Rectangular Dielectric Resonator Antenna (RDRA) for Wireless Applications

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ABSTRACT: A Rectangular Dielectric Resonator Antenna (RDRA) made up of Roger material having permittivity $\varepsilon_r=10.2$ is presented. The resonator shape is choosing such that it has compact size and wide frequency coverage. RDRA is one of the main kinds of DRA that provides some more advantages compared with spherical and cylindrical ones like it can be used to control the impedance bandwidth of the antenna. Dielectric Resonator Antennas (DRAs) have attracted considerable attention due to their high radiation efficiency (no conduction loss) [3]. The mode degeneracy can be avoided in case of RDRA’s by properly choosing the two aspect ratios (AR) (width/length and height/length) of the resonator. The geometry is analyzed by using Ansoft’s High Frequency Simulation Structure (HFSS) software.

KEYWORDS - Rectangular Dielectric Resonator Antenna (RDRA), Aspect Ratio (AR), Impedance bandwidth.

I. INTRODUCTION

In recent years, DRA (Dielectric Resonator Antenna) have more significant use in wireless applications. The DRA have many advantages, as this has no metal inclusion the ohmic losses which are high at higher frequencies, which are completely avoided in DRA. Number of different structures was analyzed like cylindrical, hemispherical and triangular [1]-[2]. Every shape has its own characteristics and has its own advantages in terms of size and other dimensions.

The use of high permittivity dielectric material as a radiation element provides advantages like very good radiation efficiency, low profile, and temperature coefficient, light weight etc [5]-[6]. Different feeding mechanisms can be used for widening the bandwidth. DRA should be excited for modes having small Q factor to radiate efficiently. Circular polarization (CP) and dual-polarized operations for DRA’s have been reported in recent years. Antennas providing CP radiated waves need additional circuitry such as 3 dB shifters or 90° transmission line phase shifters [4]. In this paper, a single-point feed CP rectangular dielectric resonator antenna with wide band impedance bandwidth is presented. Here it is observed that the radiation efficiency of DRA is much better than microstrip antenna. Although microstrip antennas are also good enough in terms of compact size, its radiation efficiency is not as good as DRA.

The purpose of this investigation is attempting to design RDRA that is sufficiently compact and in addition has a proper impedance bandwidth and also has a good 3-dB bandwidth. The full analysis of proposed antenna was performed using Ansoft’s HFSS.

II. DESIGN AND CONFIGURATION OF ANTENNA

A. GEOMETRY DESIGN DETAILS

Fig. 1(a) and (b) shows side and top view of the proposed antenna respectively. RDRA having permittivity of $\varepsilon_r=10.2$ is mounted on the cavity having dimensions as $x = y = z = 25$ mm. The main DRA has the dimensions $x = y = z = 12.5$ mm. The air volume has height of 35 mm and radius is 30 mm. The feed gap is having the thickness of 1 mm. Annular ring is 5.8 mm outer length and a width of 1 mm.

The geometry for this Dielectric Resonator Antenna basically consist of five basic objects listed as Air volume, Rectangular DRA, Rectangular cavity, Annular ring and Feed gap. For a single DRA element, there are basically two general approaches to produce a circular polarized wave: single point feeding and dual point feeding [3]. To analyse radiation effects, we create a transparent air volume surface sufficiently far from the model which is a virtual object having radiation boundary. The figure 1 shows that Rectangular shaped DRA is placed on the Rectangular cavity. The annular feed ring has surface area means it is a sheet object, i.e. it has no volume. Since the annular feed ring will not have a material assignment but the material parameter has volumetric assignment. In this antenna, the annular feed ring is the controlled aperture through which the E-fields will radiate.
In this design Ports define surfaces exposed to non-existent materials through which excitation signals enter and leave the structure. One lumped port is defined for this design. Lumped ports are similar to wave ports such ports can be located internally. The Lumped port has the impedance of 100 ohms for this antenna design. The purpose of Lumped port is to compute S-parameters at the port. The engineering focus for this antenna design is on the behaviour of the antenna itself, not its feed. Therefore, the geometry is fed with a lumped port across the annular slot, or gap object.

**B. Boundary Conditions**

The following types of boundary conditions are used for this antenna design

1. **Radiation** This type of boundary simulates an open problem that allows waves to radiate infinitely far into space. The air volume object is defined as a radiation boundary.

2. **Perfect E** This type of boundary models a perfectly conducting surface in a structure, which forces the electric field to be normal to the surface. In this antenna Design, the bottom face of the air volume object is defined as a perfect E boundary.
3. **Perfect H** This type of boundary forces the tangential component of the H-field to be the same on both sides of the boundary. For this geometry, the aperture is defined as a perfect H boundary, the E-fields will radiate through it. If it was not defined as a perfect H boundary, the E-field would not radiate through and the signal would terminate at the aperture.

4. **Symmetry** In structures that have an electromagnetic plane of symmetry, such as this antenna design, the problem can be simplified by modelling only one-half of the models and identifying the exposed surface as a perfect H or perfect E boundary. For this antenna, a perfect H symmetry boundary is used.

### III. SIMULATION RESULTS AND DISCUSSION

The value of relative permittivity was chosen on the basis of commercially available high dielectric constant material and the radiating optimum impedance matching was studied using the Ansoft’s High Frequency Structure Simulator (HFSS).

Fig. 2(a) shows the simulated return loss of the prototype antenna. The simulation shows the impedance bandwidth ($S_{11} < -10$dB) around 0.45 GHz and close the resonance at 5.625 GHz.

The simulated return loss ($S_{11}$) parameter of the Rectangular DRA as a function of frequency. The proposed antenna has bandwidth ranging from 5.45 to 5.85 GHz.

The simulated value of VSWR is approximately 1.35 on a linear scale. The plot of VSWR is shown in fig. 2 (b) which indicates the better value at resonant frequency 5.625 GHz.

![Fig 2(a) Return loss (S11) at Resonance Frequency](image1)

![Fig 2(b) Plot for VSWR at solution frequency = 1.23](image2)
Fig 3(a) Illustrates the 3-D View of Radiation Pattern for Total Directivity

Fig 3(b) Illustrates the 3-D View of Radiation Pattern for Total Gain

Fig 4 Radiation Pattern for LHCP and RHCP for theta = ‘0 deg’
In general to achieve best coupling the DRA must be fabricated from high permittivity material but to have a wide bandwidth the DRA must have a low dielectric constant. The application of the Rectangular DRA will be greatly enhanced if the dielectric antenna can generate the linear and circularly polarized radiation waves simultaneously. The radiation pattern at 5.65 GHz is shown in figure3.

IV. CONCLUSION

The Rectangular shaped DRA has been proposed and investigated. The antenna is excited by a gap feed. A bandwidth of 0.4 GHz and high gain is achieved at the resonant frequency of 5.625GHz. The proposed antenna has good radiation characteristics over the operating bandwidth. As a result the proposed Rectangular DRA is attractive and can be practically used for different wireless application.

REFERENCES


AUTHOR BIOGRAPHY

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