Compact Dual-Band and Wideband Aperture-Coupled Dielectric Resonator Antenna

Rachid CHELGHOUM*, Zitouni MESSAI

Laboratory of Electronic and advanced Telecommunications, Departement of Electronics, University Mohamed El Bachir El Ibrahimi of Bordj Bou Arreridj, Algeria

*Corresponding author's e-mail: rachid.chelghoum@univ-bba.dz

ABSTRACT

A compact dual-band and wideband dielectric resonator antenna, the dielectric resonator is a combination of three rectangular joined with the side of a cylindrical with the same heights that is located in the center of FR-4 substrate, the proposed antenna was excited through the rectangular aperture coupled with a microstrip feed. Optimizing the design parameters results, in an impedance bandwidth of 14.7%, covering the range from 6.77 to 7.85 GHz in the lower band, and a relative bandwidth of 30.8% from 9.45 to 12.9 GHz in the upper band. The design has been developed and simulated using EM software "HFSS".

Keywords: Dual-band, Aperture coupling, Dielectric resonator Antenna (DRA).

1 Introduction

The development of wireless communications has created additional demand for advancement in antenna technology. Antennas have become essential part of human life, and are used in several domains such as airplanes, automobiles, mobile phones, networks, radar, satellites and sensors. The first dielectric resonator antenna (DRA) was introduced by Long et al. in 1983 [1]. Since then, several researchers have focused on investigating DRAs. The bandwidth of the dielectric resonator antenna is inversely related to the dielectric constant, and may limit the choice of values for a given application. [2]. The DRA modes depend on the DR dimensions and permittivity, as well as on the feeding mechanism [3]. In this work, the design of a dielectric resonator antenna (DRA) is proposed using a unit of three rectangular and one cylindrical dielectric resonators that are located in the center of the substrate, and excited by the microstrip feed line.

2 Geometry and Antenna Design

After optimization, the design and dimensions of the proposed antenna are depicted in Figure 1. A combination of four dielectric resonator shapes, three rectangular joined with a cylindrical, the material used is an alumina of permittivity $\varepsilon_r = 9.4$ and loss tangent of 0.006 is mounted on the FR-4 substrate with $\varepsilon_{sub} = 4.4$, $\tan \delta = 0.02$, with the thickness of 0.8 mm, and size of Ls×Ws = 30×30 mm2. Then, a microstrip feed line underneath the substrate, with a characteristic impedance of 50 Ω is used for antenna excitation, and the aperture coupling is cut from the center of the ground plane, which is located above the substrate. The Optimized geometric parameters of the proposed antenna are Ls=30mm, Ws=30mm, T=0.8mm, a=4.5mm, D=6mm, h=10mm, Ld=3mm, Lf=19.5mm, Wf=1.5mm, La=8mm, Wa=1.5mm.

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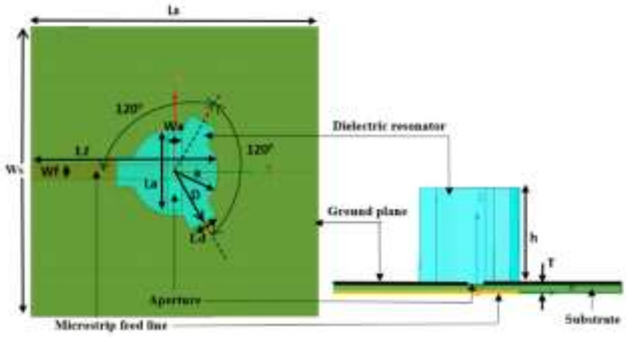

(a) (b)

Figure 1: *Proposed Dielectric Resonator Antenna, (a) Top view. (b) Side view with parameters shown.*

In this section, different shapes of dielectric resonators are studied to observe their effects on the reflection coefficient (S_{11}) and bandwidth ($S_{11} \leq -10dB$). Firstly, the dielectric resonator is cylindrical only (without rectangular), secondly, the effect of combining a rectangular with a cylindrical and their rotations (rotation angle 120^0). The third step is the effect of adding the two rectangular with a cylindrical at different positions (rotation angle 120^0) and finally the three rectangular united with the cylindrical, the geometric shape is illustrated in Figure 1.

The simulated reflection coefficient of the proposed antenna (three rectangular united with cylindrical) is presented in Figure 2.

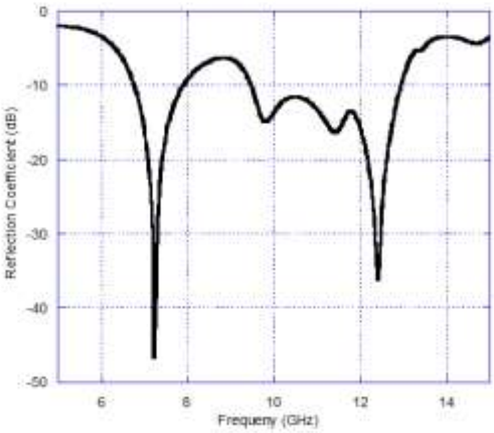

Figure 2: *Simulated reflection coefficient of the proposed dielectric resonator antenna.*

The resonant frequency of the cylindrical dielectric resonator antenna (CDRA) excited in the HEM11δ mode can be derived from [3], [4].

$$f_r = \frac{c}{2\pi a\sqrt{\varepsilon_r}}\left(1.71 + \frac{a}{h} + 0.1578\left(\frac{a}{2h}\right)^2\right)$$

Where **a** and **h** are the radius and the height of the cylindrical dielectric resonator, **c** is the velocity of light in free space, and $\boldsymbol{\varepsilon_r}$ the relative permittivity of the dielectric resonator, the calculated resonant frequency for these dimensions and with the properties of the dielectric resonator is 7.6 GHz.

3 Results and Discussion

The proposed antenna gives a dual-band, the lower band operates at 7.2 GHz with a maximum gain of 5.87 dB is obtained, and the upper band has three resonant frequencies at 9.8, 11.4 and 12.4 GHz with maximum gains of 5.95, 6.46 and 5.47 dB are obtained respectively (see Figure 3). The addition of three rectangular gives other resonant frequencies and broadens the bandwidth.

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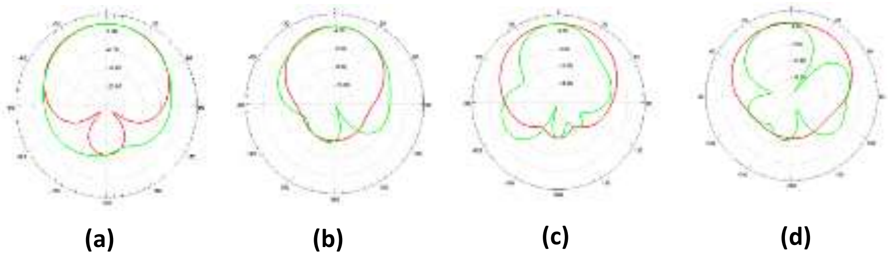

XZ plane, YZ plane

Figure 3: *Simulated radiation patterns in XZ and YZ planes, (a) at 7.2 GHz. (b) at 9.8 GHz. (c) at 11.4 GHz. (d) at 12.4 GHz.*

4 Conclusion

A novel structure of dielectric resonator consisting of three rectangular united with a cylindrical. The various parameters are studied to observe their effect on the reflection coefficients, Bandwidth and radiation patterns. In this study, a dielectric resonator antenna gives a dual-band. One of these is wide, with an impedance bandwidth of 14.7%, covering the range from 6.77 to 7.85 GHz in the lower band, and 30.8% relative bandwidth from 9.45 to 12.9 GHz in the upper band.

How to Cite

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