Design of a Dual Frequency and Dual Circularly Polarized Microstrip Antenna Array with Light Weight and Small Size

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***Abstract*-A novel dual frequency and dual circularly polarized microstrip antenna array is introduced in this paper. By placing two 2 × 2 microstrip antenna arrays on the same broad with unique fashion and taking out the dielectric substrate around the element, the small size antenna array with light weight was designed and manufactured. The array is designed and optimized with the help of HFSS10 software. The return loss, radiate pattern, gain and the axial ratio plots of the array are measured, which agree well with the simulated results.**

I. Introduction

Microstrip antenna (MPA) has been widely used in the mobile and satellite communications, due to its light weight, low profile and circularly polarized performance [1-3]. Recently, more researchers are interested in the design of dual-polarized patch antenna. The reason is that it can provide polarization diversity to reduce the multipath fading of the received signals or furnish frequency reuse to double the capacities of the mobile communication systems [4]. However, these antennas usually has a complex configuration, such as stacked fabric [5] or complex feeding structure [4][6], which brings much difficulty to the fabrication and production of the antenna.

In this paper, a novel dual frequency and dual circularly polarized microstrip antenna array of S band is presented, which is constituted of two irrelated 2 × 2 microstrip antenna array that works at different frequency and different polarization. And by laying the two array across to each other, all the patches are designed on one substrate which size is 20cm×20cm. By taking out the dielectric substrate around the element, the weight of the array is just 72% of that has no substrate cut. With the help of HFSS10 software, the lower band array has a simulated 1dB gain bandwidth of 3.5% from 1.94 to 2.01GHz, and a maximal gain of 12.19dB. The upper band array has a simulated 1dB gain bandwidth of 3.9% from 2.14 to 2.1925GHz, and a maximal gain of 11.4dB. Across the gain bandwidth, all axial ratios of the array are less than 2dB. Compared with the measured results, preferable agreement has been obtained.

II. ELEMENT DEGIGN

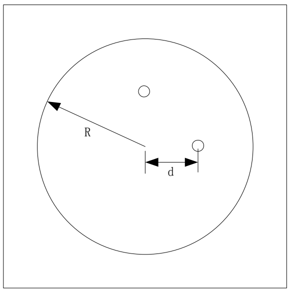
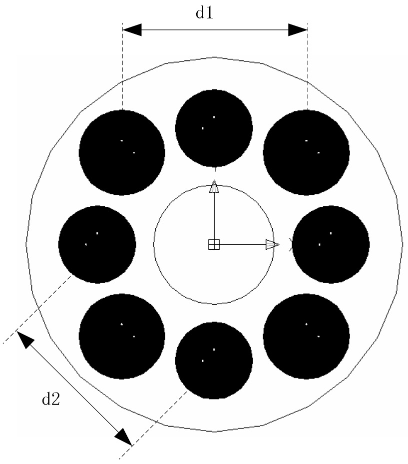


Figure 1. The configuration of element

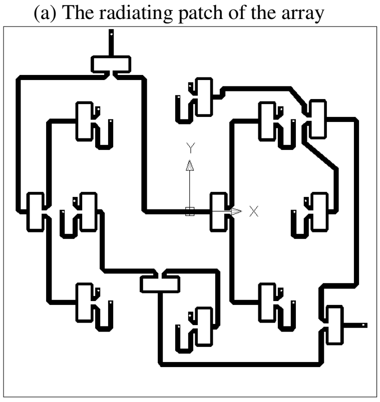
The element shown in Figure1 is designed with a single layer to remain low profile. Circular patch is chosen for convenience embedding the two arrays, which radius is R. Two feeds with 90° phase difference are placed along the orthogonal directions with a spacing d away from the patch center, which realizes circular polarization. The relative permittivity and the height of the substrate are 2.2 and 3mm partly. The radius of the patch that works at 2GHz is 22.8cm while the radius of the patch that works at 2GHz is 20.5cm. The substrate between the patch and ground has a thickness of 3mm and relative permittivity of 3.5. The position of the feeding point d directly affects the return loss S11 and the coupling degree S21. Via optimizing the position of the feeding point d, it can be found that the excellence position d of the antenna that works at 2GHz is 7cm, while that works at 2.19GHz is 5cm.

III. ARRAY DESIGN

Basing on the circular patch discussed above, the dual frequency and dual circularly polarized microstrip antenna array is designed, which is shown in Figure 2. The radiating elements shown in Figure 2(a) consists of 8 circular patches, in which 4 patches work at 2GHz and the other 4 patches work at 2.19GHz, and they are interveined one another to reduce the horizontal size. Because the Wilkinson power divider has advantages such as small output power difference and high isolation between the two ports [7]. Here Wilkinson power divider is chosen to form feeding network, as shown in Figure 2(b), in which two irrelated feeding networks are intersected to each other . The outside length of the ground plane is 20cm. The space between the patches that work at 2 GHz is denoted to be d_1 which is 98mm(0.65λ, λ is the free space wavelength), while that work at 2.19 GHz is denoted to be d_2 which is 84.8mm(0.62λ). As seen in figure 2(a), the substrate is designed in ring form, thus the weight of the array is reduced by 28% compared with that filled completely with the dielectric substrate.



(a) The radiating patch of the array

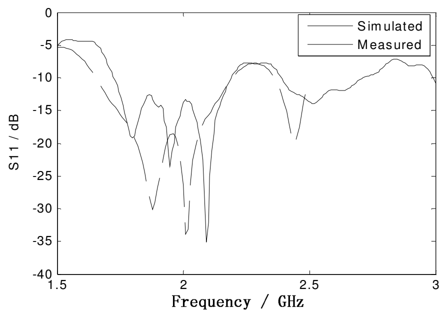


(b) The feeding network of the array

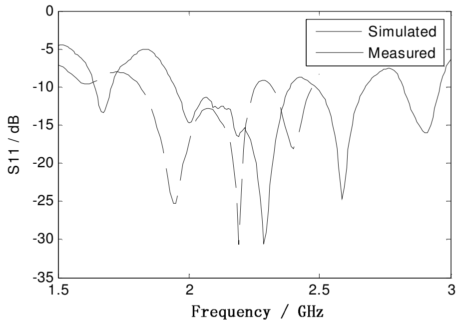
Figure 2 The structure of the array

IV. MEASUREMENTS

The corresponding mirostrip antenna array has been fabricated. Because the array has two irrelated sub-arrays, Measurements are implemented one another. Figure3(a) shows the simulated and measured return loss characteristics (S_{11}) of the array that works at 2GHz, where the simulated bandwidth defined by S_{11} less than -10dB is about 25% from 1.7 to 2.19GHz. Figure3(b) shows the simulated and measured return loss characteristics (S_{11}) of the array that works at 2.19GHz, where the simulated bandwidth defined by S_{11} less than -10dB is about 22.7% from 1.9 to 2.4GHz.



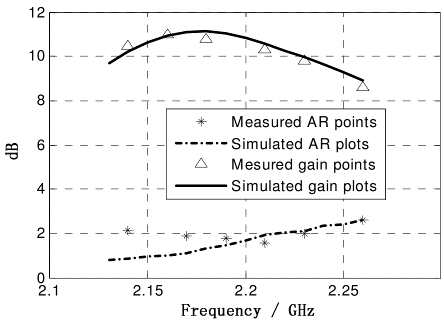
(a) The simulated and measured S_{11} of the lower band array



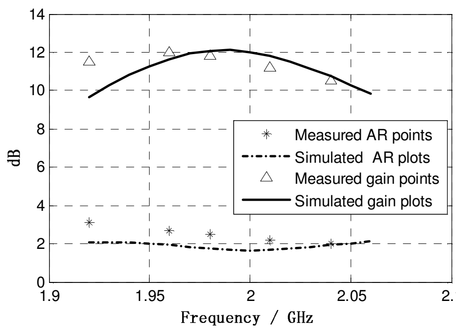
(a) The simulated and measured S_{11} of the upper band array

Figure 3 The simulated and measured S_{11}

To verify the simulated results of the gain and the axial radio (AR), the antenna array is measured in the anechoic chamber. Figure 4 shows the simulated plots and measured points of the gain and AR against frequency. It can be seen that, the maximum gain of the array works at 2 GHz is about 12dB, which is similar to the simulated result. But the shift of the center frequency can be detected and the maximal gain appears at 1.96GHz instead of 2GHz. The difference is probably owing to the fabrication error and the tolerance of the relative permittivity of the substrate. Similarly the array works at 2.19GHz has difference of the center frequency, which maximum gain appears at 2.16GHz instead of 2.19GHz. From the measured points of the AR, during the 1-dB gain bandwidth the measured AR is less than 3dB, which agrees well with the simulated results.

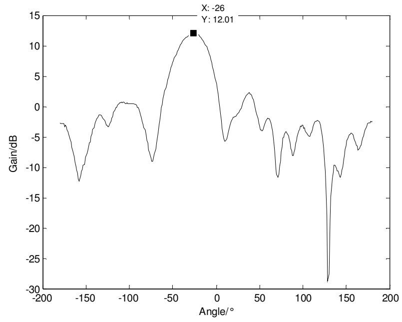


(a) The lower band array

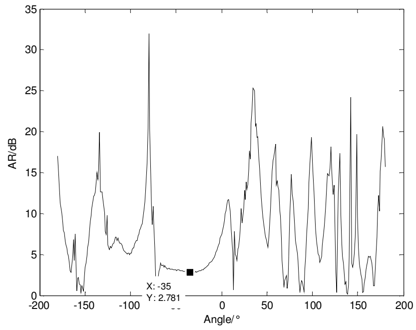


(a) The upper band array

Figure 4 The simulated plots and measured points of the gain and AR against frequency

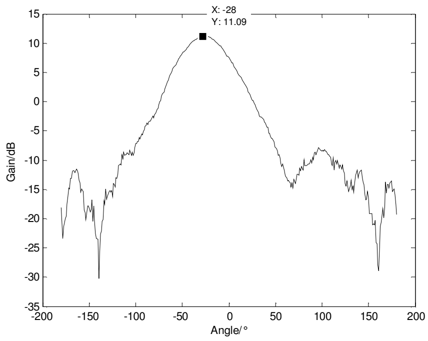


(a) The gain pattern

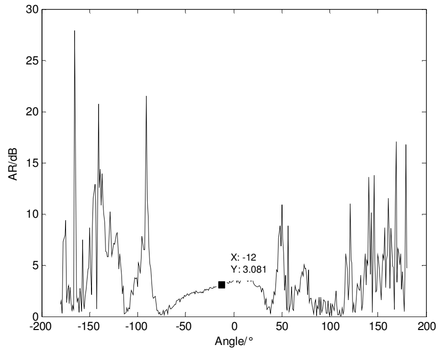


(b) The AR pattern

Figure 5 The measured far-field radiation patterns at 1.96GHz



(a) The gain pattern



(b) The AR pattern

Figure 6 The measured far-field radiation patterns at 2.16GHz

Figure 5 and Figure 6 gives the measured far-field radiation patterns at the frequency 1.96GHz and 2.16GHz. It can be seen that the maximum gain appears at -28° not at 0° ,the reason is simply that the initialized position of the rotating platform is not at the 0° direction. Still good symmetric patterns have been obtained. Figure 7 shows the fabricated antenna.

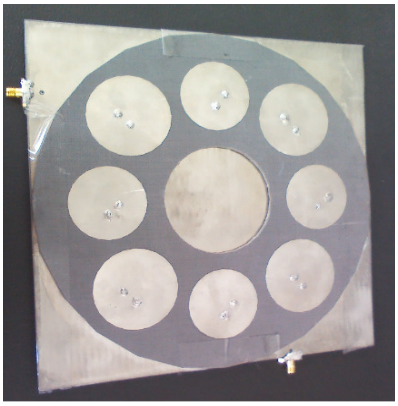


Figure 7 The fabricated antenna

V. CONCLUSION

A novel dual frequency and dual circularly polarized microstrip antenna array is presented in this paper. By laying the two array across to each other, the horizontal size of the antenna array is reduced. And by taking out the dielectric substrate around the element, the weight of the array is reduced by 28%. The designed array was fabricated and measured in this paper, which shows preferable performance.

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