ULTRA-WIDEBAND DUAL POLARIZED PROBE FOR MEASUREMENT APPLICATION

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***Abstract*-A two-element ultra-wideband dual polarized antenna with resistance loaded is proposed in this paper. Vivaldi antenna is selected as the element and resistive loading in its slots leads to a compact structure. A bandwidth ranging from 0.9GHz to 10.5GHz(11.67:1) for VSWR less than 2.5 is achieved, and isolation between two ports is better than 20dB.A prototype is fabricated, and the measured results are in agreement with the simulated theory by Ansoft HFSS 13. It indicates that this antenna can be used as the probe in anechoic chamber.**

Key Words: ultra-wideband; Vivaldi antenna; dual polarized; probe

I. INTRODUCTION

Recent years have seen a rapid growth in the development of ultra-wideband(UWB) technology, primarily driven by the increasing requirements of modern radar, electronic warfare, wireless communication, and radio telescope systems that require very wide bandwidth. Ultra-wideband antennas and arrays specially act the key roles in ultra-wideband technology [1]. And Vivaldi antenna is one of the most familiar ultra- wideband antennas.

Vivaldi antenna, which was first introduced by P. J. Gibson, is one of the endfire antennas fed by microstrip line. With its continuous, non-periodic and gradual changing structure, Vivaldi antenna can theoretically radiate travelling wave in a quite wide band. The electric field vector of the Vivaldi antenna is parallel to the substrate, and it is linear polarized on its two major radiation planes [2]. As it has the advantages of good symmetry property, simple structure and high gain, and it is very easy to be integrated and manufactured, Vivaldi antenna is always widely used in many fields, such as ultra-wideband communication, radar systems, and antenna measuring system [3] [4].

In the antenna measuring process, sometimes, the performance of dual polarization or cross polarization of the antenna under test (AUT) is required. Then, using a dual polarized probe can be quite effective without turning the AUT. In order to further improve the performance of this kind of antenna, especially in impedance bandwidth and miniaturization for low frequency, previous researchers have done a lot of effort, and some special shapes for the radiation arms are designed, for example, corrugated ripples [5], bunny ear-shaped combline [6], composite function tapered slots [7] and so on. In this paper, a cruciform dual polarized probe which is composed of two Vivaldi elements is presented, and the application of resistance loading leads to a compact structure conspicuously.

II. CONFIGURATION AND DESIGN STRATEGY OF LOADED VIVALDI

As shown in Figure 1, a single-element Vivaldi antenna, which has the property of linear polarization, is primarily presented. The metallic radiator is shaped by two symmetrical exponential curves. Expressions of the curves are showed in Equation (1), as follows,

$$y = \pm(c_1 e^{Rx} + c_2), \tag{1}$$

$$c_1 = \frac{y_2 - y_1}{e^{Rx_2} - e^{Rx_1}}, \qquad c_2 = \frac{y_1 e^{Rx_2} - y_2 e^{Rx_1}}{e^{Rx_2} - e^{Rx_1}} \tag{2}$$

Where, both c_1 and c_2 are constants that can be calculated by Equation (2); (x_1, y_1) and (x_2, y_2) are respectively the top and bottom points on the exponential tapered curve; and R is the exponential factor that regulates the breadth of the tapered slot.

Approximately, the cut-off wavelength at low frequency of the Vivaldi antenna is about twice the maximum width of the exponential tapered curve, the radiation performances at high frequency of the Vivaldi antenna is restricted by the minimum width of the exponential tapered slot, and the minimum width of the curve is about 2% the cut-off wavelength at high frequency [8]. Actually, the final accurate dimension can be obtained only by optimization. According to the expected

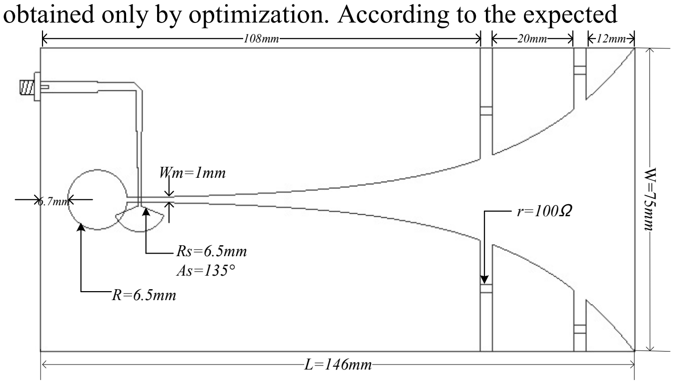


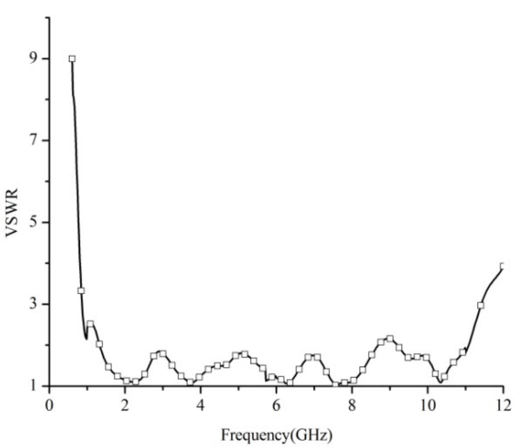
Figure 1. Geometry of the proposed antenna

operating frequency range, the radiation patch of the Vivaldi antenna is printed on a substrate of Teflon (ε_r=2.65) material, 75mm× 146mm, with the thickness of 1.0mm.

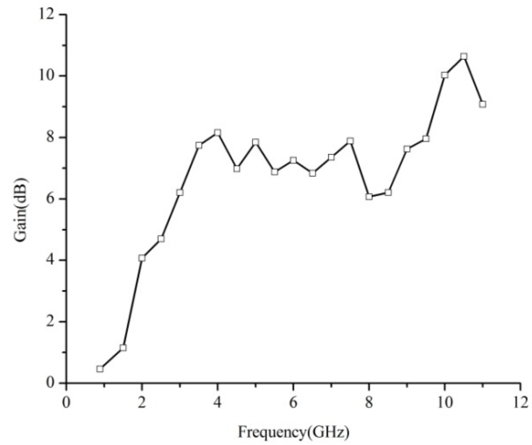
Then a classical microstrip-slot balun is made to feed to Vivaldi antenna. With the balun connected to the exponential tapered radiator, feeding is balanced and the Vivaldi antenna realizes the property of ultra wide-band. Optimization of the structure and geometric dimension of the balun is difficult but pivotal in the whole designing process.

The balun is made up of three parts. Firstly, a circular resonator which is used to achieve the impedance matching of the microstrip transmission line; secondly, the microstrip transmission which works as an impedance converter, is used to realize the matching from 50Ω-microstrip to the input impedance at the feeding point of the antenna. Generally, the theoretical impendence value of the middle segments can be calculated by looking up the Chebyshev impedance conversion table. And the third part is the fan-shaped structure which is used to realize the terminal load matching can be equal to grounding terminal.

Furthermore, two pairs of gaps are etched, and four 100Ω-chip resistors are loaded on the radiation arms symmetrically. It is clear that this structure can make the antenna achieve good impedance matching characteristics in the expected working frequency, especially at the low frequency. Figure 2(a) leads us to a conclusion that the proposed antenna has good VSWR less than 2.5 in 0.88 to 11.28GHz (12.82:1). On the other hand, part of the electromagnetic energy radiated by the antenna is absorbed by load resistance, and naturally the antenna gain decreases, especially in the low frequency range. The plot of the dependence of gain upon frequency is shown in Figure 2(b). Taking into account the fact that high gain is not strictly required when used as a probe in antenna measurement system, this design is still feasible. In this way, geometric dimension of the antenna can be reduced significantly.



(a)



(b)

Figure 2. Simulated results of the loaded Vivaldi antenna. (a) VSWR, (b) Gain

III. THE UWB DUAL POLARIZED PROBE

Based on the loading Vivaldi antenna expounded above, an ultra-wideband dual polarized probe is introduced in this paragraph. The probe is cross shaped by laying the two antenna elements orthogonally, and slots are designed particularly on two dielectric substrates, avoiding cutting off the feeder line. The fabricated prototype is shown in Figure 3.

Figure 4(a) reveals the VSWR graph of the simulation result by Ansoft HFSS 13 and the measurement result of the fabricated prototype. VSWR of port1 is a little higher than that of port2, and the measurement result conforms to the simulation result well. Deterioration of return loss is caused by the coupling effect between the two antenna ports. Though

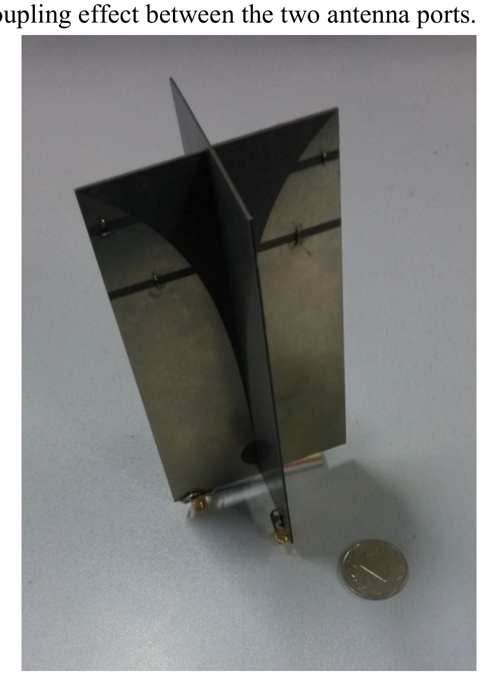
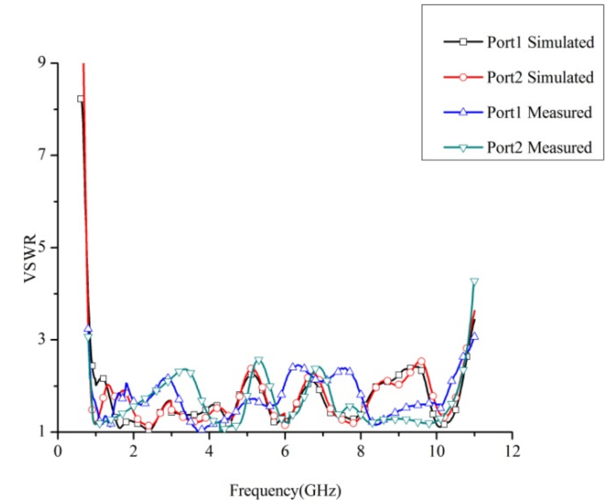
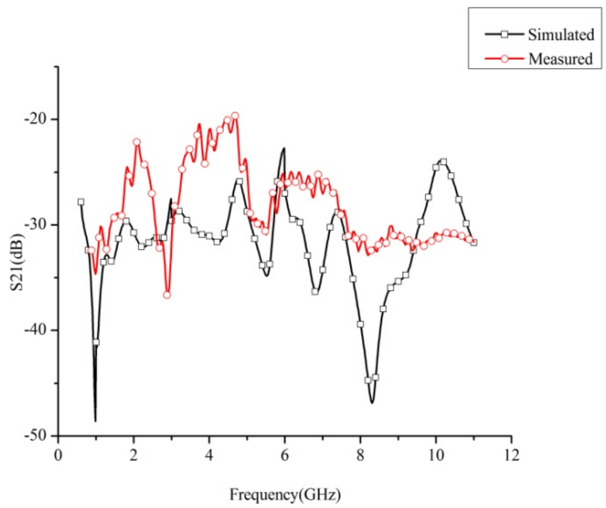


Figure 3. Photography of the fabricated proposed antenna.



(a)



(b)

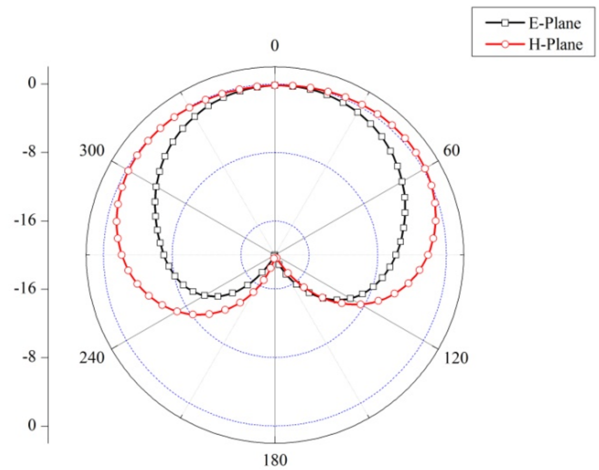
Figure 4. Simulated and measured results of the UWB dual-polarized probe.

(a) VSWRs, (b) S_{21} parameters

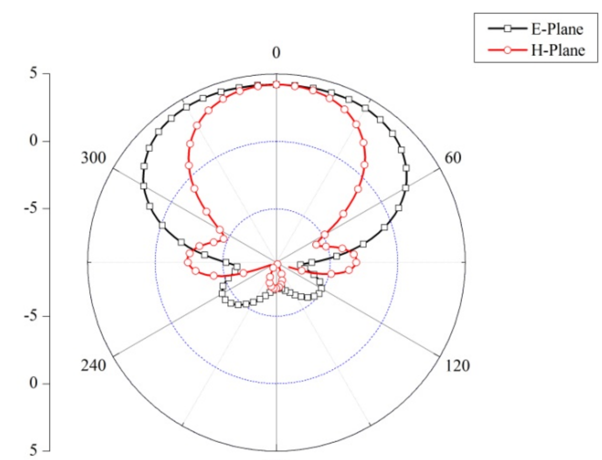
VSWR becomes worse than the result of linear polarized antenna mentioned in Part I, especially at high frequency, it is acceptable in application in the bandwidth ranging from 0.9 to 10.5GHz for VSWR less than 2.5.

In Figure 4(b), it can be seen that the measured S_{21} parameter is not as good as the simulation result, especially in low frequency band. Difference may be related to the precision in manufacture, and the error caused by uncertainty of instrument also should be taken into account. However, the measured S_{21} parameter is better than 20dB in the whole band. Isolation described by the S_{21} parameter, means the degree of coupling between the two ports for the dual polarized probe. High isolation reveals that weak coupling effect exists between the two independent antenna elements when they work respectively. It indicates that this design can be satisfied with the engineering requirement well.

The dual polarized probe has good performance in endfire. Far field radiation patterns are computed in the two principal planes, E-plane and H-plane. Figure 5 shows the gain patterns at some frequency points typically. It can be seen that gain in the principal radiation direction is 0.52dB at 1.0GHz, 4.19dB at 2.0 GHz, 6.78dB at 5.8GHz, 8.23dB at 7.0GHz, and 9.17dB at 9.8GHz. The E-Plane and H-plane radiation patterns of the two ports are symmetrical, they have wide beam performances and the beam width nearly decreases when the frequency increases.



(a)



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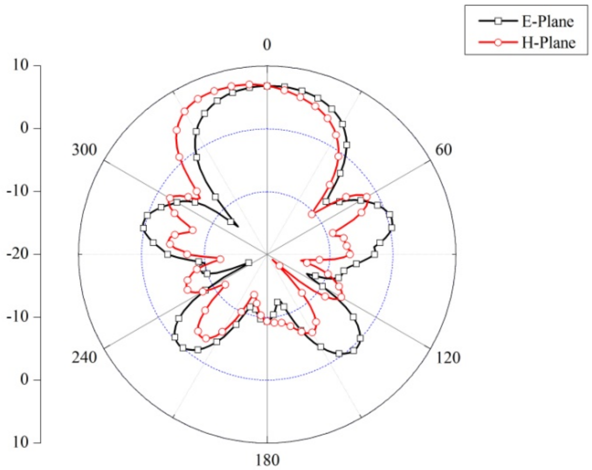
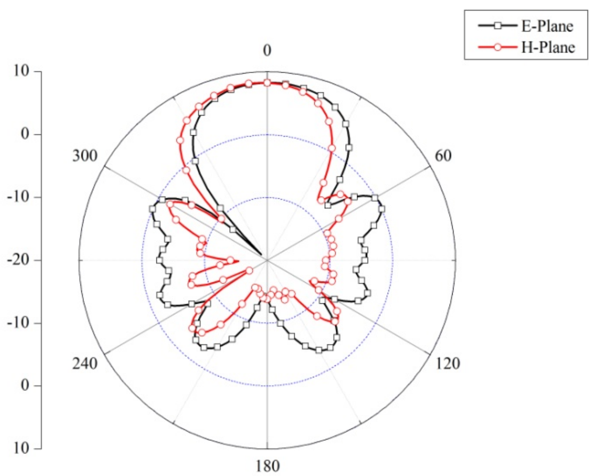
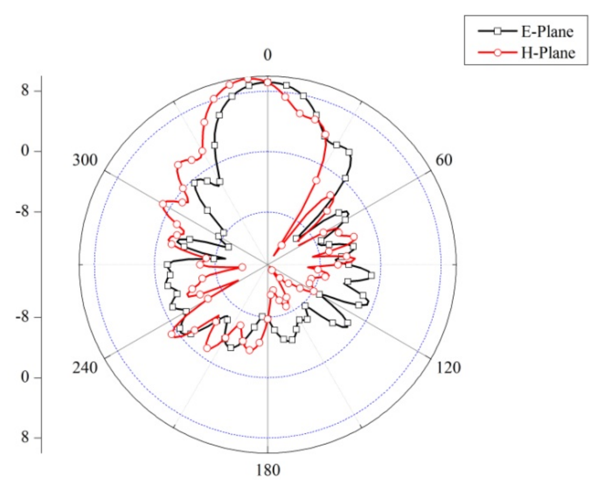


(c)



(d)



(e)

Figure 5. Radiation patterns in E-Plane and H-Plane of the dual-polarized probe at:(a) 1.0GHz, (b) 2.0GHz, (c) 5.8GHz, (d) 7.0GHz, and (e) 9.8GHz (unit: dB)

IV. CONCLUSION

An ultra-wideband dual polarized probe composed of two Vivaldi antenna elements is presented in this paper. Shown as the gain patterns, this antenna has a good property of endfire. Without a very rigorous requirement for gain, load resistance is used to decrease the dimension of the antenna effectively. Compared with the current designs in other papers, this structure does well in miniaturization. Moreover, a suitable balun is made to ensure that this antenna can work in the entire band of 0.9GHz to 10.5GHz. Conformity of the simulation results and measured results of VSWR and isolation indicates that this probe can meet the requirement of engineering, and it can be used in anechoic chamber for measurement.

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