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The Invention Relates to a Substrate Integrated Cylindrical Dielectric Resonator Antenna Loaded with a Dielectric Block

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Abstract

A substrate integrated cylindrical dielectric resonator antenna fed by microstrip line and working in millimeter wave band is designed.The antenna dielectric substrate is inlaid with two concentric circular arrays of holes and blind holes, which are isolated from the substrate to form a cylindrical dielectric resonator, above which are two layers of dielectric blocks.A rectangular slot is arranged between the dielectric substrate and the antenna substrate.The designed antenna has a resonant frequency of 57.4GHz, impedance bandwidth of 0.8% (57.2-57.7GHz), gain of 4.78dB, and excellent performance.

Keywords

Dielectric Resonator Antenna, Substrate Integration, Millimeter Wave, Cylindrical, Medium Block.

1. Introduction

In 1983, as researchers Wireless communication is a kind of communication mode that uses the characteristic of radio wave signal to exchange information in free space.With the continuous progress of science and technology, wireless communication has achieved rapid development [1-2].With the rapid development of wireless communication, people have higher requirements on the quality of wireless transmission.As an important component in wireless communication system, antenna needs to meet some specific performance, such as high efficiency, miniaturization, multi-band, etc., to support 5G's communication requirements of high rate, low delay and low loss.Since the Dielectric Resonator Antenna (DRA) was proposed, it has been widely concerned for its advantages of no ohmic loss and easy miniaturization design.Therefore, the research on multi-band dielectric resonator antenna (DRA) for 5G wireless communication will have a significant impact on the development of the new generation of wireless communication [3-4].

Dielectric resonator antenna (DRA) is a dielectric resonator which is placed on a metal ground plane and excited by a specific feed mode to form radiation.The antenna uses the energy stored in the medium to reflect back and forth to form electromagnetic oscillations, so as to realize the radiation and reception of electromagnetic waves [3].Compared with patch antenna, dielectric resonator antenna (DRA) has high radiation efficiency (>95%) due to no conductor loss and surface wave loss.At the same time, the dielectric resonator antenna (DRA) has the characteristics of wide selection range of dielectric constant (6-140) and low machining error requirements, which makes the design of dielectric resonator antenna (DRA) more flexible and more suitable for microwave band and millimeter band [4].Literature [5-7] proposes that stacked dielectric resonator antennas can obtain

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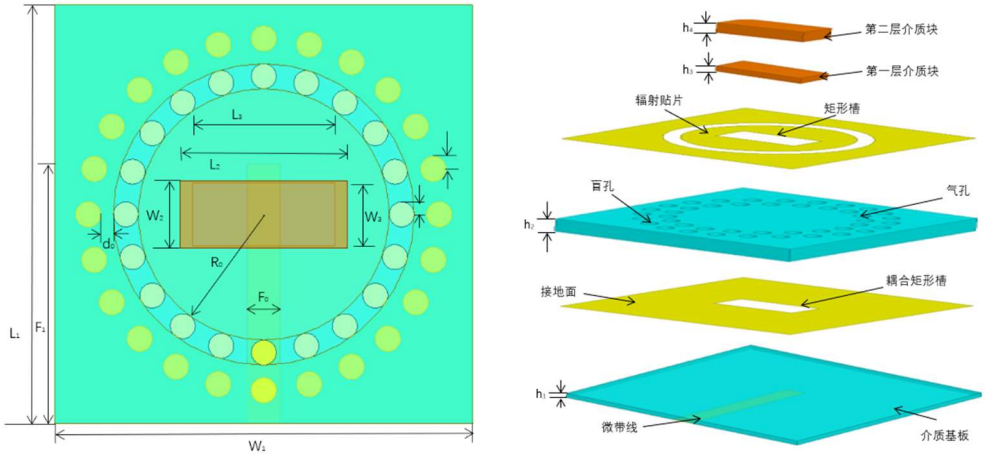
wider bandwidth than single dielectric resonator antennas.In addition, the higher antenna gain performance of dielectric resonator antenna (DRA) is also studied [8].The principle behind this advantage is the stack structure.In this paper, the cylindrical dielectric resonator antenna (DRA) is stacked with two rectangular dielectric layers.The gain of the antenna is enhanced by the stacked structure.

This paper designed a kind of loading medium piece of substrate integrated cylindrical dielectric resonator antenna (DRA), antenna is made up of medium at the top of the rectangular block and antenna in the middle of the dielectric substrate (i.e., dielectric resonator) and feed at the bottom of the dielectric substrate which is composed of three parts, using microstrip line feed, and by increasing the rectangular dielectric block method, greatly improving the antenna gain,The antenna can be applied in the millimeter wave band.

2. Antenna Design

In the antenna The structure of stacked cylindrical dielectric resonator antenna (DRA) designed in this paper is shown in Figure 1, in which Figure 1 (a) and (b) are the top view and structure diagram of each layer of the antenna respectively.The antenna is composed of three parts: a rectangular dielectric block at the top, a dielectric substrate in the middle (i.e. a dielectric resonator) and a feeder substrate at the bottom. The radiating patch radiates electromagnetic waves outwards.In the medium layer antenna dielectric substrate, the cylindrical dielectric resonator antenna (DRA) is isolated by using a concentric circular array of pores in the lower dielectric substrate, so that the electromagnetic energy is confined within the cylindrical dielectric resonator.Dielectric resonator antenna (DRA) is a medium layer dielectric resonator which is placed on the metal ground surface on the bottom layer, and the dielectric resonator is excited by the feed mode of microstrip coupling to form radiation.The antenna uses the energy stored in the medium to reflect back and forth to form electromagnetic oscillations to realize the radiation and receiving of electromagnetic waves.Microstrip line is used to feed in the bottom layer of feeder substrate.A rectangular slot is etched on the metal ground surface above the top of the feed substrate to excite the dielectric resonator antenna. This feeding mode can improve the antenna gain.On the top layer of radiation patch, a circular hole with rectangular slot is designed to obtain the radiation surface of Dielectric Resonator Antenna.Above the radiant surface are two rectangular dielectric layers of thickness h3 and h4 respectively.



(a) (b)

Figure 1. Antenna structure of cylindrical dielectric resonator (a) top view (b) antenna structure of each layer

The dielectric material of the antenna feed medium substrate and the first layer rectangular medium block is Rouges 5880, the dielectric constant is εr1 =2.2, the length, width and height of the antenna

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medium substrate are L1=5mm, W1=5mm, h1=0.127mm, respectively.The length of the first layer rectangular medium block is L2=2mm, width is W2=0.8mm, and height is h3 =0.254mm.The dielectric material of the antenna dielectric substrate and the second layer rectangular dielectric block is Rogers 6010LM, the dielectric constant is εr2 =10.2, the length, width and height of the antenna dielectric substrate are L1=5mm, W1=5mm, h2 =0.63mm respectively.The length of the second rectangular medium block is L2=2mm, the width is W2=0.8mm, and the height is h4 =0.635mm.There are two rows of cylindrical holes with spacing d0 =0.15mm with radius r =0.15mm and height h2 =0.63mm on the substrate of dielectric resonator antenna.

The center of the antenna radiation patch layer is a circular patch with a radius of R0=1.5mm, and the rectangular slot in the circular patch is L3=1.7mm in length and W3=0.75mm in width.The length of the coupled rectangular groove in the ground is L3=1.7mm, and the width is W3=0.75mm.The length and width of the bottom feed microstrip line are F1=3.1mm and F0=0.39mm, respectively.

3. Antenna Performance Analysis

In this paper, Ansoft HFSS 15 electromagnetic simulation software is used to analyze the performance of the substrate integrated cylindrical dielectric resonator antenna (DRA) loaded with rectangular dielectric block.

As shown in Figure 2, S11 of the dielectric resonator antenna realizes working in the millimeter wave band.

The dielectric resonator antenna has a working frequency of 57.2-57.7GHz, an absolute bandwidth of 0.5GHz, an impedance bandwidth of 0.8%, and a center frequency of 57.4GHz up to -22.9dB.The antenna directions are shown in Figure 3 and Figure 4, wherein Figure 3 is the three-dimensional direction and Figure 4 is the direction of plane E-H.As can be seen from Figure 3 and 4, the symmetry of the antenna radiation direction diagram is good, and the main lobe of the direction diagram is large.As can be seen from Figure 3, the maximum gain of the antenna can reach 4.78dB;However, the bandwidth of the antenna is not wide enough, and it is proposed to improve it by changing the shape of the rectangular medium block, which needs further study.

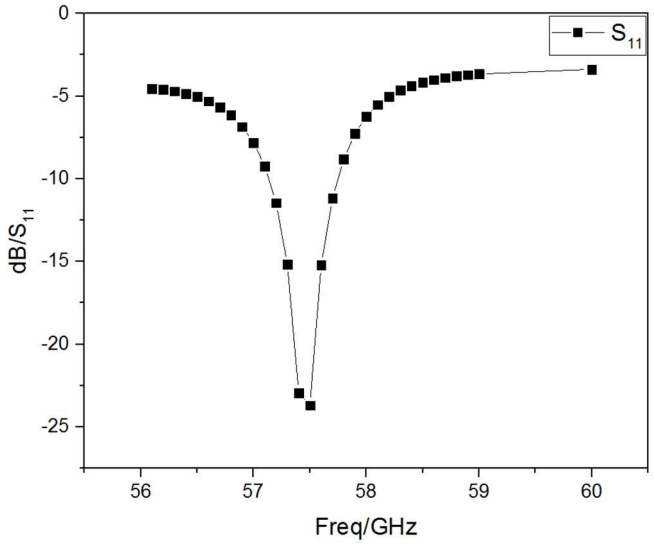

Figure 2. S_{11} of dielectric resonator antenna

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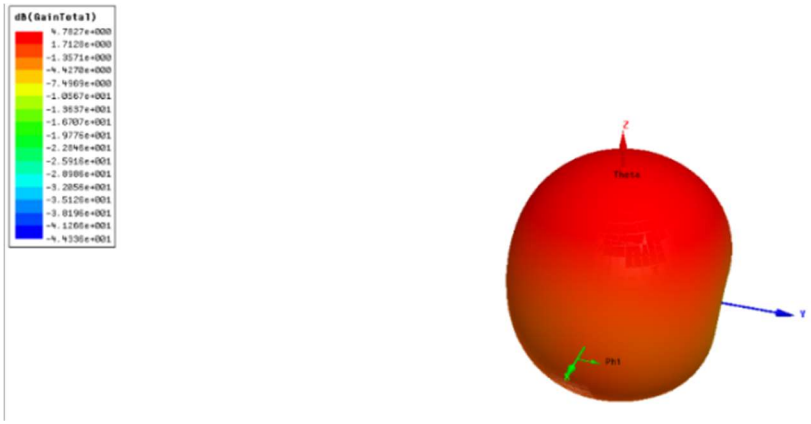


Figure 3. Three-dimensional direction diagram of dielectric resonator antenna

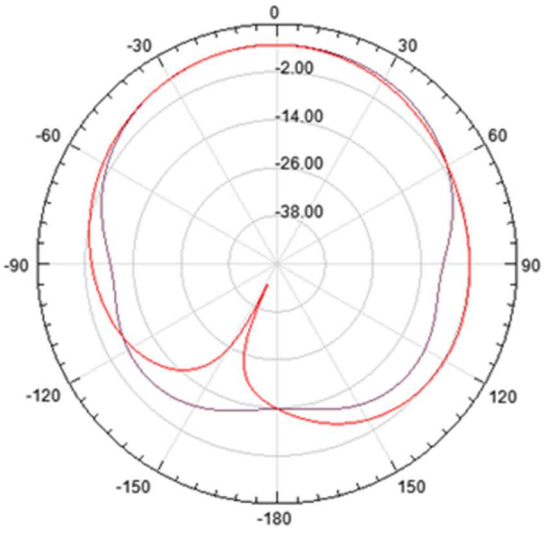
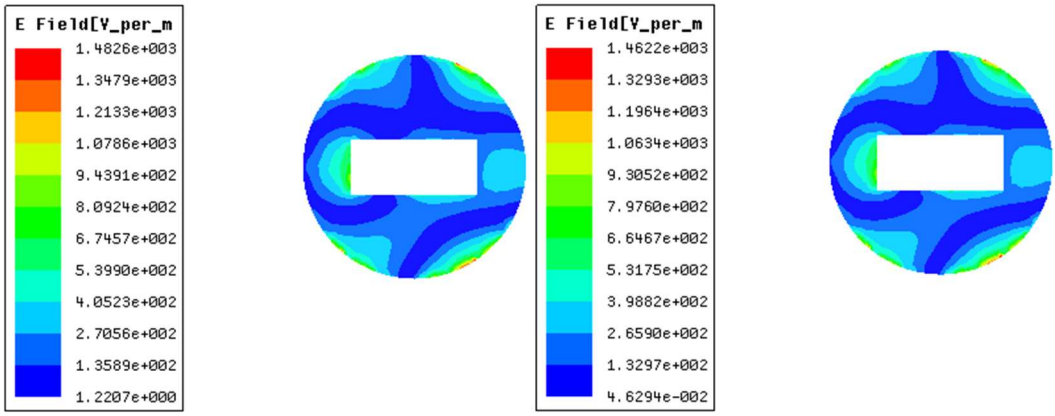


Figure 4. direction diagram of plane E-H of dielectric resonator antenna

Figure. 5 shows the current distribution of the ground plate and radiant patch with rectangular groove at two frequencies (57.4GHz and 57.9GHz).At 57.4GHz and 57.9GHz, the current is mainly concentrated on the edge of the radiation patch and the left part of the rectangular slot, as shown in Figure. 5 (a) and (b).As shown in Figure.5 (c) and (d), when the ground surface is rectangular slot, the current is mainly distributed in the middle and lower part of the rectangular slot and the lower edge of the ground surface at 54.6GHz and 56.5GHz.



(a)57.2GHz (b)57.9GHz

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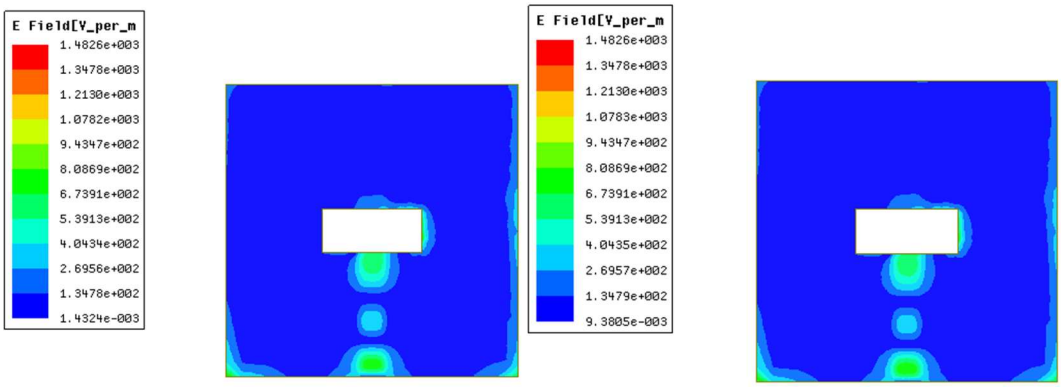

(c)57.2GHz (d)57.9GHz

Figure 5. Surface current distribution of ground plate and radiation patch at different frequencies conclusion

4. Conclusion

In this paper, A substrate integrated cylindrical dielectric resonator antenna loaded with dielectric block is designed in this paper. Microstrip line is used to feed, SIW cavity structure is used to isolate the cylindrical dielectric resonator antenna, and the gain of the antenna is improved by adding dielectric block, and the performance of the dielectric resonator antenna is optimized. The designed antenna can work in millimeter wave band and has high gain. The dielectric resonator antenna still has some shortcomings, such as the impedance bandwidth of the antenna is not wide enough, and it is proposed to improve it by changing the shape of the coupling groove and the size of the rectangular dielectric block, which needs to be further studied.

Acknowledgments

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