

Study of Ring Dielectric Resonator Antenna with Multi-Loaded Monopole Antennas

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Abstract: A Ring Dielectric Resonator Antenna design with an air gap between the dielectric resonator and ground plane, loaded on single and double monopole antenna.

In this proposed antenna the monopole and RDRA is both centre about the same axis. This Antenna is simulated using a CST Microwave studio. This simulated result show the Return loss and Radiation pattern of around covering the frequency range of 3-8GHz.

Index Terms: DRA, CST, RDRA

1. INTRODUCTION

The Ring Dielectric Resonator Antenna consists of a cylindrical DRA where a center cylindrical section of radius b has been removed. Feeding the Ring DRA with a probe located at the center, will excite the $TM_{01\delta}$ mode, which radiates similarly to an electric monopole. The effect of increasing the ratio of inner to outer radius (b/a) of the Ring resonator on the resonant frequency and Q- factor. Increasing the b/a ratio result in an increase in the Q-factor; however, in order to maintain the same resonant frequency, the outer radius a must be increased. For an approximate threefold increase in the outer radius, the Q-factor decreases by about 14 times. Whether this decrease in the Q-factor will result in a similar increase in bandwidth will depend on the level of coupling of the $TM_{01\delta}$ mode of the DRA to the probe. An air gap can also be introduced between the Ring DRA and the ground plane to further enhance the bandwidth. Dielectric resonator antennas (DRA) offer the following attractive features:

- The dimension of a DRA is of the order of $\frac{\lambda_0}{\sqrt{\epsilon_r}}$

, where λ_0 is the free-space Wavelength and ϵ_r is the dielectric constant of the resonator material. Thus, by Choosing a high value of ϵ_r ($\epsilon_r \approx 10 - 100$), the size of the DRA can be significantly reduced.

- There is no inherent conductor loss in dielectric resonator. This leads to high radiation efficiency of the antenna. This feature is especially attractive for millimeter (mm) wave antennas, where the loss in metal fabricated antennas can be high.

RING DRA- LOADED MONOPOLE

A hybrid antenna has been developed, which consists of a combination of monopole and ring DRA. The combined antenna can be design to radiate an omnidirectional pattern for over a 3- 8 bandwidth, while maintaining a return loss of 10 db or better. This compact antenna design is ideally suited for ultra wideband communication applications requiring omnidirectional coverage.

The monopole antenna is excited by a coaxial probe, and it also serves to excite the RDA, so that only a single feed is required.

2. ANTENNA DESIGN

The Design of the Ring DRA has been studied using CST microwave.

- The monopole antenna height (t) is chosen to be one- quarter wavelength at the lowest frequency (f_1) of the desired frequency band that is, $t=\lambda_1/4$, where λ_1 is the wavelength corresponding to frequency f_1 .also a thin diameter is chosen for the monopole:

$$0.008\lambda \leq d \leq 0.016\lambda$$

- The spacing (s) between the monopole and inner DRA radius (b) is also chosen to be a small fraction of wavelength:

$$0.013\lambda \leq s \leq 0.016\lambda$$

- The resonant frequency (fh) of the TM018 mode of the DRA should be chosen approximately 2.5 times the resonance frequency f_1 , guidelines for the DRA dimensions are :

$$b=d/2+s$$

$$a=b/0.3$$

$$0.4\lambda \leq h \leq 0.5\lambda$$

- Finally the dielectric constant for the DRA can be determined using :

$$\epsilon_r = (\pi / 2h)^2 + (4.71/a)^2 / (2\pi f_{h/c})^2$$

Where c is the speed of light.

To improve the radiations characteristic and return loss of the RDRA, few studies have been proposed:-

- RDRA non loaded monopole
- RDRA loaded on single monopole
- RDRAloaded on double monopole

Designing of RDRA with multi-loaded monopole antennas used dimensions parameters are given in table 1:

Table: RDRA– Loaded monopole Designs

parameters\ no. of monopoles	RDRA non loaded monopole	RDRA loaded on single monopole	RDRA loaded on double monopole
Frequency Band(GHz)	3-8	3-8	3-8
a (mm)	9.5	9.5	9.5
b (mm)	2.9	2.9	2.9
g (mm)	5.2	5.2	5.2
h (mm)	21.2	21.2	21.2
r_{m1} (mm)	1.0	1.0	1.0
r_{m2} (mm)	1.0	1.0	1.0
h_{m1} (mm)	37.5	37.5	37.5
h_{m2} (mm)	37.5	37.5	37.5
ϵ_r	9.4	9.4	9.4

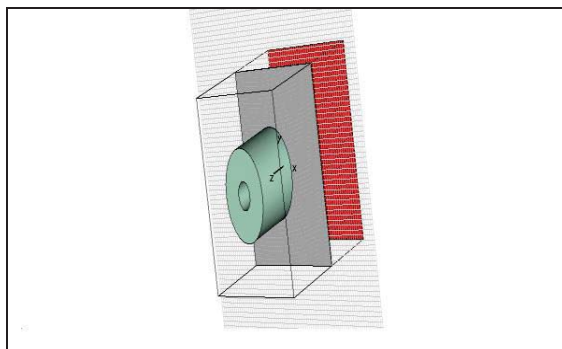


Fig. 1 Antenna configuration of ring DRA without monopole

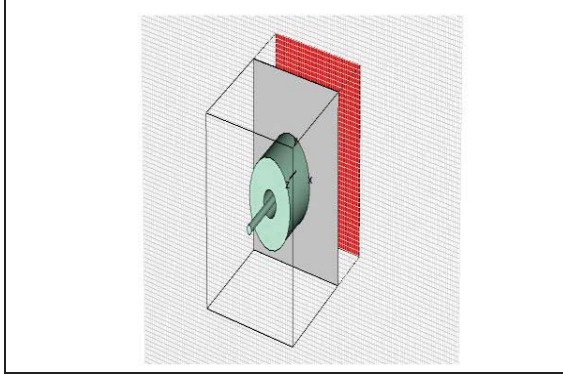


Fig. 2 Ring DRA antenna with single monopole antenna

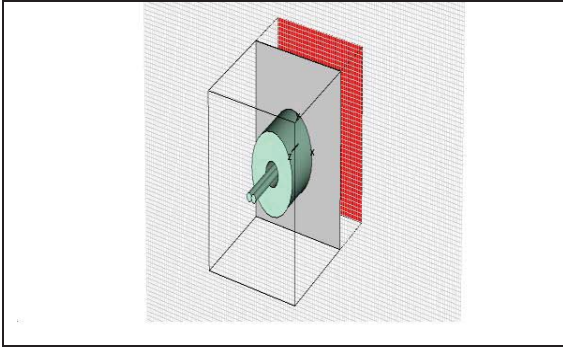


Fig.3: Antenna configuration of Ring DRA with double monopole.

The Antenna configuration of the Ring DRA is shown in fig. 1, fig.2, fig.3. The RDRA is placed above a conducting ground plane. In the present work, the ground plane size of 20mm×20mm is considered and the material used in this work is Alumina with dielectric constant of 9.4.

The dimensional parameters of the Ring DRA are given in table 1. Here a is the outer radius of Ring DRA , b is the inner radius of Ring DRA , g is the gap between RDRA and ground plane , h is the height of RDRA, r_{m1} and r_{m2} are the radius of monopole , h_{m1} and h_{m2} are the height of monopole and ϵ_r is the dielectric constant of material.

3. RESULTS AND DISCUSSION

The proposed Ring DRA is analyzed using CST Microwave studio suit. The simulated return loss of the ring DRA plotted against frequency is shown in Fig.

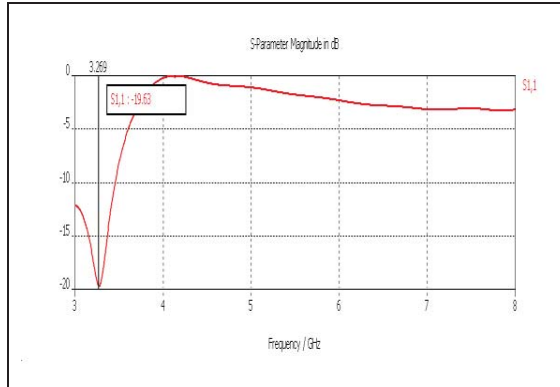


Fig.4 Simulated return loss of RDRA without monopole.
From the measured result, the return loss is -19.63db, resonance frequency is 3.269GHz.

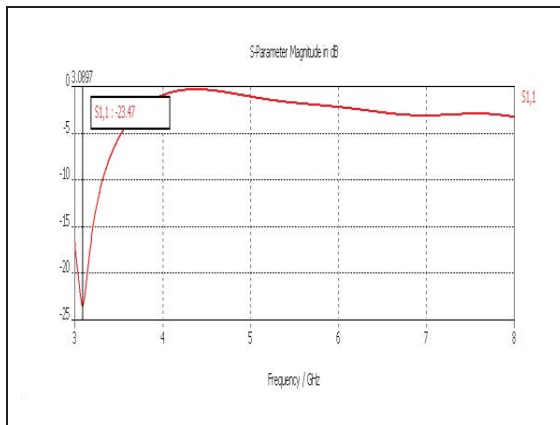


Fig. 5 simulated return loss of RDRA with single monopole.
From the measured result, the return loss is -23.47db, resonance frequency is 3.0897GHz.

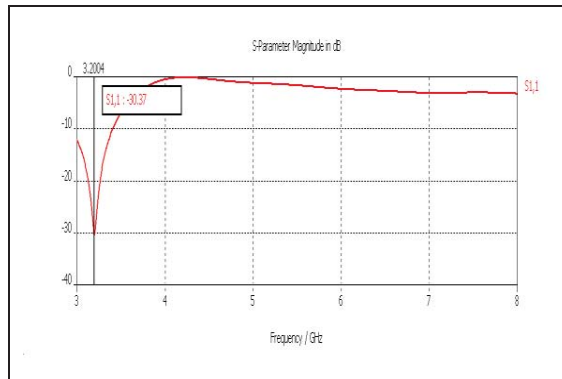


Fig.6 Simulated return loss of RDRA with double monopole

From the measured result, the return loss is -30.37db, resonance frequency is 3.2004GHz. This experiment work is carried out by varying the number of poles. The proposed DRA is analyzed using CST software. The simulated return loss of the RDRA plotted at three different conditions. It is observed that the double monopole loaded ring DRA's return loss is better as compared to single monopole loaded ring RDRA

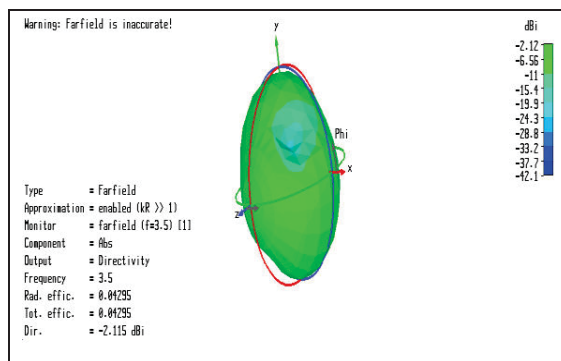


Fig.7: 3D view of Radiation pattern of RDRA without monopole.

Far field $f=3.5$ at frequency 3.5GHz, the radiation efficiency is 0.04295, total efficiency is 0.04295.

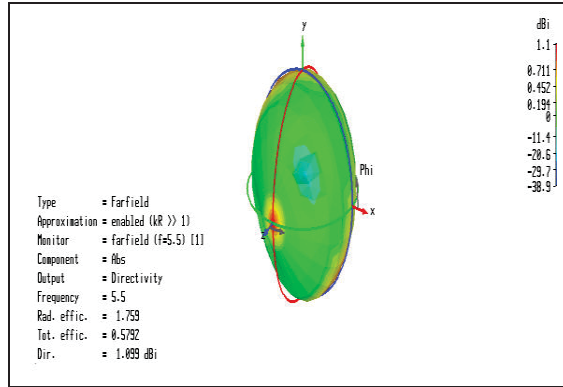


Fig.8: 3D view of Radiation pattern of RDRA with single monopole.

Far field $f= 5.5$ at frequency 5.5GHZ, the radiation efficiency is 1.759, total efficiency is 0.5792.

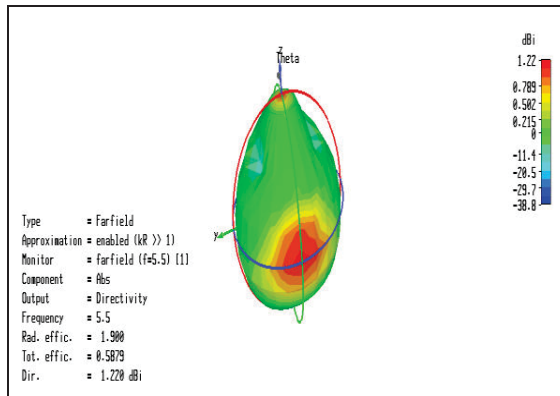


Fig.9: 3D view of Radiation pattern of RDRA with double monopole.

Far field $f= 5.5$ at frequency 5.5GHZ, the radiation efficiency is 1.900, total efficiency is 0.5879.

This experiment work is carried out by varying the number of poles. The proposed DRA is analyzed using CST software. The simulated radiation pattern of the RDRA plotted at three different conditions. It is observed that the double monopole loaded ring DRA's radiation pattern is better as compared to single monopole loaded ring RDRA.

4. CONCLUSION

The presented active antenna is able to cover 3-8GHz. The RDRA is fabricated from Alumina. Return loss of RDRA with non- loaded monopole antenna is -19.63 db and -23.47db with single loaded monopole and -30.37db with double monopole antenna. Finally, return loss and radiation pattern of RDRA are measured at multi-loaded monopole antennas. It provide us with better

noise carrier to noise ratio then the DRA loaded with double monopole antenna and it is evident that the Alumina is a good candidate for realizing a DRA.

In future work we will frequency agile, by loading it with some device such as Tunnel diode, Impatt diode, Gunn diode, MOS capacitors. By changing the biasing of an active device, the frequency of DRA also gets changed, hence the DRA become frequency agile.

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