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A Design of an Ultra-Wideband Coplanar Waveguide Antenna

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***Abstract*—A kind of the small Ultra-wideband antenna is proposed in this paper. Its size is 34 mm x 30 mm x 1.6 mm, which is smaller than the other normal ultra-wideband antennas. And this design uses a shape of the annular umbrella to substantially increase the bandwidth. Its impedance bandwidth is from 1.1 GHz to 9.6 GHz. The antenna feed through coplanar waveguide. And its structure is simple and integration is easy. In addition, the HFSS simulation results show that this kind of antenna has the very good impedance and radiation characteristics within the whole working frequency band, which is used in the broadband wireless communication system.**

Keywords—Ultra-wideband antenna; Annular umbrella; Coplanar waveguide feed; Wireless communication

I. INTRODUCTION

Ultra-wideband signal refers that relative bandwidth in -10dB is greater than 20% or absolute bandwidth is more than 500M [1]-[4]. With the rapid development of wireless communication technology, people have further requirements for the size, structure, shape and performance parameters of the ultra-wideband antenna [5]-[6]. Ultra-wideband technology is widely used in medical and health, disaster rescue, geological exploration and other fields, and it becomes a research hotspot in recent years.

This antenna uses the coplanar waveguide (CPW) structure [7]-[13]. There are many kinds of antennas with coplanar waveguide feed, such as coplanar waveguide feed broadband antenna [14]-[17], coplanar waveguide feed circular polarization antenna [18]-[23], coplanar waveguide feed multi-mode antenna [24]-[25]. CPW has the following advantages: first, the ground layer of CPW is in the same layer of medium plate with the signal lines, easy to connect other microwave devices in series or in parallel rather than drill hole on the substrate, which can realize the miniaturization of circuit and signal integrity; At the same time, the parasitic parameters is so small that can be neglected; It is easy to improve the density of integrated circuit. Second, CPW of dispersion characteristics of a transmission line is better than that of the microstrip line, and the circuit is suitable for the application of broadband antennas; Moreover, the radiation loss is relatively small, and CPW can significantly improve the polarization purity and work efficiency of the antenna. Finally, CPW can transfer the odd pattern and even pattern signal, which can increase the flexibility of the antenna design.

CPW antenna consists of two parts, one is feed part and the other is radiating part. Feed part adopts coplanar waveguide, whose benefit is that feed layer and antenna radiating surface can be on the same plane. Thus, the antenna can easily connect with the radio frequency circuit of back end, which can also easily integrate with PCB circuit. And it can improve the antenna impedance matching characteristics to some extent.

This paper is from the simple rectangular patch antenna [26], through the reasonable design of antenna patch [27], with coplanar waveguide feed way, to guarantee the realization of the ultra-wideband antenna.

II. STRUCTURE DESIGN

A. Design principle of CPW planar monopole antenna

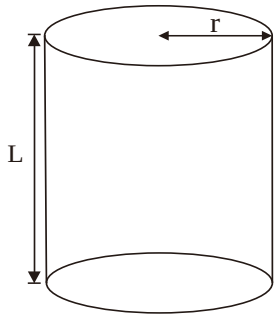


Fig. 1. The cylinder model

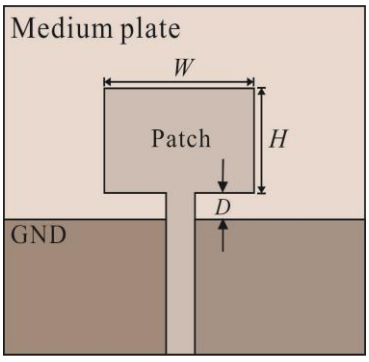


Fig. 2. The rectangle radiation patch monopole antenna

The size of the planar monopole antenna is mainly determined by the low frequency band. For regular shape radiation patch of the planar monopole antenna, the low frequency point whose standing wave ratio reaches a certain specified value can be calculated by the cylinder approximation method. The figure 1 and figure 2 show the basic model of the cylinder. The cylinder can get a rectangle through cutting along the bus, which is the rectangular patch to estimate, as shown the rectangle radiation patch monopole antenna.

Low frequency point of the antenna can be estimated by formula 1, where fL is the low frequency point frequency, and the units of L, r and g is mm, which can get a better approximation, through it an antenna prototype can be preliminarily designed.

$$f_L = \frac{72}{L + r + g} \tag{1}$$

B. *The structure design of coplanar waveguide feed annular umbrella antenna*

The antenna is printed on the dielectric substrate whose size is 34 x 30 mm2. In this paper, the dielectric substrate use the FR4 material which relative dielectric constant was 4.4, and its thickness h is 1.6 mm. The antenna feeds by coplanar waveguide, and its ground is the same layer with the radiation patch. Feed structure is equivalent to the complanation of coaxial. At the same time, ground layer can also be seen as part of the radiation patch. The ultra-wideband antenna which uses the coplanar waveguide feed has the advantages of small size and easy integration.

The radiation patch of Ultra-wideband antenna can be designed to a variety of different shapes, and this design uses annular umbrella shape of patch to substantially increase the work bandwidth to ensure the realization of ultra broadband. The shape of radiation patch as shown in figure 3.

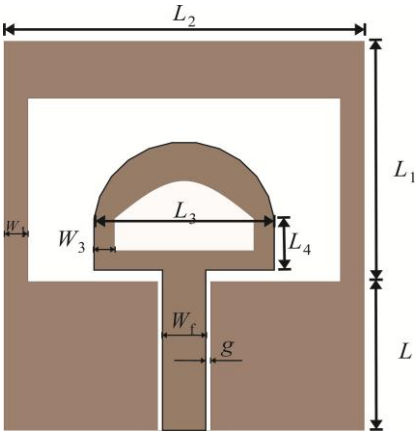


Fig. 3. The structure annular umbrella antenna

III. PARAMETERS DESIGN

This paper uses commercial electromagnetic simulation software AnsoftHFSS15.0 to simulate and optimize the parameters, and is respectively compared with rectangular reference radiation patch antenna and Y shape coplanar waveguide antenna, as shown in figure 4 and figure 5.

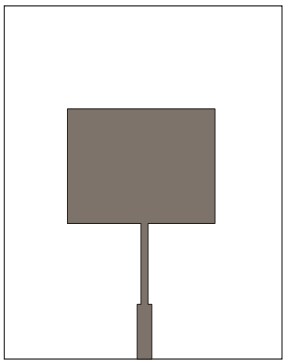


Fig. 4. Rectangular reference radiation patch antenna

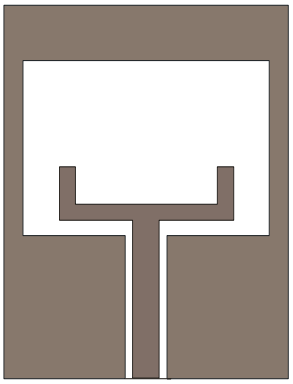


Fig. 5. Y shape coplanar waveguide antenna

Rectangular reference radiation patch antenna is the rectangular radiation patch antenna. It is made up of the simple rectangular patch, whose feeder with a barron line in order to achieve impedance matching. And its length and width is respectively 30.21mm and 37.26mm. Its return lost is as shown in figure 6, which shows that the bandwidth is only 0.15GHz. (S11<-10dB). By adjusting the length and width of the rectangular patch, it can change the working frequency of antenna. And VSWR of rectangular patch antenna is as shown in figure 7.

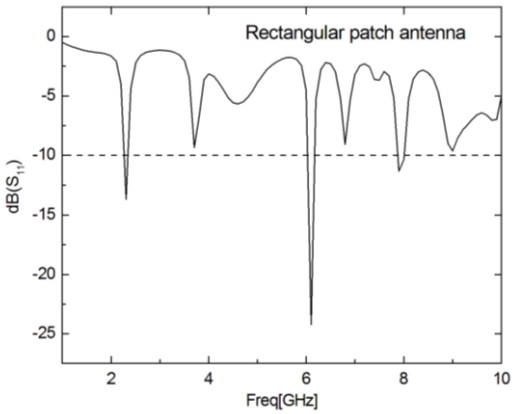


Fig. 6. Return lost of rectangular patch antenna

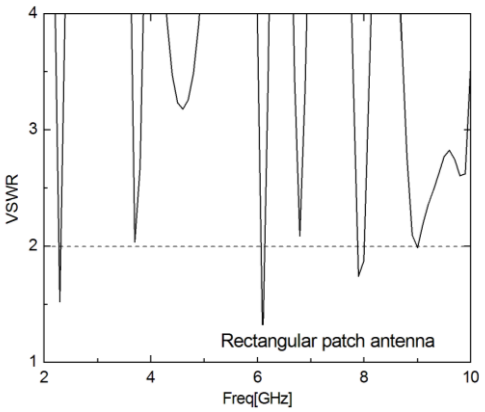


Fig. 7. *VWSR* of rectangular patch antenna

Antenna 2 uses Y type coplanar waveguide antenna. The length and width of patch is respectively 4.5mm and 18mm. The simulation result in figure 8 shows that the bandwidth can be improved to 7.5 GHz. It can meet the job requirements of ultra-wideband, but the frequency band is not rational in low frequency. The VSWR of antenna 2 is as shown in figure 9.

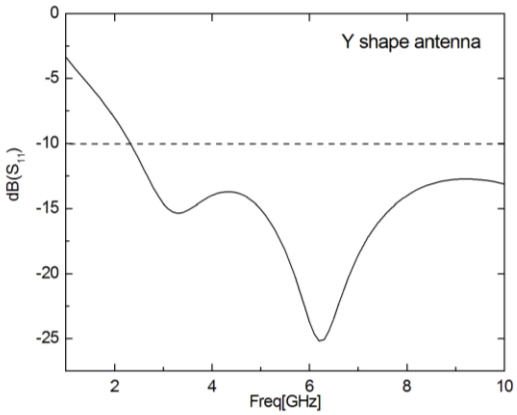


Fig. 8. Return lost of Y shape antenna

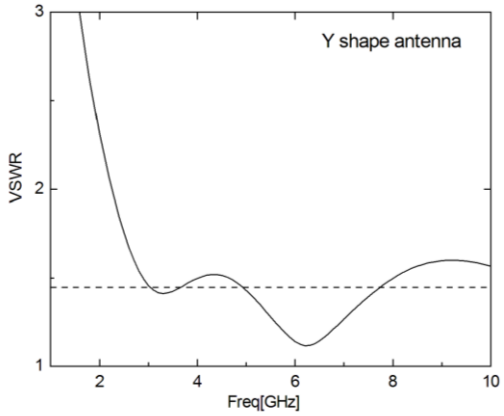


Fig. 9. *VWSR* of Y shape antenna

The band of umbrella radiation patch antenna will be further widen on the basis of Y shape antenna. When the parameters of antenna are as shown in table 1, the simulation results show that the bandwidth will further widen to 8.5GHz. And it also has the good radiation in low frequency band, as shown in figure 10. And the VSWR of umbrella radiation patch antenna is as shown in figure 11.

TABLE I. THE PARAMETERS OF THE ANTENNA

parameter	L	L_1	L_2	L_3	L_4	S
Size/mm	13	21	30	18	4.5	1
parameter	W_1	W_2	W_3	W_f	g	h
Size/mm	2	5	1.7	3.6	0.4	1.6

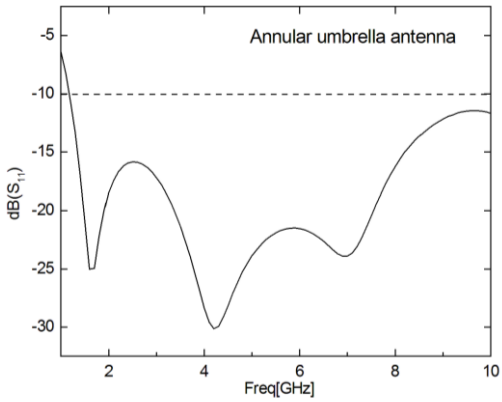


Fig. 10. Return lost of annular umbrella antenna

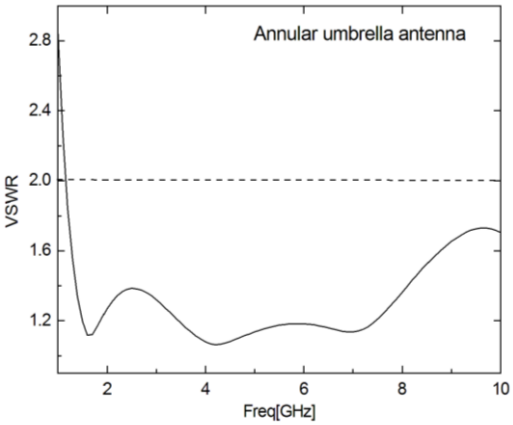


Fig. 11. *VWSR* of annular umbrella antenna

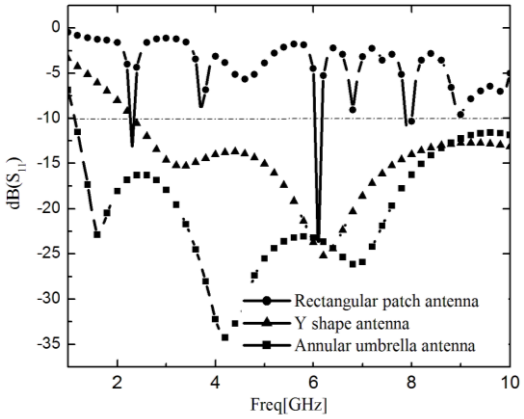
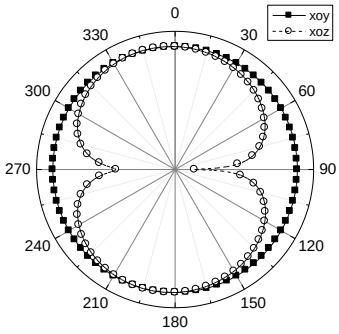


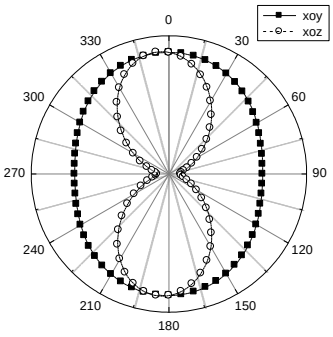
Fig. 12. The antenna structure

As shown in figure 12, these are return lost of three antennas. From it we can clearly see the rectangular patch antenna only have a radiant point on the 6 GHz, and the bandwidth is very narrow. When using coplanar waveguide feed, at the same time to change shape to Y type, the working band of antenna will substantially increases from 2.4 GHz to 10 GHz. Under the premise of without changing the coplanar waveguide feed to change the radiation patch shape into a annular umbrella, it can further increase the bandwidth and work effectively from 1.1 GHz to 9.6 GHz, and it has good performance in low frequency band.

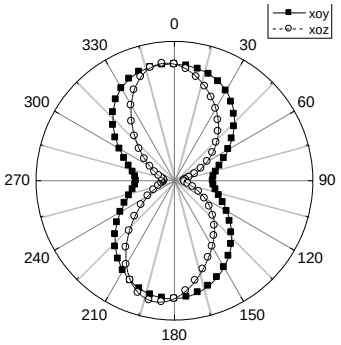
At the same time, figure 13 presents direction figure of *xoy* plane and *xoz* plane of annular umbrella coplanar waveguide antenna in the frequency point of 1.5GHz, 3GHz, 5GHz, 7GHz and 9GHz. By figure can be seen, annular umbrella radiation patch antenna has good omnidirectional radiation in the whole work frequency from 1.1GHz to 9.6GHz. Although in high frequency part the directional of the work frequency deteriorates, but it still meets the requirements of design and production.



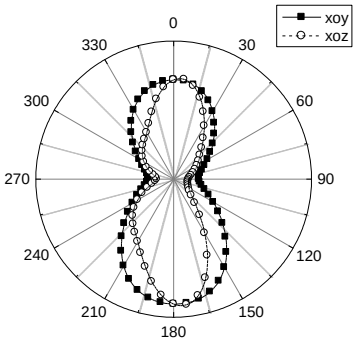
1.5GHz



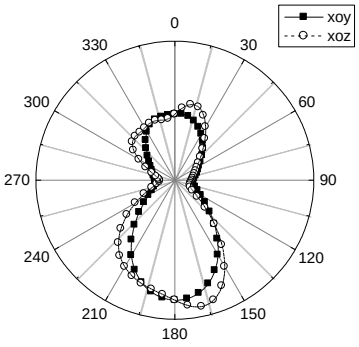
3GHz



5GHz



7GHz



9GHz

Fig. 13. Direction figure of the antenna

The measurement of annular umbrella radiation patch antenna uses AV3629 vector network analyzer. Figure 14 shows the simulation and measurement results, which shows the measurement results and the simulation result are approximately the same. The deviation is mainly that the dielectric constant of medium plate is not uniform, or due to the size deviation in the antenna processing and the SMB connectors welding, or because of the measurement environment factors. But these deviations are in the acceptable range. And the real antenna is as shown in figure 15.

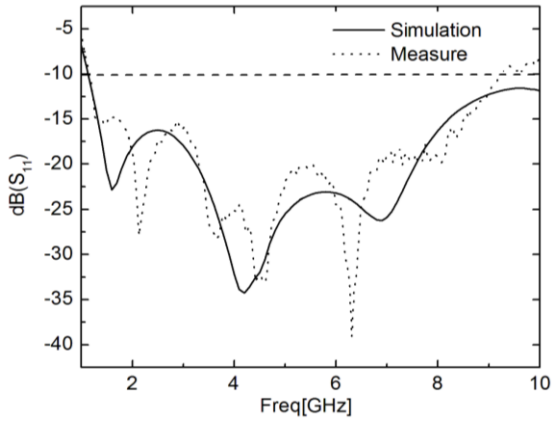


Fig. 14. Simulation and measurement results of antenna

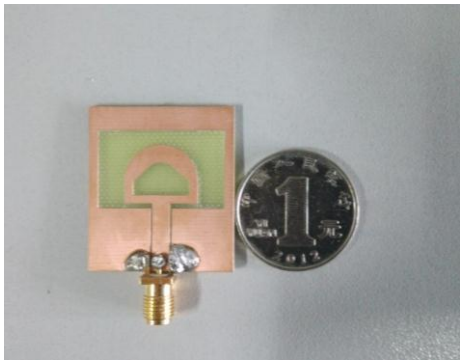


Fig. 15. Real figure of the annular umbrella Antenna

IV. THE CONCLUSION

This article presents a new kind of ultra-wideband coplanar waveguide antenna and uses software AnsoftHFSS15.0 to simulate. With rectangular patch antenna radiation and Y type radiation patch antenna compared, the results show that the antenna working bandwidth is bigger than others, which can meet the requirements of a variety of market frequency, and the radiation pattern also approximately meets the demand of omnidirectional nature. At the same time, the antenna has the characteristics of small size, easy processing, simple structure, and easy integrating with microwave circuit. And it can be effectively used in the wireless communication system.

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