Effective Design on Low Sidelobe of Vivaldi Antenna in Multi-Antenna Systems

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***Abstract*—An effective design on low sidelobe of Vivaldi phased array antenna in multi-antenna systems is presented in this article. The proposed antenna is printed on the Rogers RO4003 substrate. By choosing a proper selection of dimensions and structures of the hollow parts in the traditional Vivaldi antenna can get better isolation performance in multi-antenna systems. The antenna retains the advantages of ultra-wideband to work at the 4.8GHz to 10.4GHz and the relative bandwidth is 73.68%. The maximum scan angel is 60° and VSWR below 3. The quality of a multi-antenna system depends on effects of low frequency antennas to high frequency antennas, this antenna provides a way to solve the scattering problem among multi antennas.**

Keywords—low side-lobe; Vivaldi antenna; multi-antenna systems; phased array

I. INTRODUCTION

At present, traditional communication system, for its narrow bandwidth, low speed, including selective fading caused by multipath propagation, and serious interference which would result in the performance degradation, could not meet the growing demand for now large capacity data service. To solve these problems, in last few years, with the rapid development of communication technology, to realize working in complicated environment, multi-frequency antenna and multi-antenna arrays have drawn more and more attention.

Multi-frequency antenna can work in different bands in one antenna. It has the advantage of simple structures and low cost, but most multi-antennas are work in a relatively narrow-band. So, to satisfy ultra-wide band's need, multi-antenna has been proposed [1-3]. A compact MIMO antenna system with high isolation for ultra-wideband applications has been reported in the literature [4]. The antenna's radiation pattern is a very important parameter, which indicate the distribution of the antenna's electromagnetic radiation energy in space. The literature [5] provide the research of the multi-antenna's radiation pattern on the metal platform.

In this article, an effective design on low sidelobe of Vivaldi Antenna in multi-antenna system is proposed after analyze the above reported papers. By hollowing a proper selection of dimensions of the part, the traditional Vivaldi antenna can get a better isolation performance in multi-antenna systems. To reduce the height of the proposed antenna, the sidelobe can be reduced furthermore. The antenna retains the advantage of ultra-wideband to work at the 4.8GHz to 10.4GHz at the same time with the relative bandwidth of 73.68%. And it shows the sidelobe of the multi-antenna system lower about 5dB to the common ultra-wideband antennas.

II. STRUCTURE&PARAMETERS

A. *Structure*

The proposed antenna structure and dimensions are most shown in Figure1. In the design, this radiation reduction of Vivaldi antenna is proposed with the shape of the metal patches modified. Under the condition that the distribution of the current keeps almost unchanged, to hollow the metal patches can reduce the radiation area directly. The hollow parts based on a modified exponential line which is different from the antenna to get a better performance by changing the dimensionalities and positions. By adjusting the length of slot, the resonant frequency can decrease. It's available in low frequency to small size. Because of many variables in this antenna, control variable method is adopted. This microstrip antenna is printed on a Rogers RO003 substrate with dielectric constant of 3.55. It's economical and practical for array antenna. Meanwhile, the proposed antenna has advantages at low side-lobe, small size large scan angel and easy fabrication.

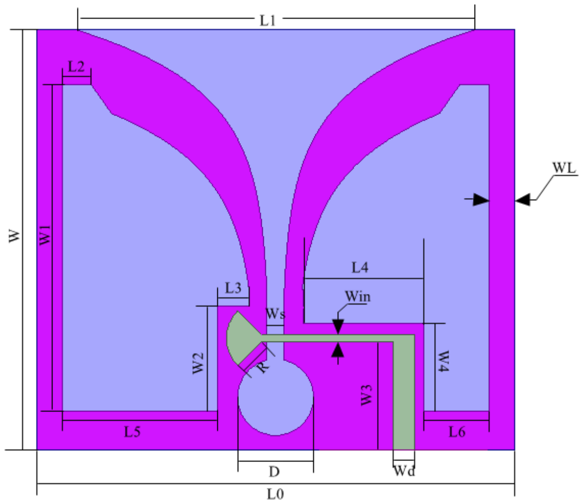


Figure.1 Structure of antenna

B. Function

In a multi-antenna system, the low-frequency-antenna would be the biggest problem to the system because high-frequency-antenna could shelter from it. This phenomenon would cause high VSWR and high sidelobe. To solve these problems, the proposed antenna is modified upon traditional Vivaldi antenna. To reduce the whole height, the length of the slot line should be reduced. But the length of the slot is vital to the resonate frequency. The size of hollow part of proposed antenna is the most important reason to reduce the sidelobe, which also can influence the magnitude of active VSWR. What's worse, the improper hollow part would stir the higher-order mode.

III. SIMULATION RESULTS AND ANALYSIS

According to the simulation results of HFSS software, it can be seen that the antenna's VSWR all below 2.8. The VSWR with different scan angles of the antenna is shown in Figure 2. It can be seen from the figure the antenna can realize a large scan at 60°. This kind of antenna has a property that the worst active VSWR occurs without scanning.

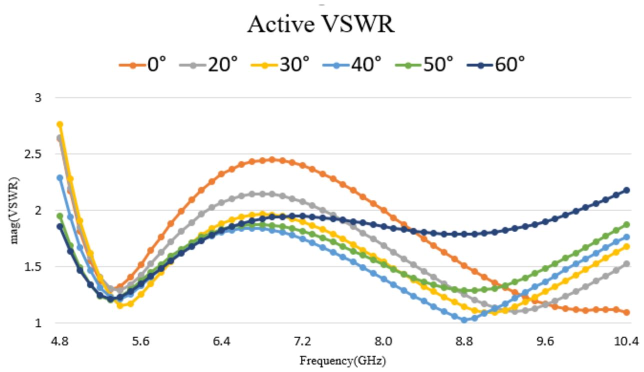
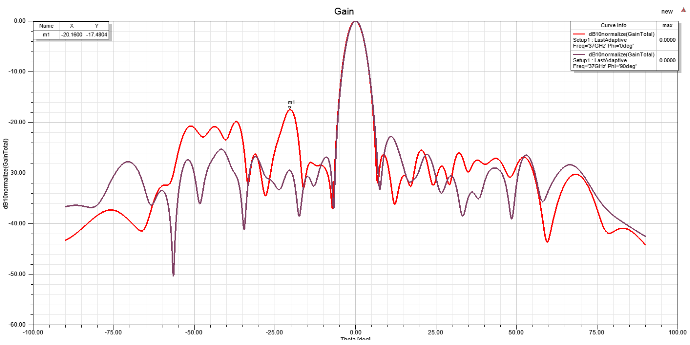
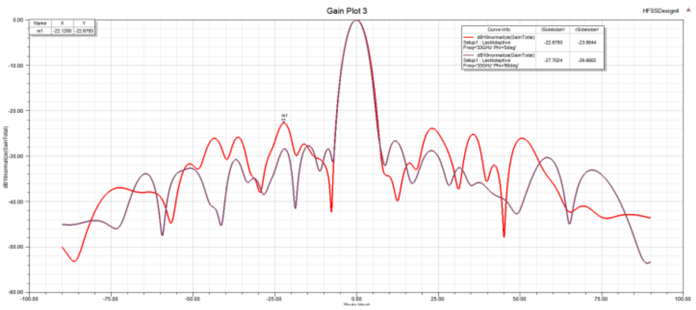


Figure.2 The active VSWR parameter of the proposed antenna

In order to reflect the low sidelobe character, this modified antenna would be compared with the normal ultra-wideband antenna in the same multi-antenna system. The gain of this system is shown in Figure 3. It can be seen that the sidelobe of the system has been downed apparently. The gain from sidelobe to the main lobe of normal ultra-wideband antenna is 17.48dBi, and the gain from sidelobe to the main lobe of proposed antenna is 22.68dBi. The optimization of sidelobe can reach more than 5dBi.



(a) the normal ultra-wideband antenna



(b) the proposed antenna

Figure.3 Gain of the two kinds of antenna in the same multi-antenna system

Through multiple simulation and optimization, the final size parameters of the modified Vivaldi antenna are shown in Table I. The two exponential lines can be described as in

$$y=c_1e^{ax}+c_2 \tag{1}$$

When the parameter of a changed, the resonant frequency would be changed.

Table. I The final size parameters of the proposed antenna

L0	*L1*	*L2*	*L3*	*L4*
13.2	11.1	0.8	1	3.3
L5	*L6*	*W*	*W1*	*W2*
4.3	1.8	11.6	9	2.88
W3	*W4*	*Ws*	*Win*	*Wd*
3	2.4	0.48	0.19	0.58
WL	*D*	*R*		
0.7	2.11	1.06		

IV. CONCLUSION

An effective design on low sidelobe of Vivaldi phased array antenna in multi-antenna systems is presented in this article. The suggested antenna has modified from the normal ultra-wideband antenna. By hollowing a proper dimensions and location parts of the radiation area, this antenna can get a better isolation performance in multi-antenna systems. Compared to the traditional ultra-wideband antenna in the same multi-antenna system, the gain between the main lobe to the sidelobe can be optimized at more than 5dBi which provided a way for multi-antenna system to solve the sheltering problems. After reducing the height of the proposed antenna as much as possible, the sidelobe can be reduced furthermore. The antenna retains the advantage of ultra-wideband to work at the 4.8GHz to 10.4GHz at the same time with the relative bandwidth of 73.68%.

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