A Dielectric Resonator Antenna for UWB Applications

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Abstract

A stacked ultra-wideband dielectric resonator antenna of rectangular shape is presented. The antenna is composed of a dielectric resonator and a thin dielectric segment. Both reside above a ground plane, and is excited by a coaxial probe. Unlike in previous designs that have a dielectric resonator of a lower permittivity above one or more thin segments of higher permittivity, the top dielectric resonator in this antenna has a higher permittivity than the lower segment. Theoretical results show that an ultra-wide band 10-dB return loss, from 3.1 GHz to 10.7 GHz, can be achieved.

Introduction

Dielectric resonator (DR) antennas are attractive due to their advantages of low loss and high efficiency and research to broaden its bandwidth is being conducted. Configurations such as hybrid DR [1-2] and shaped DR [3] have been considered. Recently, stacked DR antennas (DRAs) [4], without any metallic resonators, have been developed for wideband applications. This DRA is composed of a dielectric DR and a thin dielectric segment. They reside above a ground plane, and is excited by a coaxial probe. The DR has a higher dielectric constant than that of the dielectric segment.

In this paper, a compact stacked DRA is designed for 3.1 – 10.6 GHz ultra-wideband (UWB) applications. With the application of the image theory and attaching a shorting plate to one terminal of the DRA, the DR and the dielectric segment are cut in half and hence an even smaller volume is obtained, without compromising the excellent bandwidth of the original DRA. This method has been applied in [2] but the antenna structure investigated here is different.

Antenna design and results

The geometry of the proposed DRA is shown in Fig. 1. As can be seen, the DR, which has a dielectric constant ε_2 is above a thin dielectric segment of a dielectric constant ε_1, where $\varepsilon_2 > \varepsilon_1$. In this work we assume both the DR and the dielectric

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segment are rectangular. Below the segment is a ground plane. The dielectric segment could be a low permittivity material, such as high-density foamed polystyrene. In this work, TMM10 and RT/Duroid 5880 are considered for the DR and the dielectric segment.

In order to reduce the size of the DRA, the image theory is applied to the structure. A shorting plate is placed at one end of the DRA. As shown in Fig. 1, this plate is connected to the ground and there is no gap between the DR and the plate. This metallic plate is a crude approximation to a perfect electric wall and it creates a vertical electrical field null in the dielectric resonator. The shorted DR and its quasi-image (made by the approximate electric wall) are expected to behave as a full-size DRA.

The DR and the dielectric segment have dimensions of $a \times b \times h_2$ and $a \times b \times h_1$, respectively. There is no gap between the DR and the dielectric segment. In the right figure (in Fig. 1), the DR and dielectric segment are made transparent to illustrate the feed probe. The main design parameters of the antenna are a, b, h_1, and h_2.

The proposed antenna was investigated, simulated and optimised using Ansoft HFSS and CST Microwave Studio commercial software systems. In our investigation, the materials selected for the DR and dielectric segment are TMM10 and RT/Duroid 5880, which have dielectric constants of *9.2* (ε_2) and *2.2* (ε_1), respectively. The initial values of the design parameters are: $a=18$ mm, $b=18$ mm, $h_1=1.6$ mm, and $h_2=9$ mm. The probe has a diameter of *1.3 mm*. The size of the ground plane is 40×40 mm^2. Using the tuning and optimisation functions of HFSS, the proposed antenna was investigated, and finally an ultra-wide-band DRA design was obtained.

The parameters of the final design are: $a=12.0$ mm, $b=8.0$ mm, $h_1=3.2$ mm and $h_2=12$ mm. The predicted return loss is shown in Fig. 2. The operating bandwidth of the antenna, determined by $|S_{11}|< -10$ dB, is from about 3.1 GHz to *10.7 GHz*. The total size of the final DRA design is $12 \times 8 \times 15.2$ mm^3 or $0.124\lambda \times 0.083\lambda \times 0.157\lambda$ at *3.1 GHz*.

Figs. 3 illustrates theoretical radiation patterns of the antenna at 3.2 GHz, 6 GHz and 10 GHz. It can be seen that radiation patterns at the three frequencies are similar due to the symmetrical structure in the YOZ plane.

Conclusion

A compact, stacked, rectangular dielectric dielectric resonator antenna is successfully designed for 3.1 – 10.6 GHz UWB applications. A dielectric resonator with a higher permittivity is placed above a thin dielectric segment with a lower permittivity to broaden the operating bandwidth. Applying the image theory, a shorting plate is attached to one narrow wall of the DRA to successfully reduce its size.

Acknowledgement

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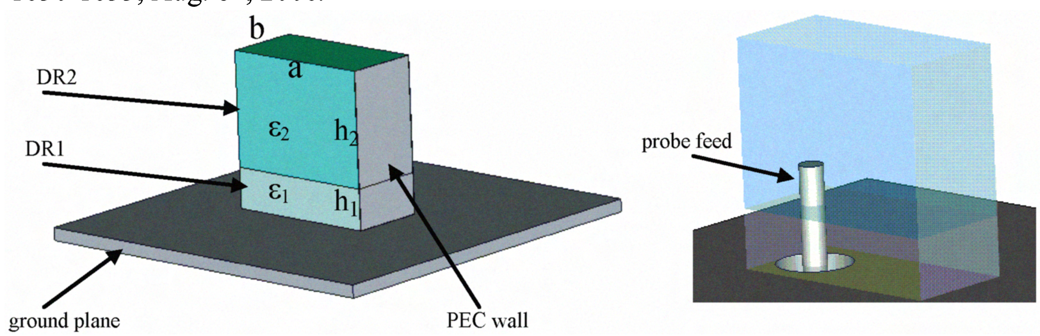

Fig. 1 Configuration of the proposed DRA

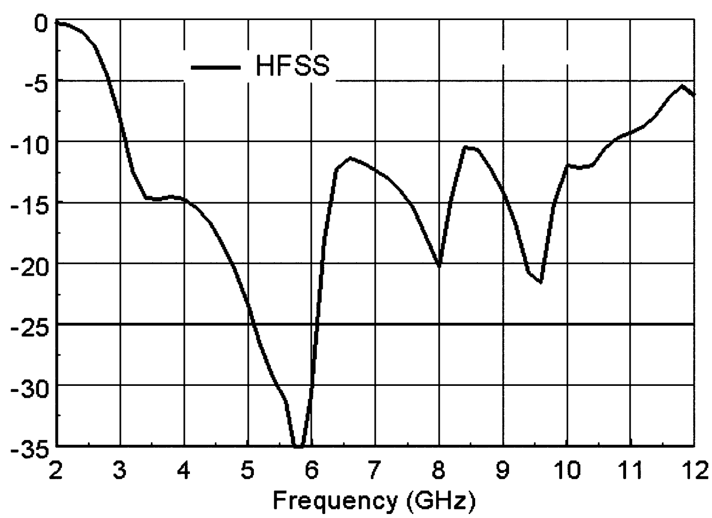

Fig. 2 Theoretical return loss of the proposed DRA

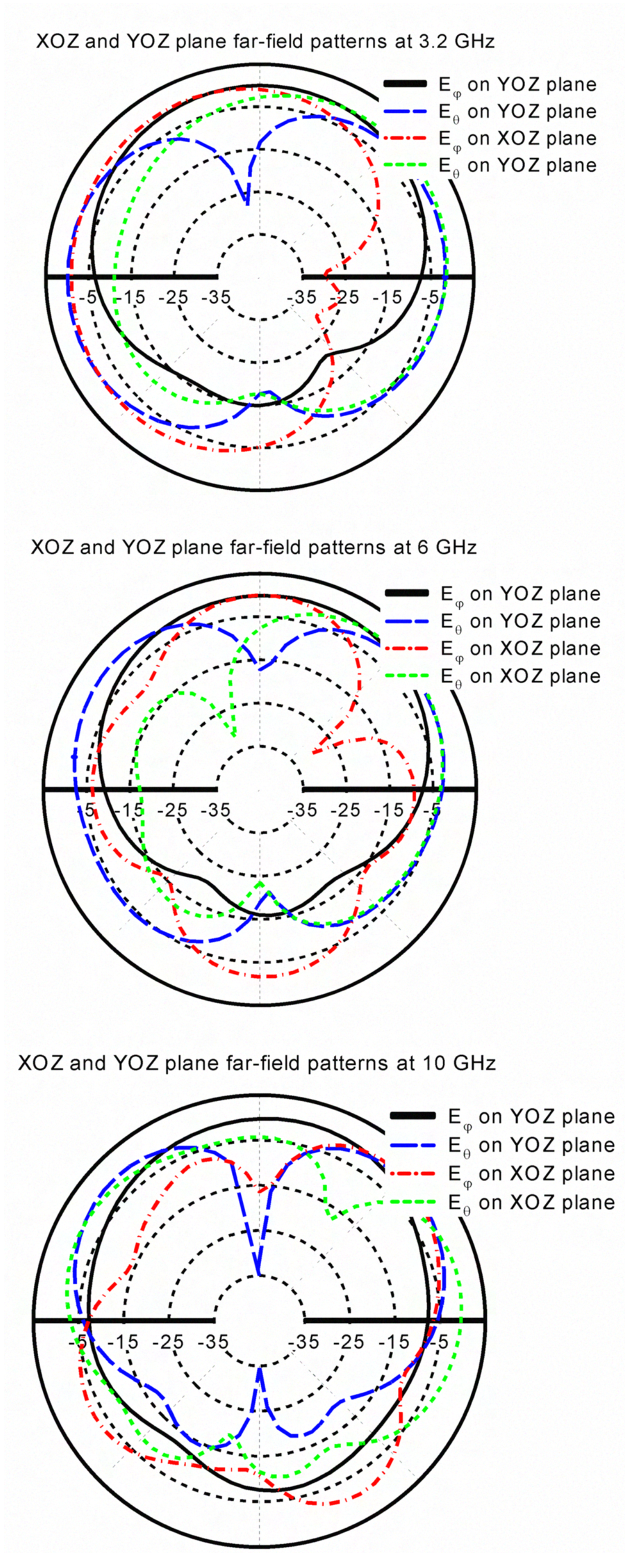

Figure 3 Radiation patterns of the proposed antenna at 3.2 GHz, 6 GHz and 10 GHz