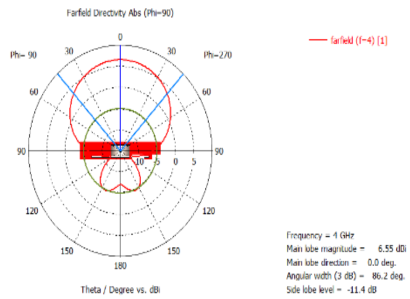


**Fig 8: Far-field 1D measurement at 4GHz**

For the proposed CDRA the main lobe magnitude is 6.55dBi and main lobe direction 0.0deg and the angular width (3dB) is 86.2 deg and the sidelobe level is -11.4B.

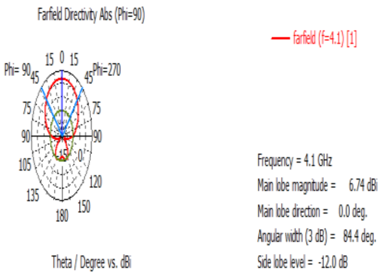


**Fig 9:Far-field 1D meaurement at 4.1GHz**

For the proposed CDRA the main lobe magnitude is 6.74dBi, and main lobe direction is 0.0deg and the angular width (3dB) is 84.4deg and the sidelobe level is -12.0dB.

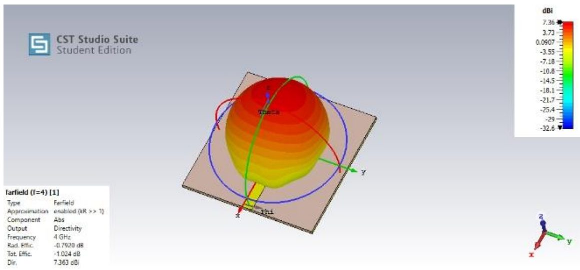


**Fig 10: Far-field 3D measurement at 4GHz**

The far-field is measured at 4GHz. The directivity of the proposed CDRA is 7.363dBi.The radiation efficiency is -0.7920dB and total efficiency is -1.024dB.

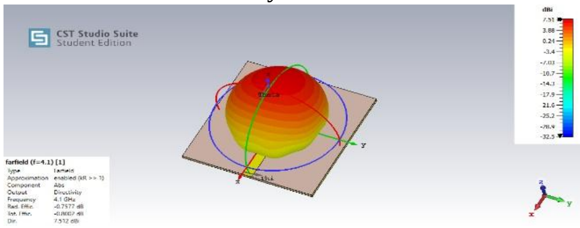


**Figure 11: Far-field 3D measurement at 4.1GHz**

The far-field radiation is measured at frequency 4.1GHz. The directivity of the proposed CDRA is 7.512dBiThe radiation efficiency is -0.7577dB and the total efficiency is -0.8002dB.

## V. CONCLUSION

The Cylindrical dielectric resonator antenna is designed and simulated by using CST microwave studio software in this paper. The proposed antenna is operating in the sub6GHz band. The far-field pattern and S parameters and VSWR are measured at the resonant frequency as per theoretical at 4GHz and 4.1GHz. The radiation efficiency at 4GHz is -0.7920dB and the total efficiency is -1.024dB and thedirectivity is7.363bBi and at 4.1GHz the radiation efficiency is -0.7577dB and the total efficiency is -0.8002dB and the directivity of the CDRA is 7.512dBi.The CDRA is better than a microstrip patch antenna. So the proposed antenna can be used in 5G applications and it can be used as an antenna element in Massive Mimo antenna array configurations.

## ACKNOWLEDGEMENTS

I thank my guide for his support and encouragement to complete this work.

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*Retrieval Number: 100.1/ijeat.B20421210220*
*DOI:10.35940/ijeat.B2042.1210220*
*Journal Website: www.ijeat.org*



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