A Compact Antipodal Vivaldi Antenna with Improved Radiation Performance

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***Abstract* – An Antipodal Vivaldi antenna (AVA) with improved radiation and gain characters is proposed in this letter. In order to expand the frequency at the low-end bandwidth, three sets of slots are opened on each side of the antenna fins. For the purpose of increasing its performance at high frequency, the substrate structure between the arms of the antenna was designed as a triangular structure, thus minimizing the phase difference across the antenna aperture. This structure can improve the radiation at high frequency and raise the antenna gain by preventing the main beam from splitting as conventional Vivaldi antenna does. Also, this method does not increase the dimension of the antenna. The antenna analysis and design was carried out by CST software. The simulation result confirms the feasibility of the design.**

***Index Terms* — Antipodal Vivaldi Antenna (AVA), slot antenna, triangular structure.**

1. Introduction

Because of the exponential curve of its radiation flare structure, the Antipodal Vivaldi Antenna is an UWB antenna. The AVA can be conveniently printed on substrates. It, due to easy to manufacture and integration, finds a wide application in fields of UWB communication, UWB imaging, ground penetrating radar, UWB array and so on. For a conventional AVA, generally, the low-end operating frequency is confined by its dimension, and the up-end operating frequency is restricted by its unstable radiation pattern due to the main beam splitting as frequency increases. Thus, the bandwidth wider than that of conventional AVA is desirable by some applications.

Much research work has been done to expend the AVA's low-end frequency, mostly by modifying its arm structure in order to change the route of electric current. For example, reference [1]-[3] employ rectangular slots to restrain the low frequency current on outside edge of the fins; reference [4], [5] replace the sharp edge angles into smoothly changing curve to improve the low frequency impedance, and reference [6]-[8] design slots with special shape, which not only attain good VSWR, but also enhance the radiation character at low end frequency. There are also reported works relating to the AVA's gain and radiation improvement at high frequency, such as adding directors at the front of antennas[2], using lens to decrease the phase error at the antenna aperture[4], employing metal ellipses[9] or high permittivity substrate[10] at antenna aperture to change the field distribution. But these methods enlarge the dimension of the antenna.

In this letter, the substrate between the arms of the AVA was designed as a triangular structure, working as a wave guiding structure to improve the gain and main beam pattern at high frequency. By this way, an obvious benefit is the unchanged dimension of antenna. Three sets of slots were opened on both antenna fins to expand the low-end frequency. Section 2 describes the structure of the proposed antenna. Section 3 shows the simulation results of three type antennas and gives the analysis. Section 4 is the conclusion of the letter.

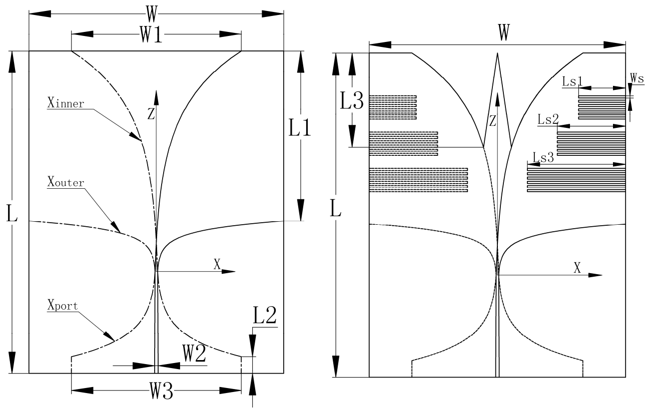
2. Antenna Design

Fig.1 (a) shows the conventional structure of AVA. The dimension of the antenna is 380(W) ×300(L) mm^2, and the thickness of the substrate is 2mm and the permittivity is 4.3. The width of the microstrip line is W2=4.2mm to match the 50Ω feeding line. The curve equations of the radiation flare are as follows:

$$x_{\text{inner}} = A_1 e^{p_1 z} \left(0 \le z \le 260\right) \quad (1)$$

$$x_{\text{outer}} = A_2 e^{p_2 z} \left(0 \le z \le 60\right) \quad (2)$$

The parameters of p1 and p2 are the tapering rate of the two exponential curves, respectively, and p1=0.015, p2=0.09.



(a) (b)

Fig.1 Schemes of the Antenas

Conventional AVA (a). Triangular structure AVA(b)

Table 1

Final Dimension Values

Dimension	Value（mm）
W1	200
W2	4.2
W3	200
L1	200
L2	20
L3	110
Ls1	55
Ls2	80
Ls3	115
Ws	2.5

The antenna proposed in this letter is shown in Fig.1 (b). There are three sets of slots on antenna fins, and the upper part substrate of the antenna is cut along the exponential curve letting the substrate in a triangular shape structure. The parameters of the antenna are listed in Table 1.

3. Simulation and Discussion

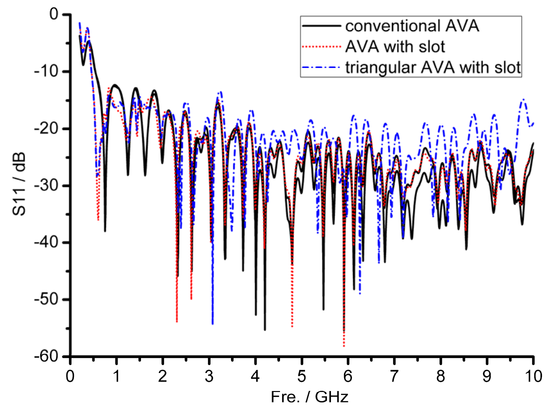


Fig.2 Reflection coefficient of three type antennas

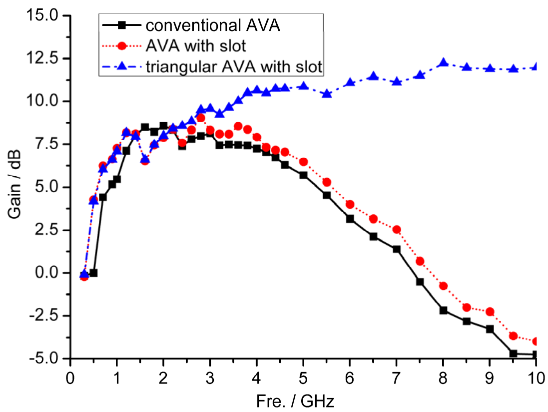


Fig.3 Gain of three type antennas

As comparison, an AVA only with slots of the same dimension is investigated and simulated too.

Fig.2 shows the reflection coefficient (S11) of three type of AVAs. The both slotted antenna's low-end frequency of S11<-10dB decreases from conventional AVA's 0.5GHz to 0.45GHz.

Fig.3 gives the curve of gain with frequency of three type of AVAs. According to Fig.3, the gain of the conventional AVA and AVA with slot starts to decrease sharply from 4GHz (7.5dB), reaching 0dB @ 7.5GHz. The major reason is due to the phase error across antenna aperture caused by current flow on the exponential curve, which leading to main beam splitting and radiation pattern serious distortion. While the antenna gain is on the rise till more than 10GHz for the new designed AVA with triangular structure, as show in Fig.3. The antenna gain reaches 12dB at 10GHz, comparing to the conventional AVA by increasing nearly 17dB.

Fig.4 shows the radiation pattern and the power flow of the triangular structure AVA. It indicates that the triangular structure converges the electromagnetic energy along the Z axial. Fig.4 (b2) clearly shows that the energy flows from the substrate triangular structure, demonstrating its wave guidance ability.

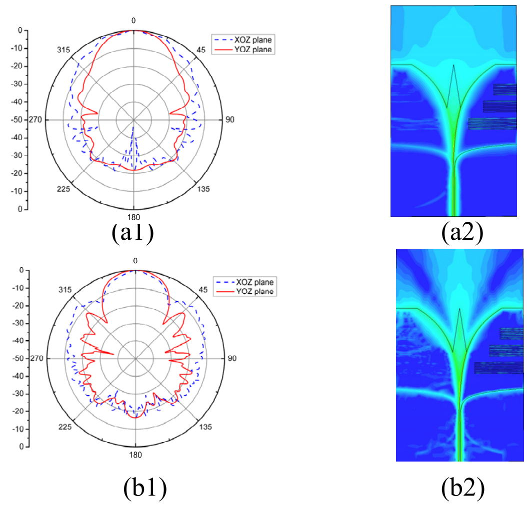


Fig.4 Radiation pattern and power flow of triangular structure AVA at 5GHz (a1), (a2) and at 10GHz (b1), (b2)

4. Conclusion

A compact slotted Antipodal Vivaldi antenna with triangular substrate structure at its aperture is proposed in this letter. The slots on the antenna fins improve the S11 and radiation pattern in low-end frequency, expending lower the work frequency to 0.45GHz. The triangular substrate structure at the antenna aperture acts as a wave guidance structure, enhancing the radiation and the antenna gain in high frequency, while not increasing the dimension of the Vivaldi antenna. The CST simulation results shows the antenna has a wide work frequency band and may be applied to UWB Radar field.

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