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An Ultra-Wideband Antipodal Vivaldi Antenna at 0.8-30.5 GHz

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***Abstract*—This paper presents a novel ultra-wideband antipodal Vivaldi antenna that operates across a frequency range of 0.8 to 30.5 GHz. The proposed antenna features an elliptical director, two radiating arms designed in inclined "Z" shapes, and serrated slots. Adding the elliptical director enhances the antenna's directivity and gain at higher frequency. Symmetrical "Z"-shaped slots on both sides of the radiating arms and serrated slots at the bottom edge are implemented to improve impedance matching at lower frequency. Simulation results indicate that the S_{11} of the antenna is below -10 dB in the frequency band of 0.8 to 30.5 GHz, with a maximum gain of 15.5 dBi. Furthermore, the radiation patterns display excellent symmetry and directivity within the operating frequency band, highlighting the antenna's superior radiation performance.**

***Keywords*—Antipodal Vivaldi antenna, ultra-wideband (UWB) antenna, elliptical director, inclined "Z" slot.**

I. Introduction

The Vivaldi antenna is recognized for its broadband capabilities, compact size, and directional radiation characteristics [1], [2]. It is widely utilized in various wireless communication systems [3], [4]. However, the performance of the Vivaldi antenna is constrained by its physical dimensions, preventing the achievement of infinitely wide frequency bands in practical applications. Vivaldi antennas with high gain and broadband has recently become a significant research focus. A broadband antipodal Vivaldi antenna has been designed in [5]. Although it has the advantage of compact and cost-effective, it exhibits poor impedance matching in low frequency. Paper [6] solves the impedance matching problem at low frequencies by employing resistance loading to enhance low-frequency impedance matching, facilitating ultra-wideband performance. However, the introduction of additional components weakens the antenna's radiation performance. In summary, designing an ultra-wideband, high-gain antipodal Vivaldi antenna is essential.

An antipodal Vivaldi antenna that operates at 0.8 to 30.5 GHz is presented in this paper. Introducing an elliptical director enhances the antenna's directivity at high frequency. Meanwhile, improve impedance matching at lower frequency by incorporating slots while maintaining the antenna's size. Consequently, the proposed antenna demonstrates wideband performance.

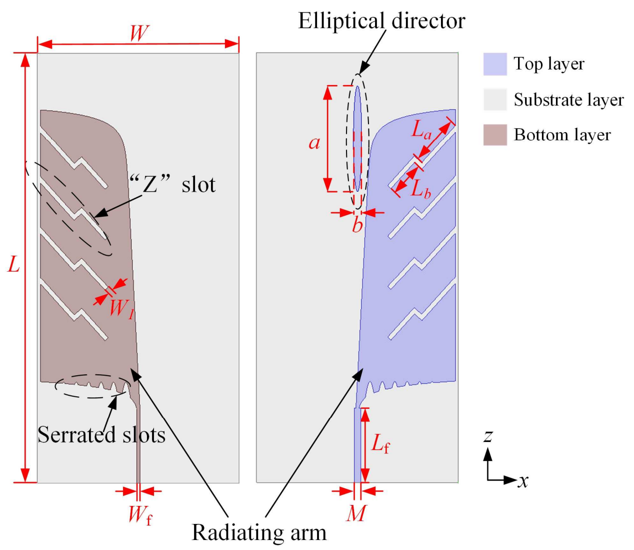

Fig. 1. The structure of the proposed Vivaldi antenna. (Parameters: W=121.93, L=260, W_1=2.7, W_f=1.93, La=30.4, L_b=21.3, L_f=45, M=4, a=32, b=2.5, x1=0, x2=60, z1=0, z2=185; unit: mm)

II. Vivaldi Antenna Design

A. Antenna Structure

This work proposes a novel antipodal Vivaldi antenna, as illustrated in Fig. 1. The presented antenna features an elliptical director and two radiating arms with inclined "Z" shapes, incorporating serrated slots. The substrate used for the antenna is Isola IS680AG, with a thickness of 0.76 mm. Notably, the radiation arms of the antenna utilize the same slot structure.

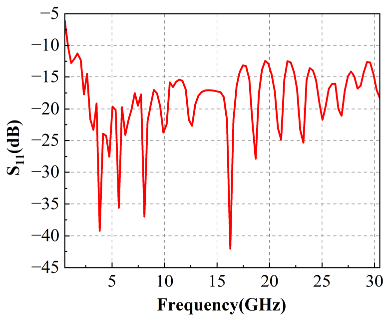

Fig.2. The simulated S_{11} of the antenna.

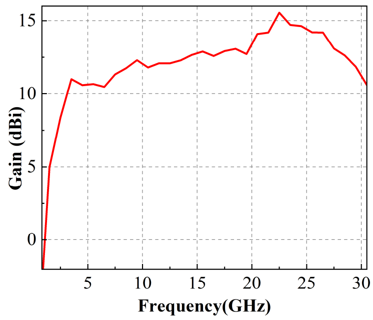

Fig.3. The simulation result of the antenna gain variation with frequency.

The following equations describe the curve of the Vivaldi antenna's radiation arm:

$$x = c_1 e^{dz} + c_2 \tag{1}$$

In this equation, d represents the opening rate index, with a value of 0.15. The starting and ending points of the index curve determine the constants $c1$ and $c2$. A 50-ohm SMA connector feeds the antenna along a rectangular microstrip.

III. Simulation Result and Analyze

Fig. 2 illustrates the simulated S_{11} of the designed antenna. The working bandwidth of the antenna, characterized by a reflection coefficient below -10 dB, ranges from 0.8 GHz to 30.5 GHz. The relationship between antenna gain and frequency is depicted in Fig. 3. The antenna gain increases with frequency within the bandwidth of 0.8 to 25.5 GHz while gradually decreasing above 25.5 GHz. Meanwhile, the simulated gains at 5.5 GHz, 10.5 GHz, 15.5 GHz, 20.5 GHz, 25.5 GHz and 30.5 GHz are 10.67 dBi, 11.8 dBi, 12.89 dBi, 14.09 dBi, 14.21 dBi and 10.61 dBi, respectively.

The simulated radiation patterns of the proposed antipodal Vivaldi antenna at frequencies at 0.8 GHz, 8.5 GHz, 15.5 GHz, 20.5 GHz, 26.5 GHz, and 30.5 GHz are presented in Fig. 4(a)–(f). These radiation patterns demonstrate good directivity and symmetry within the operating frequency band, indicating excellent radiation performance.

IV. Conclusion

This work proposes a novel ultra-wideband Vivaldi antenna structure. The designed antenna features an elliptical director and two radiating arms with inclined “Z”-shape and serrated slots. The antenna exhibits effective impedance matching in the frequency range of 0.8 to 30.5 GHz. Additionally, the radiation patterns demonstrate good symmetry, achieving a maximum gain of 15.5 dBi. In conclusion, the designed antenna provides a potential design solution for ultra-wideband antennas.

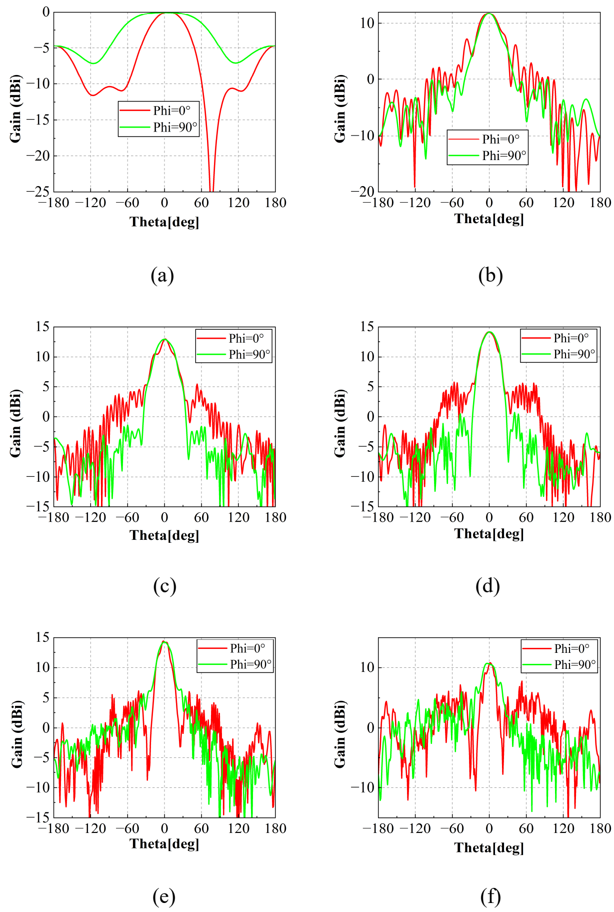

Fig.4. The simulated radiation patterns of the proposed antenna. (a) 0.8 GHz. (b) 8.5 GHz. (c) 15.5 GHz. (d) 20.5 GHz. (e) 26.5 GHz. (f) 30.5 GHz.

Acknowledgment

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