A Wide Bandwidth Circularly Polarized Microstrip Antenna Array Using Sequentially Rotated Feeding Technique

YU Tongbin[1], LI Hongbin[2], ZHONG Xinjian[1], YANG Tao[1], ZHU Weigang[1]
1. Institute of Communications Engineering, PLA University of Science and Technology, Nanjing 210007, China;
2. The First Engineers Research Institute of the General Armaments Department, Wuxi 214035, China

Abstract-A wide bandwidth circularly polarized microstrip antenna array using sequentially rotated feeding technique is presented in this paper. First a stacked microstrip antenna with tuning stub is designed, which meets wide bandwidth application. Then sequentially rotated feeding technique is introduced, basing on which a 4 element stacked microstrip antenna array with preferable axial ratio performance is achieved. The corresponding antenna array is fabricated and measured, the results of which shows that the antenna has the advantages of wide bandwidth, high gain and low axial radio, which has good application foreground.

I. INTRODUCTION

Due to light weight and low profile, Circularly polarized microstrip antenna has been widely used in the satellite communications. However, traditional microstrip antenna usually has a narrow bandwidth that is less than 3% [1-3], which limits the development and application of the microstrip antenna. Recently, stacked microstrip antennas have been widely investigated and used, because these antennas usually have a wide bandwidth, high gain and simple structure [4-6]. What's more, to improve the axial radio performance of the antenna array, sequentially rotated feeding technique is researched in this paper, which can improve the polarization purity without introducing other complex elements [7-9].

Basing on the stacked microstrip antenna element and the sequentially rotated feeding technique, a novel 4 elements microstrip antenna array is designed and fabricated. By the help of HFSS10 software, the array has been optimized, which impedance bandwidth achieves 54.5% from 1.6 GHz to 2.8GHz, and 3dB gain bandwidth achieves 19% from 1.9 to 2.3GHz, while its maximal gain is 13.5dB. Across the 3dB gain bandwidth, axial ratio of the array is less than 1.5dB. The array has been measured in the anechoic chamber, and good agreement is obtained between the simulated and measured results. The wide bandwidth and the simple structure make the designed antenna meet many applications in the modern satellite communication.

II. ELEMENT DEGIGN

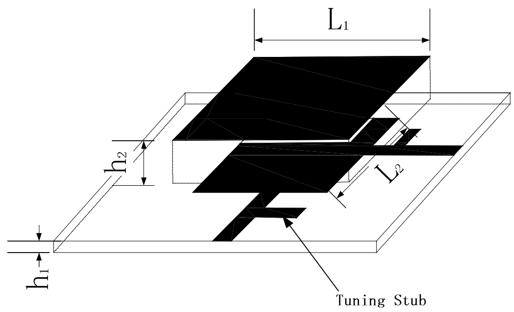


Figure 1. The configuration of element

The stacked microstrip antenna has been used as the array's element, as shown in Figure1. the element has two radiating patches, which are the upper and the lower patch. The lower patch whose side length is denoted L_1 works as inspiring element, while the upper patch whose side length is denoted L_2 works as parasitical element. The height between the two patches is h_2. Two side microstrip line feeds along orthogonal directions with 90° phase difference are used to imply circular polarization. As shown in Figure1, the feeding lines and the inspiring patch are placed at the same surface of the substrate, which relative permittivity is 2.2 and height denoted to be h1 is 0.8mm. The tuning stub is a short open 50 Ω microsrip transmission line, which length and distance from the lower patch can be used to optimize the impedance, as a result, the height between the upper and lower patches can maintain as a small value. With the help of HFSS10 software, the parameters have been optimized and validated, as L1=58, L2=46, h2=6mm. To obtain good impedance, the length of the tuning stub is tuned to be 8mm, while the distance between the lower patch and the tuning stun is 2.5mm.

III. SEQUENTIAL FEEDING DESIGN

Sequential rotation of circularly polarized array feeding involves applying both a physical rotation to the element feed point and an appropriate phase offset to the element. And it can be used to both the odd and even arrays[7].Basing on the stacked circularly polarized antenna designed above and the sequentially rotated feeding technique, 4 element circularly polarized microstrip antenna array is designed, which feeding network is shown in Figure 2. The Wilkinson power divider has been used here to provide two feeding ports that have equal magnitude and 90° phase difference. The outside length of the ground plane denoted to be Lg is 20cm and the space between the patches denoted to be d is 90mm(about 0.6λ, λ is the free space wavelength). As seen in figure 2, the elements of the array is rotated by 90° one by one, while the feeding phase in turn is also changed 90° . So the Sequential rotation of array is achieved.

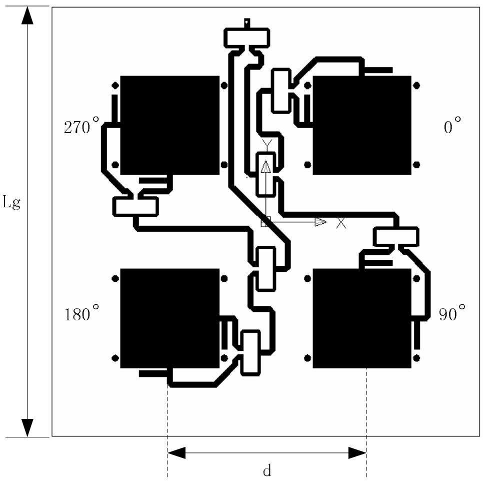


Figure 2 The structure of the feeding network

IV. MEASUREMENTS

To verify the technique used above, the sequentially rotated feeding mirostrip antenna array has been fabricated in this paper. First, the return loss (S_{11}) plots of array is measured, as shown in Figure3. It can be seen that, the measured and simulated results have some difference, which probably owns to the SMA interface and loss of the substrate. Still the measured bandwidth defined by S_{11} less than -10dB is about 25% from 1.6 to 3GHz . The measured result is a little better than the simulated ones.

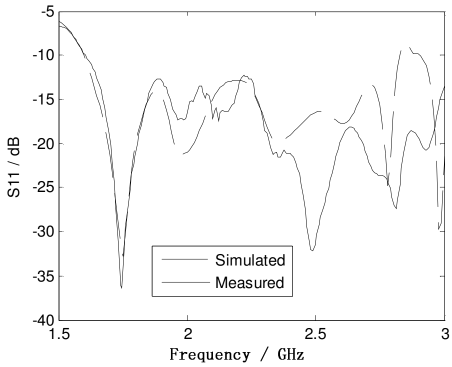


Figure 3 The simulated and measured S_{11}

Then the gain, the axial radio (AR) and the radiation pattern of the array has been 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 antenna's gain around 2.1GHz is a little smaller the simulated ones, and the axial radio around 2GHz is greater. The reason is likely the tolerance of the fabrication, which is similar to the simulated result. From figure 4, the measured gain band width defined by 1 dB is 14.3% from 1.95GHz to 2.25GHz while its maximum gain is 13.2dB at 2.2GHz. Within the 1 dB gain bandwidth, the measure AR is below 2 dB.

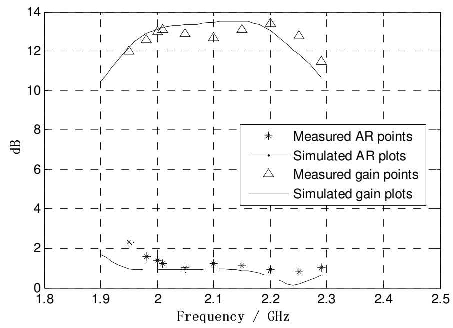
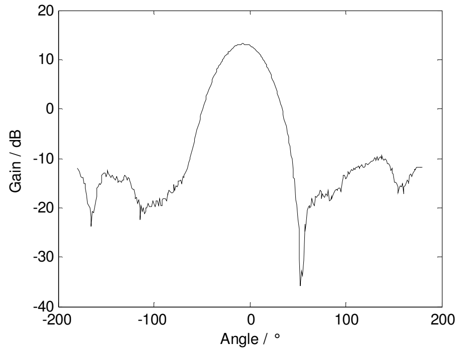
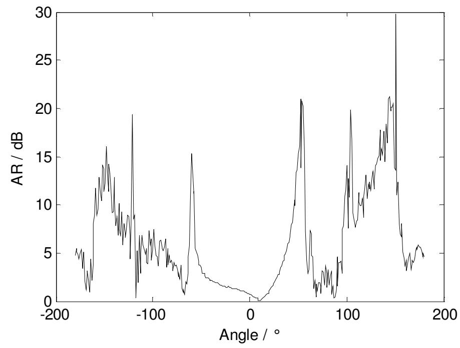


Figure 4 Tne simulated plots and measured points of the gain and AR against frequency

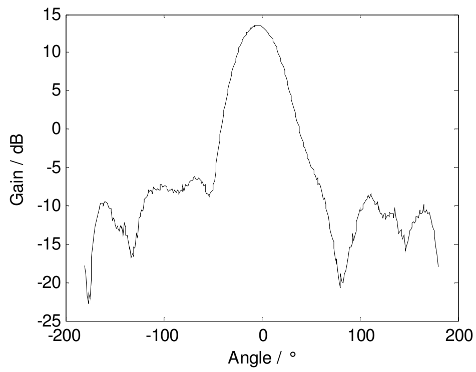


(a) The gain pattern

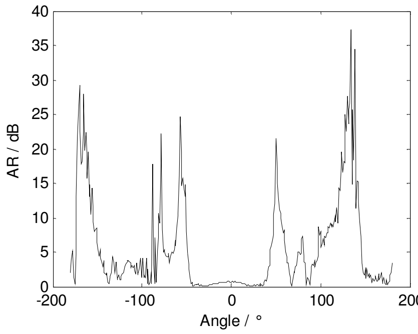


(b) The AR pattern

Figure 5 The measured far-field radiation patterns at 2GHz



(a) The gain pattern



(b) The AR pattern

Figure 6 The measured far-field radiation patterns at 2.2GHz

Figure 5 and Figure 6 gives the measured far-field radiation patterns at the frequency 2GHz and 2.2GHz. It can be seen the radiation patterns have good symmetric characteristic and the axial radio is small, which are profited from the sequentially rotated feeding technique.

The measured results given above make out that the performance of the microstrip antenna array can be notably improved by using the stacked antenna element and sequentially rotated feeding technique. The broadband impedance bandwidth is achieved by making the lower patch and the upper patch work at near frequency. The sequentially rotated feeding technique improves the polarization purity and the symmetric characteristic of the radiation pattern. The corresponding microstrip antenna array is shown in figure 7.

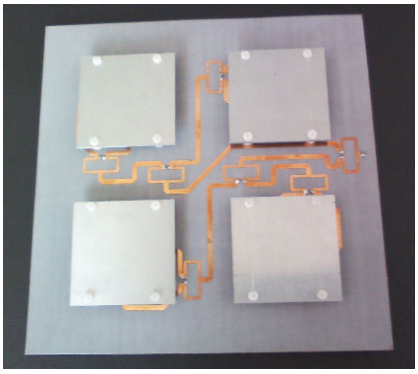


Figure 7 The fabricated antenna

V. CONCLUSION

A 4 elements stacked microstrip antenna array using sequentially rotated feeding technique is presented in this paper. The measured results approve that by using stacked microstrip antenna, the broadband impedance bandwidth and high gain have been obtained. And the sequentially rotated feeding technique can improve the polarization purity for sure.

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