# *Circular slot Vivaldi antenna with low backlobe*

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***Abstract*—a low back lobe Vivaldi antenna with bandwidth of 8-18GHz is proposed in this letter. The Decreasing the back lobe was realized by opening the circular slot, and using of metal vias solves the problem of higher order modes of strip-to-microstrip lines. The antenna was fabricated and measured through experiment, agreeing with that of computer HFSS® simulations.**

***Keywords—Vivaldi antenna; Ultra-wide band; Back lobe;***

## I. INTRODUCTION

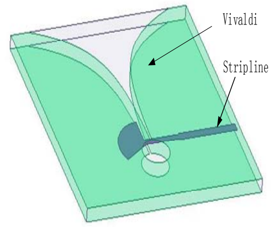
The Vivaldi antenna is a kind of highly directive antenna with a simple structure and having cross polarization value as very low. Gibson proposed an end-fire Vivaldi antenna in a compact size in 1979 [1]. As an endfire antenna, it usually achieves a performance of high gain. But the bandwidth of the Vivaldi antenna is limited due to the use of the complex type of feed structure. So, bandwidth performance was firstly improved by "Gazit" named the design as the antipodal Vivaldi antenna (AVA) in 1988 [2]. Antipodal Vivaldi antenna having theoretically infinite bandwidth but practically it is limited due to some losses. For fabrication, Vivaldi antenna can be easily printed on PCB and its feed structure is simple to implement.

In this letter, we introduce a type of Vivaldi antenna with bandwidth of 8-18GHz that was reduced the back lobe and adjust the S11 by opening the circular slot. The paper is arranged in the following manner. In Section 2, the antenna design ideas and simulation results are given. In Section 3, the measurement results are given.

## II. ANTENNA DESIGN AND ANALYSIS

### *A. Antenna Feed Design*

The Vivaldi antenna can be combined with different types of feed structures to form different types of wideband antennas with different characteristics. See Figure 1. The strip line (purple) feeds the upper and lower two Vivaldi slot line antennas (green), and the media substrate uses the Rogers 5880 (thickness: 1 mm). However, it is difficult to connect the SMA connector to the stripline, so we need to convert the stripline to a microstrip line, as shown in Figure 2. When we use this feeding method, there is a burr in the reflection coefficient, the curve is not smooth, as shown in Figure 3. The structure affected impedance matching.



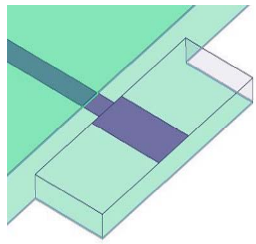



Figure 1: Stripline fed Vivaldi antenna. Figure 2: The Strip line to microstrip line structure.

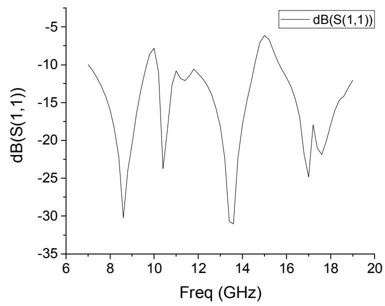
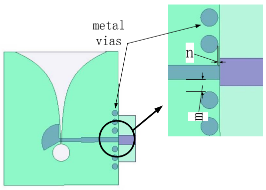



Figure 3:S11

Therefore, we chose to drill a row of metal vias on both sides of the stripline as shown in Figure 4. This method eliminates the surface current. The S11 is shown in Figure 5.

In order to facilitate processing, the diameter of the metal via is set to 1mm. Scan the position of the metal vias relative to the stripline position parameters m and n. It can be seen that when the metal is over the distance from the strip line to the hole is within 0.7mm. The reflection coefficient within the band is smooth without high-order modes. When the distance from the strip line to the via hole exceeds 0.7mm, the reflection coefficient curve appears a burr at a high frequency. Similarly, the distance of the metal via from the strip-to-microstrip covert edge has little effect on impedance matching, and metal vias are placed at the edges due to post processing requirements. Finally, the mounting position of the metal via is chosen to be m = 0.7mm, n = 0.1mm.



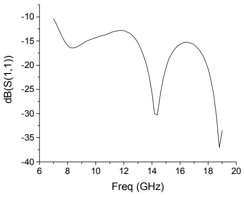
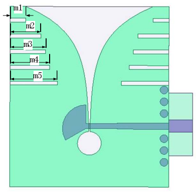




Figure 4: Metal vias structure. Figure 5: S11 with metal vias.

### B. Antenna Structure Design

The traditional method of suppressing the back lobe of the Vivaldi antenna is to open a rectangular gap on the side, the length of the gap is 1/4 wavelength, the transmission line through the short-circuited terminal at the end of one quarter causes the aperture to exhibit a high-impedance state [3] [4]. The current cannot be reached backwards through the gap, which reduces the antenna back lobe [5]. The structure of the rectangular gap is shown in Figure 6.



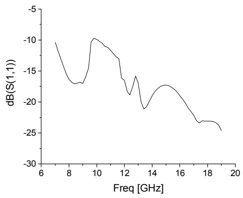




Figure 6: Vivaldi antenna with rectangular gap. Figure 7: S11

As shown in Figure 7, the reflection coefficient of the Vivaldi antenna with a rectangular gap is not smooth, and a high-Q value reflection occurs at the frequency corresponding to the design length of the gap. It can be seen from the current distribution in Figure 8, when the operating frequency is at 12.8GHz, most of the current is concentrated on the short-circuited of a rectangular gap with the length of 3.9mm. Its length is roughly equivalent to one-quarter of the wavelength of 12.8GHz, but the current does not decay completely to ignore. High-resistance state causes current to reflect back to the feed port. Caused the situation shown in Figure 7.

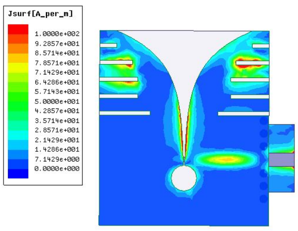



Figure 8: The current distribution of the antenna at 12.8GHz.

Considering the above reasons, we chose to use a circular slot to solve the problems [6]. The circular slot has a low Q value and a wide frequency band. It is not prone to reflectance burrs, and the effect of optimizing the back lobe is better.

The antenna is shown in Figure 9. The reflection coefficient and the E-plane pattern are shown in Figure 10 and 11. From the simulation results, the S11 of the antenna becomes smooth, and the back lobe is substantially low in the full-band. (D1=6mm, D2=1.8mm)

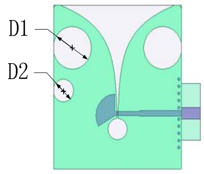
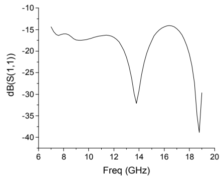



Figure 9: Vivaldi antenna with circular slot.



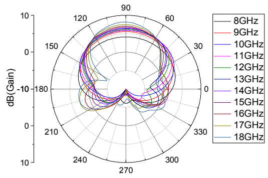
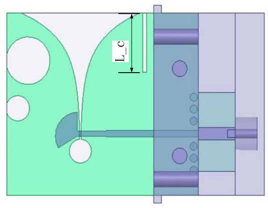




Figure 10: S11 Figure 11: E plane radiation pattern.

In order to facilitate processing and assembly, modify the model as shown in Figure 12. The metal clip on the right side of the model is used for fixing, the reflection coefficient is shown in Figure 10 and 11. L-c=7.5mm. The simulation radiation pattern is shown in Figure 15 with measurement.



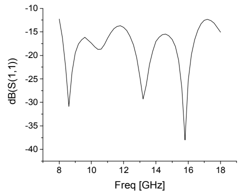




Figure 12: Vivaldi antenna with metal clip. Figure 13: S11

## III. MEASUREMENT

### A. Antenna production

Since the designed antenna element is a three-layer board, we disassemble it into two dual-layer boards. The middle strip line is printed on one of the circuit boards. The front and back sides of the two-layer board are shown in Figure 14 shows. In order to create a strip-shaped Vivaldi antenna, an epoxy resin is evenly brushed between two double-layer plates, and the two circuit boards are tightly pressed together by a press plate. After the epoxy resin is solidified, the epoxy resin is assembled with the press block. SMA coaxial connector and microstrip line connection. The assembly picture was shown in Figure 15.

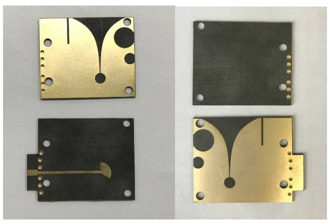


Figure 14: The unassembled picture.

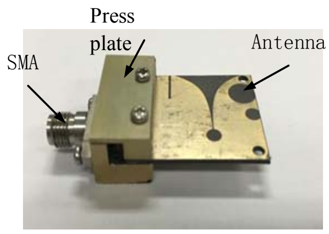
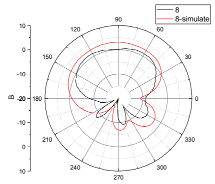


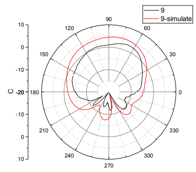

Figure 15: The assembly picture.

## B. *Physical measurement*

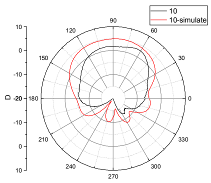
The radiation pattern of the measurement is shown in the figure 16, basically agree with simulation results. The measured Gains are shown in the Table I.



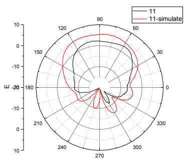
8 GHz



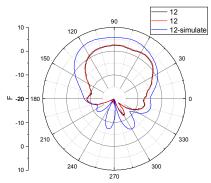
9 GHz



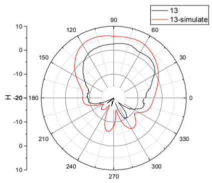
10 GHz



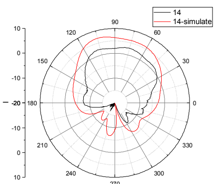
11 GHz



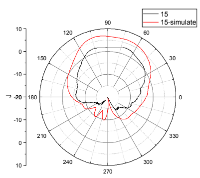
12 GHz



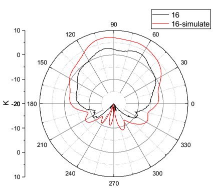
13 GHz



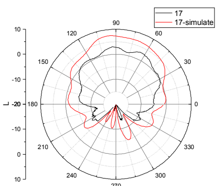
14 GHz



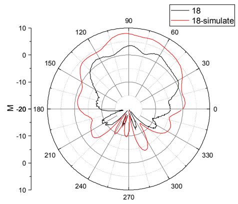
15 GHz



16GHz



17GHz



18 GHz

Figure 16: Simulation and measurement radiation pattern 8-18GHz.

TABLE I. MEASURED GAIN

| Freq/GHz | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|
| Gain/dB | 5.4 | 4.4 | 3.8 | 2.1 | 2.3 | 2.5 |
| Freq/GHz | 14 | 15 | 16 | 17 | 18 | |
| Gain/dB | 2.8 | 3.3 | 2.2 | 2.4 | 1.8 | |

## IV. CONCLUSION

In this work, we have simulated a Vivaldi antenna which operates at 8-18 GHz. Use metal vias and circular slot structure to achieve a good impedance matched and low back lobe. The measured data basically matches the simulation results.

## ACKNOWLEDGMENT

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