The design of an ultra-wide band spiral antenna

Li Zhi   Zhang Xi-yu   Sun Quan-guo
Southwest Institute of Electronic Equipment
Chengdu 610036 P. R. China

Abstract- **A new kind of spiral antenna is designed which combined the planer spiral antenna with the helical antenna, Ultra-wide band (bandwidth 25:1), miniaturized size, good radiation pattern and circular polarization can be realized by this method.**

I. INTRODUCTION

As the development of electronic warfare, the research work on miniaturized wide-band circular polarization antenna techniques has become the hot research point.

The traditional spiral antenna is composed of planer spiral antenna and helical antenna, the planer spiral antenna has the characteristic of low profile, wideband and circular polarization. The helical antenna has the characteristic of high gain. We combined them together. Then we can realize miniaturized, wide band, high gain and circular polarization antenna.

II. THE DESIGN OF THE ANTENNA

A. The Design of Spiral

In this paper we use Archimedes spiral to realize the radiation of high frequency. According to antenna theory, the size of spiral is decided by the low frequency. Usually the arm of the outermost circle will be almost a wavelength. So we can figure out the size of the planer spiral antenna, if the antenna worked at the lowest frequency with wavelength λ_{max}, use the formula (1).

$$D \approx \frac{\lambda_{\max}}{\pi} \tag{1}$$

We can easily figure out the aperture of the antenna. if we use rippled spiral. We can minimize the size to 2/3 or more. But it was still too large for the application.

The antenna contains two parts, the Archimedes spiral and the helical antenna.

Firstly we designed the Archimedes spiral. According to the simulation and optimization, the diameter of the spiral is 60mm. the planer Archimedes spiral is shown in figure 1.It worked in high frequency.

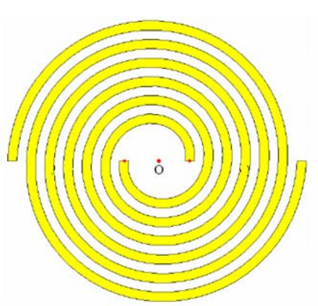

Figure 1. The planer Archimedes spiral

Secondly we designed the part which worked in low frequency. The use of helical [5] can reduce the aperture of the antenna. Figure 2 shows the helical antenna.

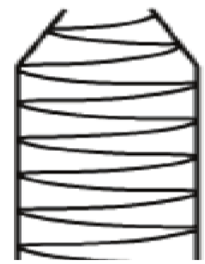

Figure 2. The helical antenna

Then we combined planer spiral with helical. The aperture of the antenna is reduced to 3/5 in compare with the planer spiral antenna of the same size. The wide band and miniaturized size is realized.

B. The Design of Balun

To match the balance structure and the wideband character of the antenna [1], We were used to choose the traditional Marchand balancer to be the feed circuit in traditional planer spiral antenna design, but it is hard to achieve ultra-wide band (bandwidth 25:1).the structure of Marchand balancer is complex and consist a lot of different part, which make it hard to machining. The microstrip line-parallel wire balancer has the character of wideband and the structure of the balancer is simple, So excellent coherence and low cost can be easily realized. In this paper we choose microstrip line-parallel wire balancer to be the feed circuit.

The antenna is fed by 50ohm coaxial-cable. We need to figure out the output impedance of the balancer, if the output impedance of the balancer is equal to the input impedance of the Archimedes spiral or almost equal. Then we realized the matching circuit [3].

Figure 3 shows the model of microstrip line-parallel wire balancer [3].

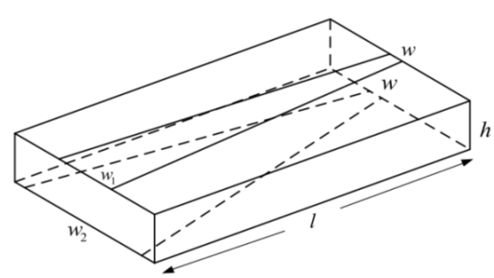

Figure 3. The microstrip line-parallel wire balancer

C. The Design of Back Cavity and Absorbing Material

In order to achieve unidirectional beam, a back cavity must be mounted to the spiral antenna, the cavity may be a hollow metal cylinder. The depth is equal to the quarter wavelength of the central frequency of the operating band. But its bandwidth is restricted [2], so we need to add absorbing material to the cavity to realize broad bandwidth and unidirectional radiation, in this paper the helical part can be used as the cavity and underprop of the planer spiral, as the design and simulation, the depth of the cavity is about 60mm. Then absorbing materials is added to the cavity to absorb the reflected energy which can destruct the forward beam. A multilayer absorbing material is designed to realize ultra-wide band wave absorbing [4], so tune the parameter of the planer spiral, helical and the absorbing material, we can adjust the resonance frequency and the bandwidth easily.

Figure 4 shows the back cavity and absorbing material of the antenna.

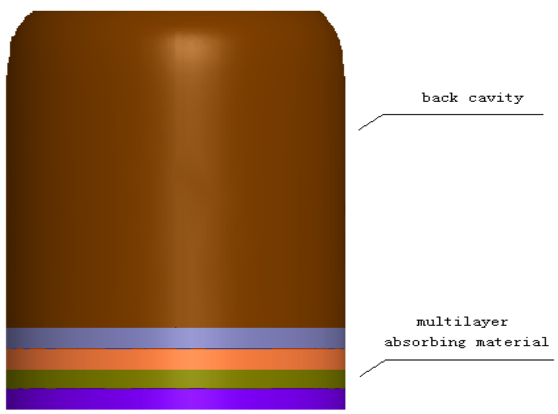

Figure 4. The back cavity and absorbing material of the antenna

III. THE SIMULATION AND TEST RESULT OF THE ANTENNA

A. The Simulation of The Antenna

The performance of the antenna can be simulated in the software HFSS. We put the frequency changing parameter into HFSS which make the simulation more accuracy. At last we compare the simulation result to the test result, they are almost the same.

B. The Radiation Pattern of The Antenna

In figure 5 "h "represent normalized radiation pattern for Horizontal Polarization, and "v" represent the normalized radiation pattern for vertical Polarization, "BW "represent the bandwidth of the antenna .

From the figure we can see that the radiation patterns for Horizontal Polarization and vertical Polarization are basically the same.

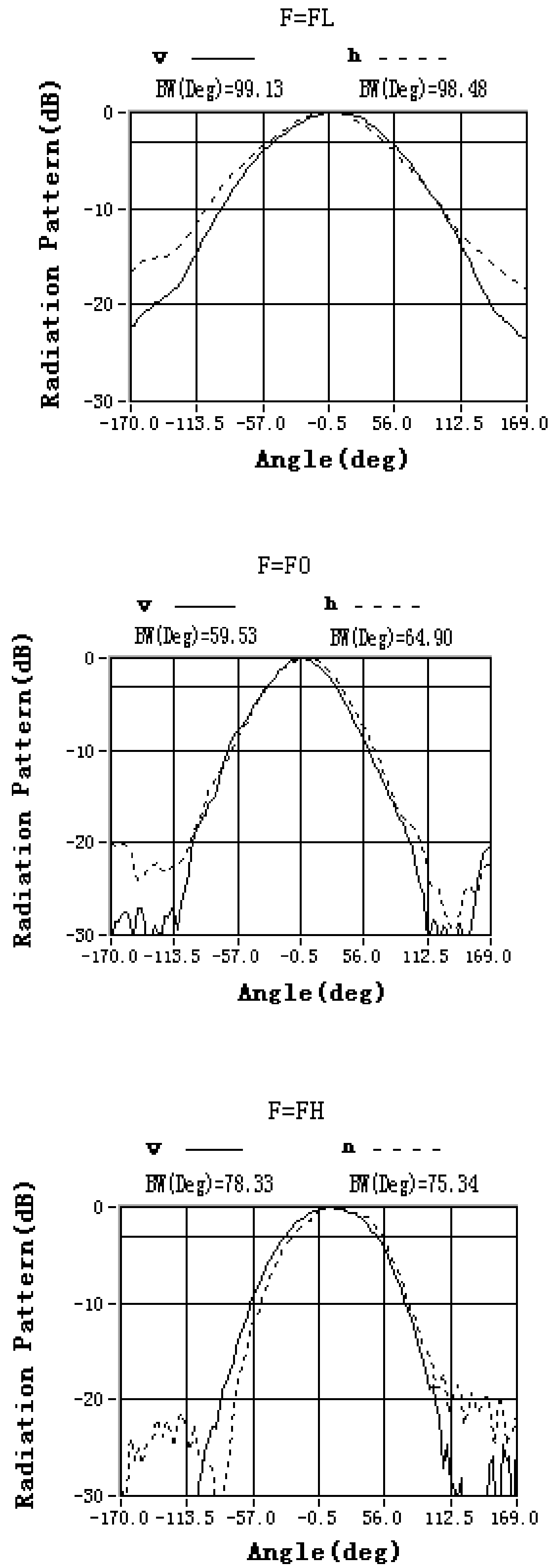

Figure 5. Measured radiation pattern for Horizontal and vertical Polarization at the low, central and high frequencies.

C. The Measured Axial Ratio of The Antenna

Figure 6 shows that both the simulation and test axial ratio of the antenna is less than 3 in wide band (bandwidth 25:1).

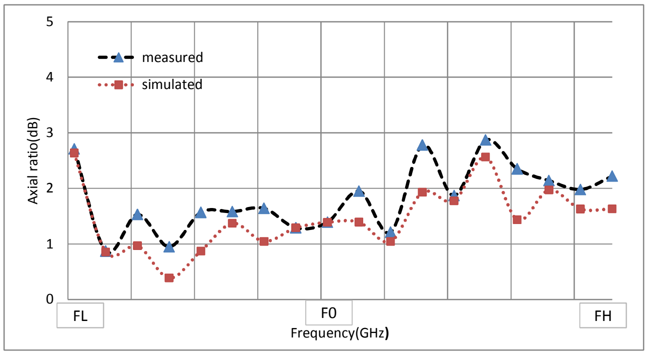

Figure 6. Measured and Simulated axial ratio of circular polarization

D. The Measured Gain of The Antenna

The gain of the antenna is in the range of -6dB to 5dB in wide band (bandwidth 25:1).according to antenna theory the antenna realized higher gain than the traditional planer spiral antenna of the same size.

E. The Measured VSWR of The Antenna

Figure 7 shows that the VSWR of the antenna is less than 3 in wide band (bandwidth 25:1).

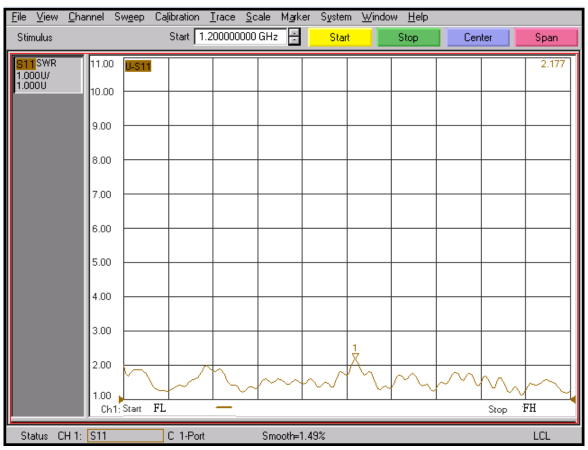

Figure 7. Measured VSWR of the antenna

According to the test result, we can see the antenna has good radiation pattern, low VSWR and axial ratio.

IV. CONCLUSION

In order to meet the demand of ultra-wide band property of miniaturized antenna, an ultra-wide band spiral antenna is designed and manufactured which achieved 38%-0ff aperture in comparison with conventional Archimedean spiral antenna. The subtle approach of combing the planer spiral with the helical antenna make the antenna presents good radiation property and ultra-wide band character.

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