# A Method to Improve the Axial Ratio of Microstrip Circularly Polarized Patch Antenna

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***Abstract*—In order to improve the axial ratio of the circular polarized microstrip patch antenna, a method is proposed in this paper. By changing the size of the rectangular slot loaded on one side of the top corner of the non chamfered patch, the axial ratio of the circular polarized microstrip patch antenna element can be improved by more than 0.6dB. Use this unit to form 2 × 2 array, the array's axial ratio can be improved by more than 1dB. Finally, the array's axial ratio is less than 2dB and its gain reaches 10dBic (in 2.4-2.5 GHz). The simulation results are in good agreement with the experimental results.**

***Index Terms*—circularly polarized microstrip antenna, axial ratio, slot loaded**

## I. Introduction

Circularly polarized patch antenna has the advantages of low profile, easy array formation and high gain, so it has been widely used in engineering[1]. Through the feed network with power division and phase-shifting function, the circularly polarized axis ratio index of the array is optimized[2]. So people feel troublesome to adjust the feed network. Therefore, how to simply reduce the axis ratio of the patch unit and achieve the low axial ratio becomes an important issue in the design of circularly polarized patch array antenna. Many researchers have proposed different ideas.[3,4].

In this paper, a method is proposed to improve the axial ratio of the patch antenna. This method is applied to design two kinds of 2×2 antenna arrays , the axial ratio of them is improved by more than 0.5dB. Finally, the axial ratio is less than 2.7dB in the frequency range of 2.4-2.5 GHz, and the circular polarization gain of the two arrays exceeds 7dBic.

## II. Antenna unit and array structure

Fig. 1 shows 2 × 2 circularly polarized antenna array with overall size of 190 × 150 × 2mm, metal patch and substrate thickness are set to one ounce. Parameters in the figure are marked as follows:l1=17.5mm, l2=l7=l10=22.5mm, l3=3.5mm, l4=20.0mm, l5=l8=l9=3mm, l6=46.3mm, l11=57mm, l12=34.2mm, lt=150mm, w0=40mm, w1=6.2mm, w2=1.8mm, w3=3.57mm, wc=7mm, wt=190mm.

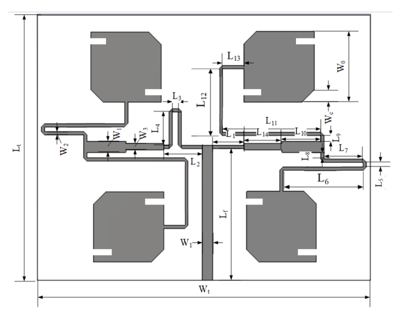

Fig. 1. Schematic diagram of bent line antenna array

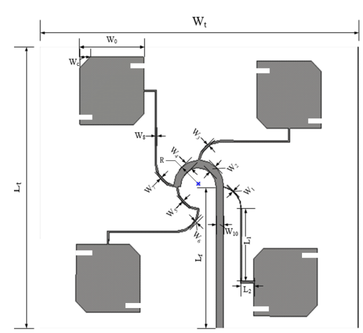

Fig. 2. schematic diagram of circular polarization array

Fig. 2 shows another antenna array based on tmm5 plate with its permittivity $\varepsilon_r$ =4.4, and the loss tangent = 0.005. The size of the array is 140 × 140 × 1.6mm, and the substrate thickness is 1.6mm. Parameters are marked as follows: w0=28.0mm, w1=0.225mm, w2=w4=3.08mm, w3=w5=w6=w7=w8=0.71mm, w10=3.4mm, wc=4.4mm, wt=140mm, l1=30mm, l2=6mm, lf=70mm, lt=140mm, r=13mm.

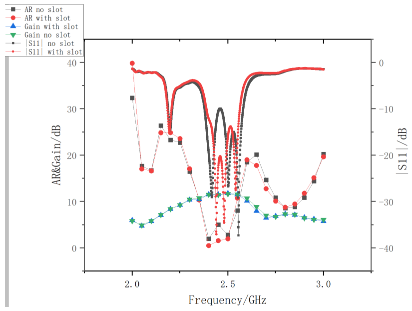


Fig. 3. schematic diagram of array I gain, axial ratio and $|S_{11}|$ parameters

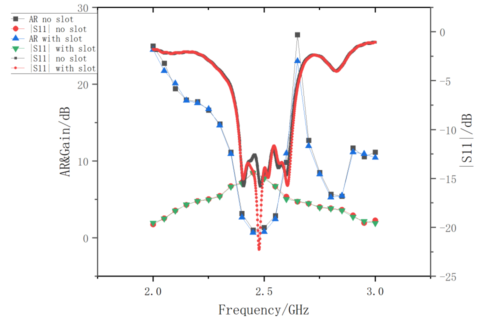


Fig. 4. schematic diagram of array 2 gain, axial ratio and $|S_{11}|$ parameters

## III. Simulation Results and Analysis

As shown in Fig. 3, within the frequency range of 2.38-2.57 GHz, the $|S_{11}|$ parameter of antenna array I is less than -10dB; within the frequency range of 2.4-2.52 GHz(working band), it is less than -12.5dB; within the frequency range of 2.4-2.45 GHz, it is less than -15dB, indicating that the antenna array matches the feed network very well. Fig. 5 also shows the simulation results of the maximum gain of the antenna array. It can be seen that the maximum gain is greater than 10dBic in the frequency range of 2.28-2.60 GHz, and the maximum gain is 11.76dBic at 2.50GHz. It can also be seen that, in the maximum radiation direction of the antenna array, the axial ratio of the antenna array is less than 2dB in the frequency range of 2.4-2.5 GHz, which proves that the antenna array of this structure can better meet the requirements of circular polarization radiation. Overall size of antenna array is 190 × 150 × 2mm.

### A. Simulation results of array

It can be seen from Fig. 4 that in the simulation results of antenna array II, the $|S_{11}|$ parameter is less than -10dB in the frequency range of 2.38-2.62 GHz, the gain is greater than 7.1dB (peak gain is 8.5dB) in the frequency range of 2.4-2.5 GHz(working band), the axial ratio is less than 2.7dB in the working band, the 3dB axial ratio bandwidth is 2.39-2.55 GHz, and the fullsize is 140 × 140 × 1.6mm. According to these data, the two-dimensional size of the circular feed structure antenna array is reduced by 32% compared with the bent line feed structure antenna array mentioned above, and the profile is lower. The bandwidth of reflection coefficient and axial ratio are also better than that of array antenna I.

## IV. Experimental Result

It can be seen from the results in Fig. 5 that the $|S_{11}|$ parameters of the actual antenna are close to the simulation results. In order to obtain array I's gain and axial ratio, the ch340 standard gain horn is used as the comparison object. The gain of the horn at 2.4-2.5GHz is 15.7-15.8dBi. The system is used to measure three frequency points: 2.4GHz, 2.45GHz and 2.5GHz. It can be seen from the figure that in this band, the axial ratio at these three frequency points are 3.66dB, 3.22dB and 3.65dB, and the gain are 11.91dB, 11.35dB and 12.03dB.

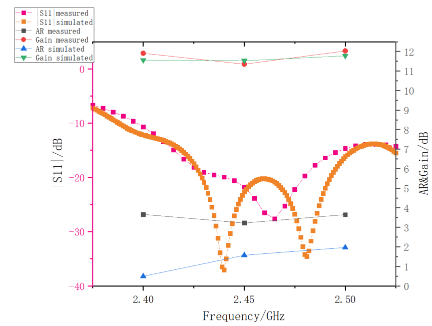


Fig. 5. $|S_{11}|$ comparison of measured and simulated results

The test results are in good agreement with the simulation results.

## V. Conclusion

In this paper, a fast iterative method to reduce the axial ratio of circularly polarized patch microstrip antenna array is proposed and applied to 2 × 2 array, the simulation and experimental results show that this method can achieve low axial ratio and wide axial ratio bandwidth, and also has strong adaptability to the feed network.

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