Broadband Circularly polarized Sequential-Rotation Array Antenna with Compact Sequential-Phase Feed

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***Abstract*—A miniaturized circularly polarized microstrip antenna array with sequential-phase (SP) feed is presented. Attributed to slotted metal walls surrounding the SP feed, an internally slotted patch array and parasitic rectangular patches, the key Performance Indicators of the antenna like the gain and the impedance bandwidth are greatly enhanced. The final results of the stimulation-testing by ANSYS HFSS show that the antenna obtains an impedance bandwidth of about 11.89% (5.41-6.09GHz) for $S_{11} < -10$-dB, a 3-dB Axial Ratio (AR) bandwidth of about 13.26% (5.64-6.44GHz), and a peak gain of 11.86dBi at 6.09GHz. When the center frequency of this antenna is operated at 5.87GHz, the usable bandwidth is 7.71% (5.64-6.09 GHz). At this point, the AR bandwidth of 450MHz is obtained.**

Keywords—Antenna Array, Circular Polarization, microstrip, sequential-phase

I. Introduction

With the development of microstrip technology in the field of modern wireless radio, the performance of circularly polarized antennas has become increasingly demanding, and a circularly polarized microstrip antenna array with enhanced gain has been proposed. Because of its compact structure, light weight, strong anti-jamming capability, and easy circuit integration, circularly polarized microstrip antenna arrays have important application prospects in modern radio fields, especially in electronic countermeasures and wireless communications[1].

There are generally two methods that can constitute a circularly polarized microstrip antenna array: 1.Uniformly feed each circularly polarized antenna to form an array. 2. Construct a circularly polarized antenna array using a continuous phase rotation feed excitation microstrip antenna [1-2]. By two spatially orthogonal linearly polarized electric field components with both amplitudes equal and the 90° out of phase, a circularly polarized antenna can be implemented. This property determines that the antenna structure in the form of sequential phase rotation can better suppress cross polarization and extend the antenna bandwidth. On the other hand, the sequential phase rotation method can well reduce the coordination of feeders through reasonable layout improving the performance of the antenna [7-8]. Therefore, the AR bandwidth of the circular polarization array antenna can be effectively improved. At the same time, the gain performance of the antenna can be increased. Because of the expandability of the antenna array, the general research focuses are on the microstrip patch antenna array that can generate circular polarized waves on the sequential phase rotation [3]. Literature [4] introduced a cross-dipole sub-circular polarized antenna with a parasitic loop resonator and its array. Because of the sequential phase of the four branches of the dipole, cross-dipoles can produce broadband circular polarization performance. In order to achieve a wider circular polarization bandwidth than orthogonal dipoles, the literature uses a parasitic open-loop resonator. Attributed to the half-wavelength resonator, the proposed antenna, can achieve a 3-dB AR bandwidth of about 28.6% (0.75GHz, 2.25-3.0GHz) by the two orthogonal branches of the dipole coupling with the resonator of the 90° out of phase. Under the guidance of the above-mentioned documents, this paper designs an antenna array, which is smaller in size and more compact in structure. This antenna has circularly polarized antennas with 4 radiating patches with their parasitic patches. The paper [5] proposed a slotted metal wall structure around the feed to improve the antenna's radiated gain. 3-dB AR bandwidth of about 17.6% was obtained by a 2×2 corner truncated patch array with a loop. Literature [6] proposed a 2×2 antenna array with broadband circular polarization performance composed of four parasitic rectangular patches. The circularly polarized feed structure consists of circular strips. Then the array elements are capacitively coupled with the four strips connected to the feed network. Finally, four parasitic patches are introduced to improve gain flatness. This antenna finally achieved a 3-dB axial ratio bandwidth of 640MHz (5.08-5.72 GHz).

Under the guidance of the above documents, a circularly polarized antenna with four radiating patches and its parasitic patch is designed. The antenna is powered by a probe so that the feed section directly contacts the antenna. For another thing, most of the feed network is isolated from the patch. Ultimately, it minimizes the parasitic radiation. In the optimization of the antenna, the bandwidth of the antenna can be improved by changing the structure of the patch. By cross-grooving the circular radiating patch, not only the current of the guiding patch is bent, but the effective length of the current path is increased, and the resonant frequency is reduced. In addition, the outer circle is chamfered so that the array element is capacitively coupled with the four strips. At the same time, during the optimization process, it was found that by adding a parasitic patch next to the radiating patch, the impedance bandwidth of the antenna can be effectively increased. Finally, a usable bandwidth of 450MHz can be achieved.

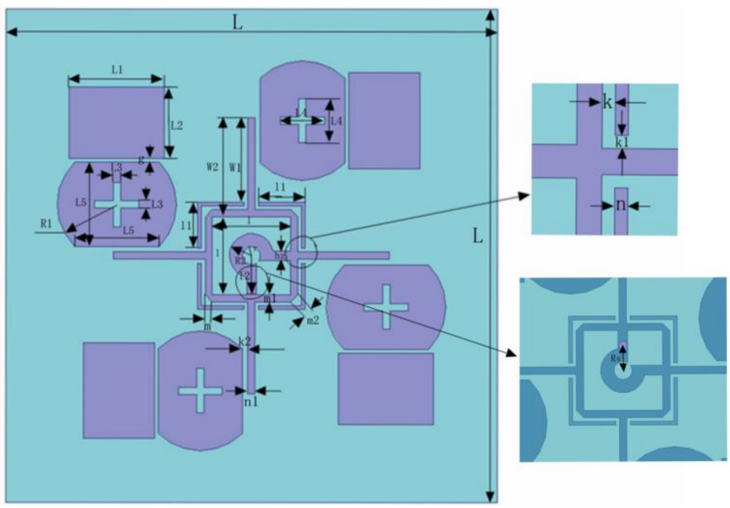

Fig.1. Geometry and dimensions of the proposed antenna array.

is fed by coupling. As shown in the Figure 2, in the optimization-process with ANSYS HFSS, it is found that by optimizing the distance g from the stripe to the patch, the AR bandwidth of the antenna varies greatly. By studying the current profile, it is accounted that the electric field induced by the induced current on the parasitic patch, which is the same as the induced current on the original chip. Comparing the array with or without parasitic patches, it was found that the electric field distribution was affected. Therefore, according to the results shown in Figure 3 and Figure 5, compared with a single array, the parasitic patch not only affects the return loss of the antenna, but also controls the direction of the antenna gain. Figure 4 shows that the axial ratio bandwidth of the antenna is improved when the antenna is attached with a metal wall compared to a single antenna array. The analysis found that the effect of the slotted metal wall on the radiating patch will change as the metal wall thickness reads and the position changes.

II. Antenna Design

The geometry of the antenna array proposed in this paper is shown in Figure 1. Use a 1.75mm thick Rogers RT/duroid 5880 (tm) dielectric plate (εr = 2.2, loss tangent = 0.0009). The overall size of the media board is L×L. A square loop is truncated from an angle of 1×1 on the inner side of a circle of 270° rotated at 0° from the feed point so that sequential phase rotation is achieved. The slotted metal wall surrounding the feed structure is introduced to improve the gain characteristics of the antenna. The radiating patch of the antenna is a square structure of L5×L5 and centered on the center of the square diagonal line, and the half diagonal is the radius R1 on the upper and lower sides of the square. Through several simulation optimizations, the final size parameters of the antenna are shown in Table 1.

Table 1 Detailed dimensions (unit: mm)

L	L1	L2	L3	L4
67	13	9.7	1	6
L5	l	l1	l2	m
11.5	10.64	6.3	5.32	0.98
m1	m2	W1	W2	hz
0.98	1.38	11.48	13.46	1.3
n1	g	r	R2	Rs
1	0.5	1.2	3	3.3
k	k1	k2	n	
0.5	0.5	0.5	0.7	

III. Experimental Results

Through the strips protruding from the sequential phase loop and the capacitors placed beside them, this antenna array

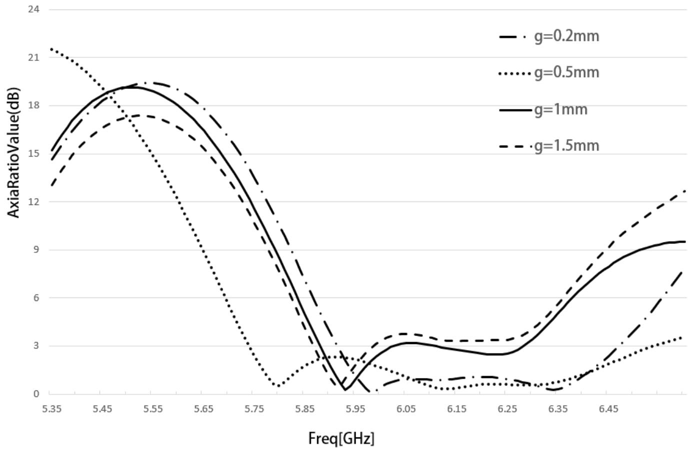

Fig.2.Simulated Axial Ratio of the 2×2 array with different g.

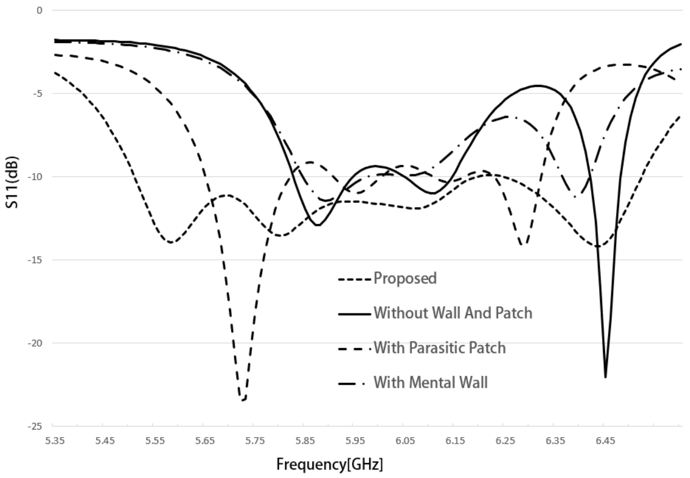

Fig.3. Simulated return loss of the 2×2 array.

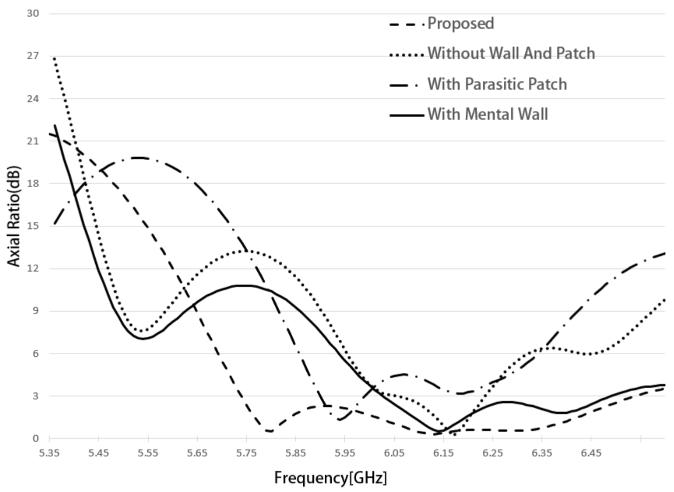

Fig.4.Simulated Axial Ratio of the 2×2 array.

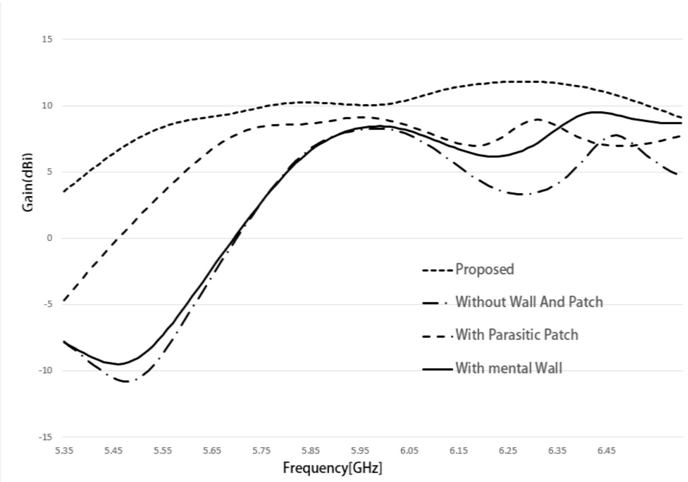

Fig.5.Simulated and gains.

IV. CONCLUSION

This paper presents a compact circular polarized antenna array. According to the simulation results of ANSYS HFSS, the antenna can still obtain flat antenna gain in the effective bandwidth of 450MHz (5.64-6.09GHz) on the basis of small size. At the same time, at the CP center frequency, 5.87GHz, the antenna gain is 10.04dBi. This antenna has the characteristics of small size, flat gain, wide impedance bandwidth and AR bandwidth, which can meet the needs of current miniaturized development of military and civilian circular polarized antenna arrays.

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