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# Design of Probe-fed Dual-wideband Cylindrical Dielectric Resonator Antenna

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## Abstract

**In this paper, a novel design of the probe-fed dual-wideband cylindrical dielectric resonator antenna is investigated. The antenna operates in 2.4 GHz and 12 GHz bands with a frequency ratio of about 1:5. The antenna consists of two dielectric resonators (DRs). The one in the lower band is a dielectric resonator antenna (DRA), and the other is a Fabry-Perot resonator (FPR) antenna (FPRA) in the upper band. The antenna is excited by vertical strips and probes to DRs at 2.4 GHz and 12 GHz, respectively.The proposed dual- wideband antenna has -10dB bandwidths of 9.51-13.61 GHz (34.2%) and 2.21-2.63 GHz (17.5%), with maximum gains of 10.66 dBi (at 12.54 GHz) and 4.32 dBi (at 2.60 GHz), respectively. This antenna has the advantage of bandwidth.**

## Keywords

**Dielectric Resonator Antenna; Fabry–perot Resonator Antenna; Dualband Antenna; Wideband Antenna.**

## 1. Introduction

Dielectric resonator antenna gradually becomes hotpot research in 1983, because of its compact structure and variety of shapes, such as hemispherical, cylindrical, and triangular[1]. Creating a hollow region through DRA, and forming a Fabry-Perot resonator antenna (FPRA) have been studied[2-3].DRA and FPRA can be fed by many various ways, such as coaxial probe feed, microstrip slot coupled patch feed, coplanar waveguide feed, and other forms. Different fed ways for dielectric resonator antennas have been studied extensively for different applications[2-5].

In [2], a dual-fed hollow dielectric antenna for dual-frequency operation is proposed. By creating a hollow cylindrical region, FPRA and hollow DRA in the microwave are formed. The advantage of the antenna is that the performance of DRA and FPRA work independently. But its upper band bandwidth is too narrow. A novel hollow dual-band hollow dielectric antenna is presented in [3]. The antenna consists of a DRA and an FPRA. It has two fed ports. One is a WR-34 waveguide, and another is a feed vertical stripe connected by the probe excitation method. Its disadvantage is that the gain bandwidth is very narrow, which needs to be further improved. This paper proposes a novel design of the probe-fed dual band and wideband cylindrical dielectric resonator antenna. It consists of an FPRA which created a cylindrical hollow region through DRA and a big DRA. Both the dual-band antenna are fed by probes and stripes. The antenna has two wide bandwidths.

## 2. Design of Probe-fed Dual-wideband Cylindrical Dielectric Resonator Antenna

### 2.1 Antenna Configuration

Figure 1. shows the configuration of the novel design of the probe-fed dual-wideband cylindrical dielectric resonator antenna. The square ground plane of the proposed antenna has the length, width, and thickness of A=130mm, A=130mm, and H=4mm. By creating a cylindrical hollow region

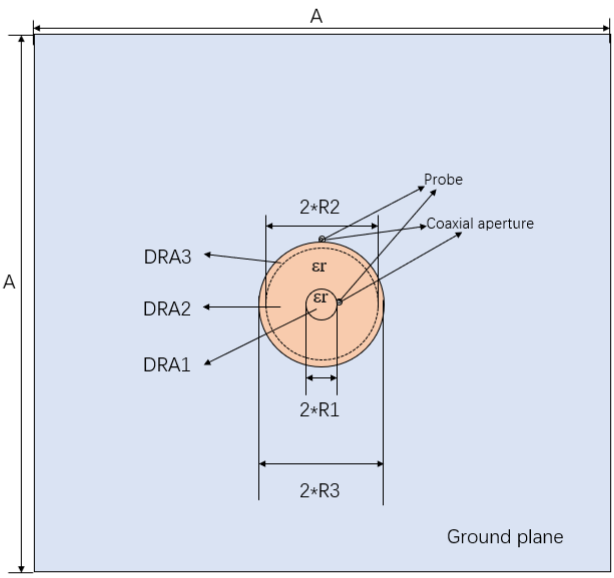
through DRA3 and adding a small dielectric resonator DRA1, a Fabry-Perot dielectric resonator antenna is formed. The dielectric constant of the DRA is εr=7. The heights of the hollow (H2) and dielectric parts (H3) should be given,

$$H2 = H1 + n * \frac{\lambda 0}{2} \tag{1}$$

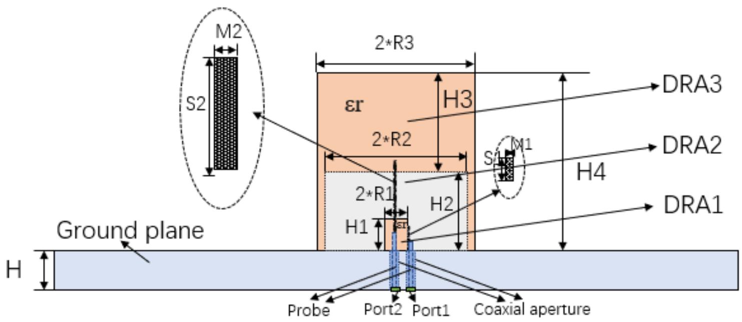
$$H3 = m * \frac{\lambda g}{4} = m * \frac{\lambda 0}{4\sqrt{\varepsilon r}} \tag{2}$$

where n and m are integers (m is odd), and λg and λ0 are resonant wavelengths in the dielectric and air, respectively. We are usually set as m = n = 1 in the conventional FPRA design for convenience. Using m = n = 1 gives H2 = 18.8mm and H3 = 2.38 mm.By adjusting m, we can make the low band resonance frequency close to 2.4GHz. It was found that the resonant frequency of the DRA is close to 2.4 GHz when m = 5.

For the design in this study, the design parameters are chosen as follows: R1=4.4mm, R2=19mm, R3=20mm, H1=6.3mm, H2=18.8mm, H3=13.95mm, H4=32.75mm, M1=1mm, S1=4mm, M2=2mm, S2=20mm. The dual-band cylindrical dielectric resonator antenna is fed by probes and stripes. The strips have different lengths and widths, connected to the probes through vias.




(a) Top view of the antenna




(b) Front view of the antenna

**Figure 1.** The configuration of the antenna

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## 2.2 Characteristic Analysis

In this paper, the DRA and FPRA are excited in their resonant mode by vertical excitation strips of different lengths and widths. The excitation strips are stuck onto the DRs directly. Figure 2. shows the simulated internal fields of the small DRA at 12 GHz. Figure 3. shows the simulated internal fields of the big DRA at 2.4 GHz. Figure 2. and Figure 3. show that typical internal HEM11δ-mode fields are observed.

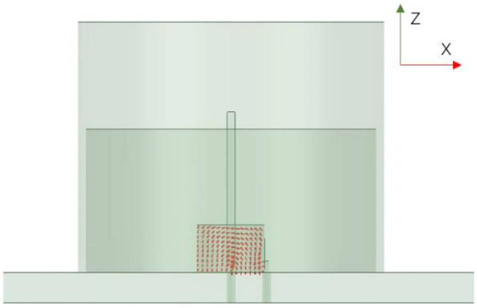



**Figure 2.** Simulated E-fields of DRA at 12 GHz (xoz plane).

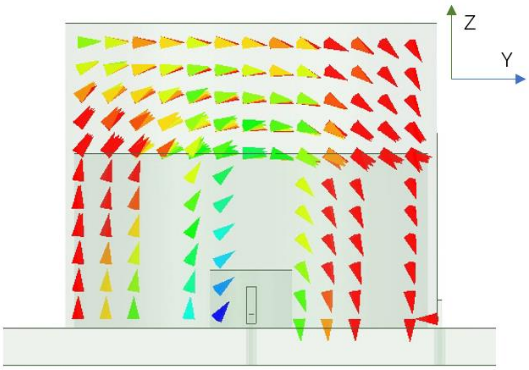
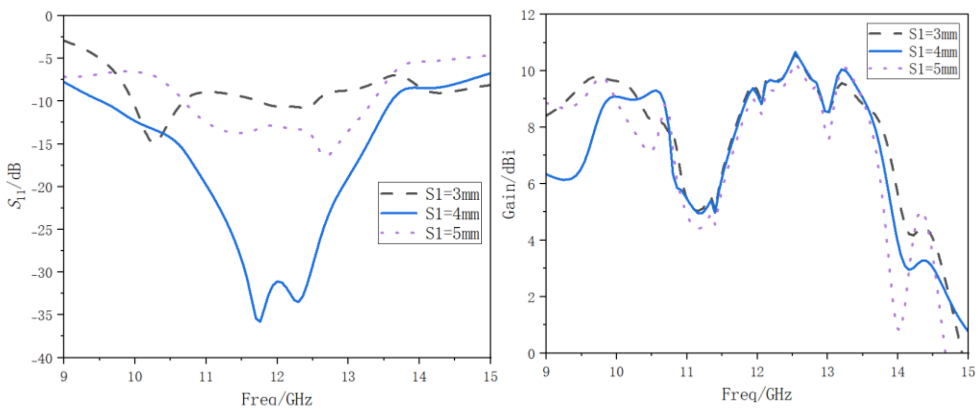



**Figure 3.** Simulated E-fields of DRA at 2.4 GHz (yoz plane).

We use ANSYS Electronics 2020 R1 electromagnetic simulation software for the simulation optimization and analysis of dual-wideband cylindrical dielectric resonator antenna. By adjusting the lengths S1 and S2 of the strips, the antenna reflection coefficients (S11) and gains are optimized. Figure 4. shows the reflection coefficients and gains for Port1 at 12GHz, and Figure 5. shows the reflection coefficients and gains for Port2 at 2.4GHz, respectively. Ports 1 and 2 do not affect each other.




(a)Reflection coefficients (b) Gains

**Figure 4.** Reflection coefficients (S11) and gains varied with S1

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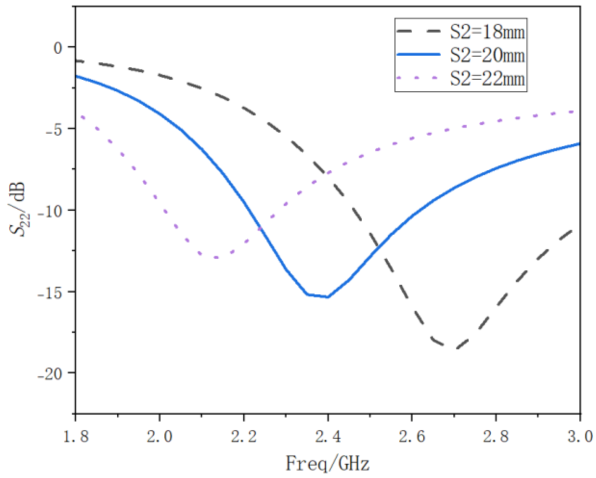
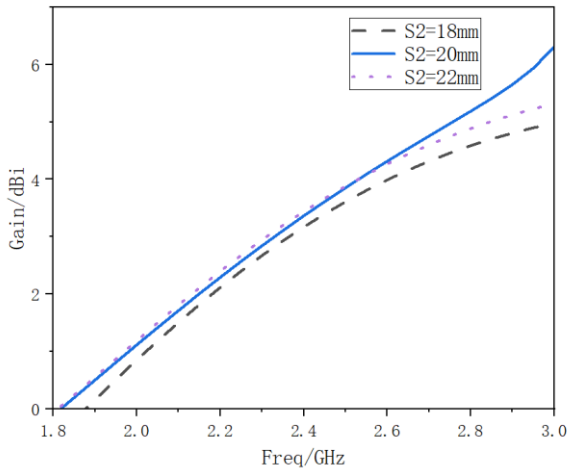
Concerning Figure 4., the length of S1 affects the matching of the antenna, and when S1=4mm the matching of the antenna is the best at 12GHz. The effect on gains is increasing with the increase of the length S1 but is not very obvious.




(a)Reflection coefficients




(b) Gains

**Figure 5.** Reflection coefficients (S11) and gains varied with S2

Regarding the inset, with the increase of the length S2, the resonance frequency turns to a lower frequency. The bandwidth of the lower band is decreasing, and S2 =20mm is selected. The influence of gains is not very obvious, but when S=20mm the gain of the antenna is the best.

## 3. Results

The antenna simulated impedance bandwidths, gains, and E-plane and H-plane radiation patterns at 12GHz and 2.4GHz are presented in Figure 6., Figure 7., and Figure 8.

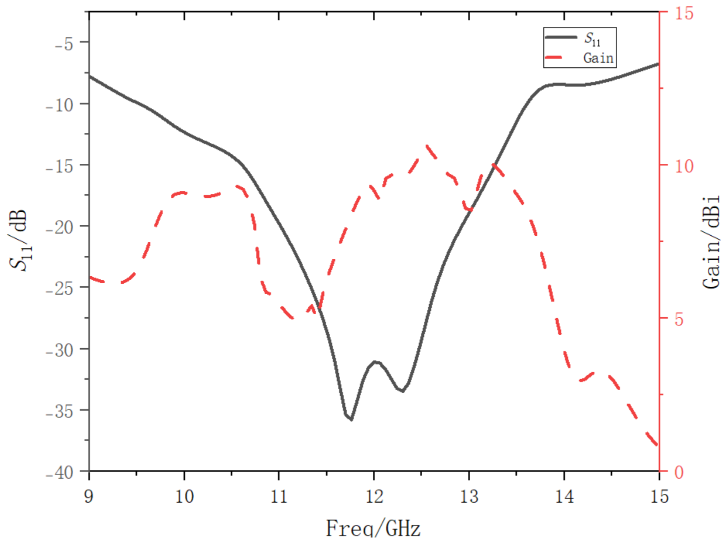



**Figure 6.** Simulated reflection coefficients (S11) and gains of FPRA

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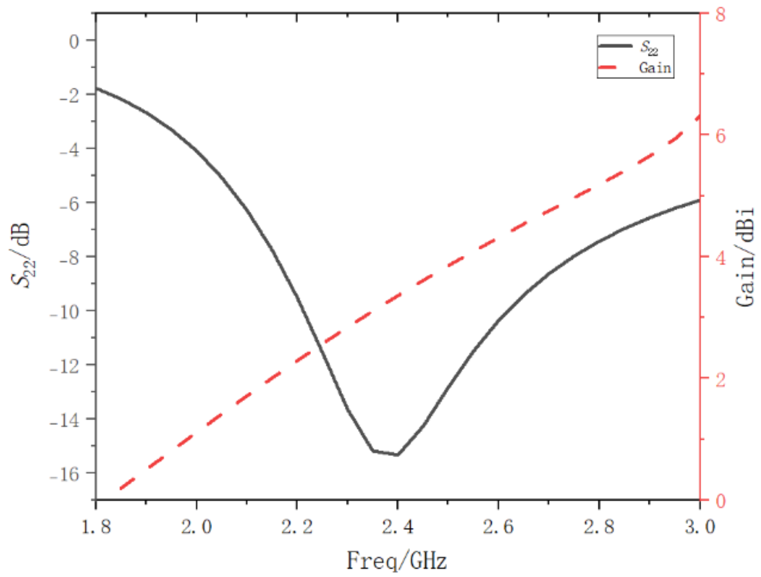
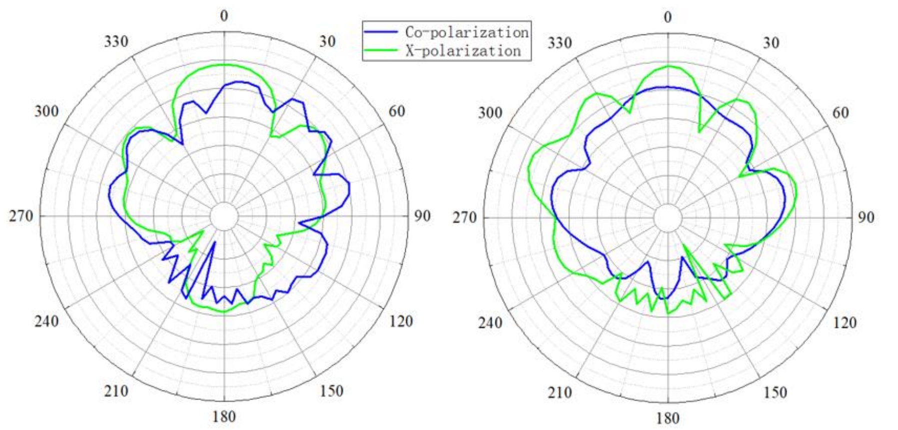
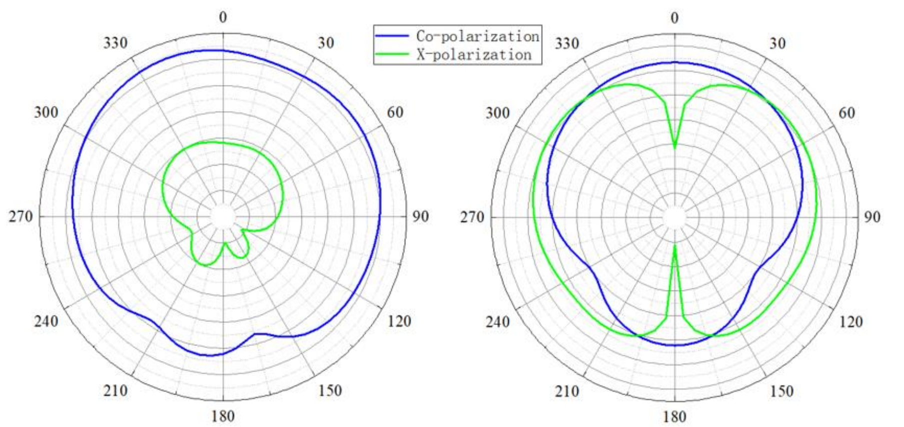



**Figure 7.** Simulated reflection coefficients (S11) and gains of DRA




(a)E-plane (a) H-plane




(b)E-plane (b) H-plane

**Figure 8.** Simulated radiation patterns of the antenna (a) 12GHz (b) 2.4GHz

Figure 6. and Figure 7. show the simulated reflection coefficients and the antenna gain of the proposed dual-wideband antenna. It has -10dB bandwidths of 9.51-13.61 GHz (34.2%) and 2.21-2.63 GHz (17.5%) in the 12GHz and 2.4GHz bands, respectively. Its maximum gains are 10.66 dBi (at 12.54 GHz) and 4.32 dBi (at 2.60 GHz), respectively.

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Regarding Figure 8(a)., we can see the cross-polarization is relatively large at 12GHz in the boresight direction, which needs to be improved. Concerning Figure 8(b)., the cross-polarization of the E-plane is small, and the simulated co-polarization field is stronger than the cross-polarization field in the boresight direction.

## 4. Conclusion

A novel design of the probe-fed dual band and wideband cylindrical dielectric resonator antenna has been proposed. By creating a cylindrical hollow region through DRA and adding a small dielectric resonator, a Fabry-Perot dielectric resonator antenna is formed. The impedance bandwidth and antenna gain are given by 34.2%, 10.66dBi (at 12.54GHz), and 17.5%, 4.32dBi (at 2.60GHz), respectively. Because of the advantages such as its wideband and compact structure, our antenna should be useful for modern broadcasting, telemetry, aerospace, and satellite communications.

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