A Flaring Planar Dipole Array Antenna

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ABSTRACT.

In this paper, based on the horn dipole antenna unit, the integrated array antenna can meet the requirements of high gain, high efficiency and high integration of millimeter wave and wireless communication. The antenna consists of five metal dipole elements arranged equidistant, and two opposite symmetrical segments with dielectric plates as dipoles are fed between metal plates. Dielectric plate is made of Teflon, a high frequency composite material, which is widely used in high frequency signal transmission and microwave communication, and its dielectric constant is very low. Achieve below -10dB $|S_{11}|$ in the frequency band 1.24GHz-2.38GHzGHz, with a maximum gain of 18.6dB. Therefore, the antenna is suitable for millimeter wave communication.

Keywords: array-antenna; millimeter-wave; wireless -communication; dipole; high gain

1. INTRODUCTION

Compared with traditional wireless communication technology, millimeter wave antennas have larger broadband and higher frequencies, which can achieve faster data transmission speed and lower latency. Due to its high frequency characteristics, the antenna has a shorter wavelength and a smaller size. Therefore, it is possible to integrate more small-size, large-scale array antennas under rich spectrum resources[1]. However, due to the high frequency of millimeter wave, high propagation loss and penetration loss will be generated during transmission. Therefore, the design of high-gain and low-loss mmwave array antenna has been a research hotspot[1].

The compact point dipole array, proposed by Ben Munk, consists of electric dipole elements arranged in a row at a certain distance[1]. This type of antenna has the characteristics of miniaturization, ultra-wideband, high gain and easy integration.

Based on the above research, it can be seen that the dipole antenna has the characteristics of simple structure, broadband characteristics and easy integration array. Therefore, based on the horn dipole antenna, this paper uses the electromagnetic simulation software HFSS antenna unit and array to optimize the size, material and shape. Finally, a 1×5 array dipole antenna with wide band and high gain is obtained.

2. ANTENNA UNIT

2.1 Antenna unit design

In the design of antenna cell, the trumpet structure is used as the unit patch. After material selection and optimization, Teflon is finally selected as the dielectric plate material, which is widely used in the field of high-frequency signal transmission and microwave communication, and has its unique advantages[4]. Since the two arms of the electric dipole are separated by the dielectric substrate on different planes, a strong coupling can be generated by establishing a plane between the overlapping parts of the two arms as the feed surface. Its unique trumpet shape and dipole spatial distribution make it occupy a smaller space, and the wider spread arm makes the unit produce greater mutual coupling[6].

As shown in Figure.1, the structure and size distribution of the linear horn antenna element are shown. The dipole unit is improved, the size of the dielectric plate material is unchanged, the end of the dipole unit is curvilinear, and the circular structure is added, and the size of the unit is shown in Figure 2.

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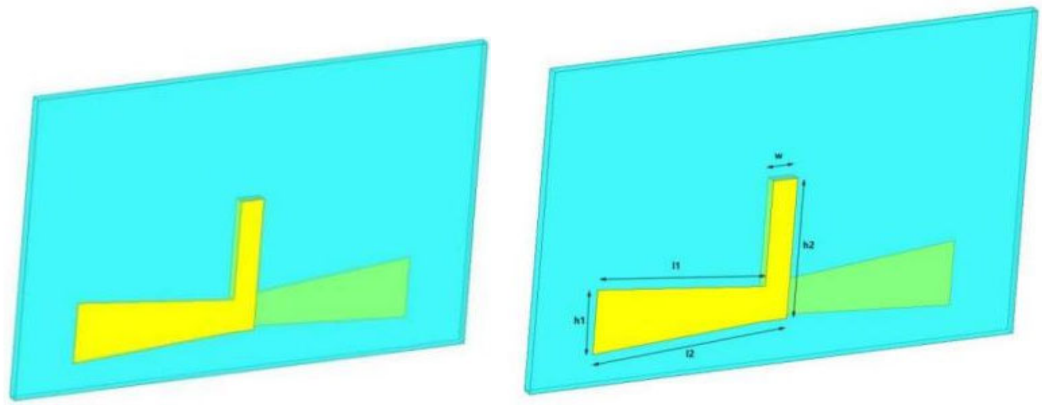
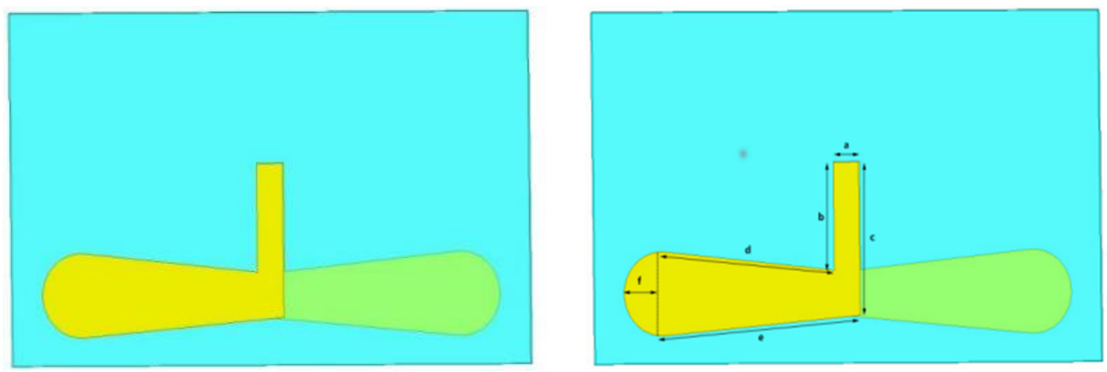
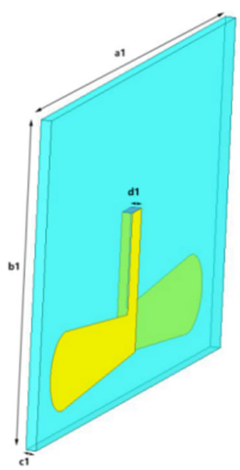


(a) (b)

Figure. 1 (a) 3D diagram of a linear horn dipole cell, (b) Dimension marking



(c) (d)



(e)

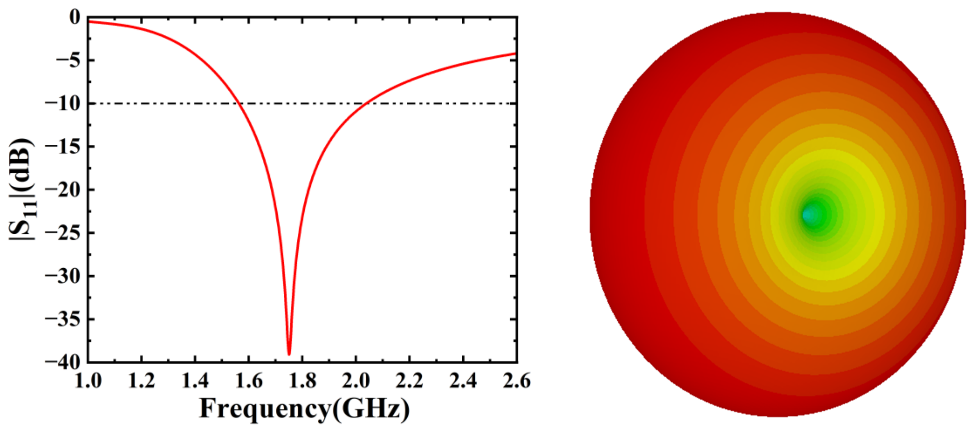
Figure. 2 (a) Optimized dipole cell structure, (b) Main view size, (c) Side view dimension

Table 1. Parameter size(unit:mm).

Parameter	a	b	c	d	e	f	a1	b1
Value	4	15.4	21.8	26.1	30.2	11.8	80	50
Parameter	c1	d1	w	l1	l2	h1	h2	alpha
Value	1.6	1.6	4	38.1	42.2	12.2	21.8	45°

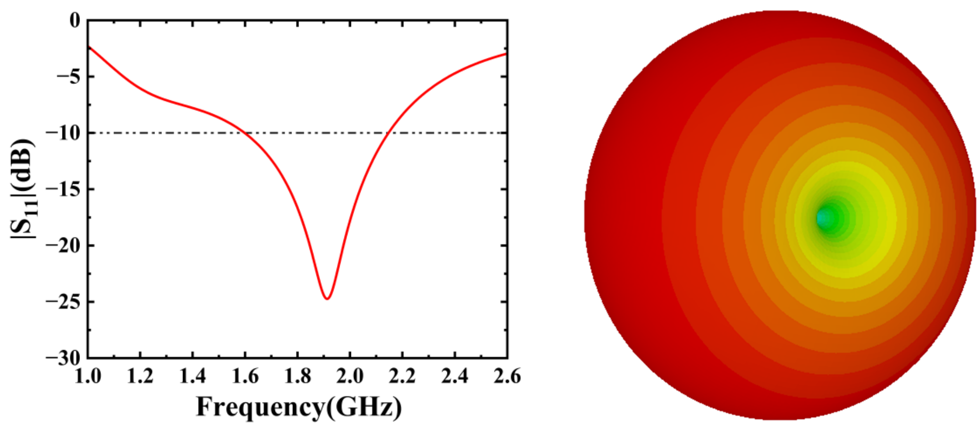
2.2 Simulation results of antenna unit

The electromagnetic simulation software HFSS was used to simulate the performance indicators of the dipole unit antenna and the improved structure, such as 3D gain diagram, return loss value $|S_{11}|$ curve diagram, etc., and the optimal structure was selected as the sub-unit of the final antenna array. Figure. 3 shows the simulation gain diagram and S-parameter curve of the linear horn dipole unit, which can be seen to operate at 1.55-2.05GHz. Figure.4 shows the simulation results of the deformed dipole element,which are shown in Figure. 2. It can be seen from the pic



(a) (b)

Figure. 3 Simulation results of linear horn antenna unit S parameter, (b)3D gain diagram



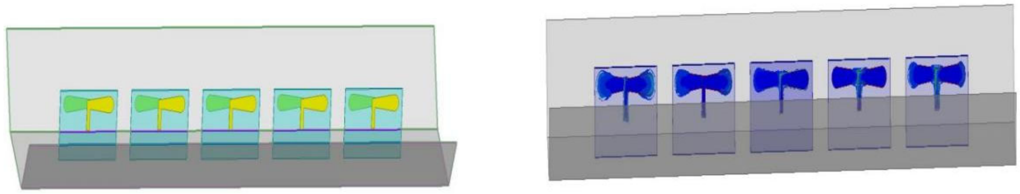
(a) (b)

Figure. 4 Simulation results of deformed horn antenna unit (a)S parameters, (b) 3D gain diagram

Compared with the simulation results in Figure.3 and Figure.4, it can be seen that the deformed unit structure has a wider bandwidth range, meets the design requirements in the frequency range of 1.59GHz-2.18GHz, and has a larger gain (up to 16.12dB) with better direction. As can be seen from the far-field image, this is a typical omnidirectional antenna. Therefore, the curved horn dipole element is selected to integrate the array antenna.

3. ANTENNA ARRAY DESIGN

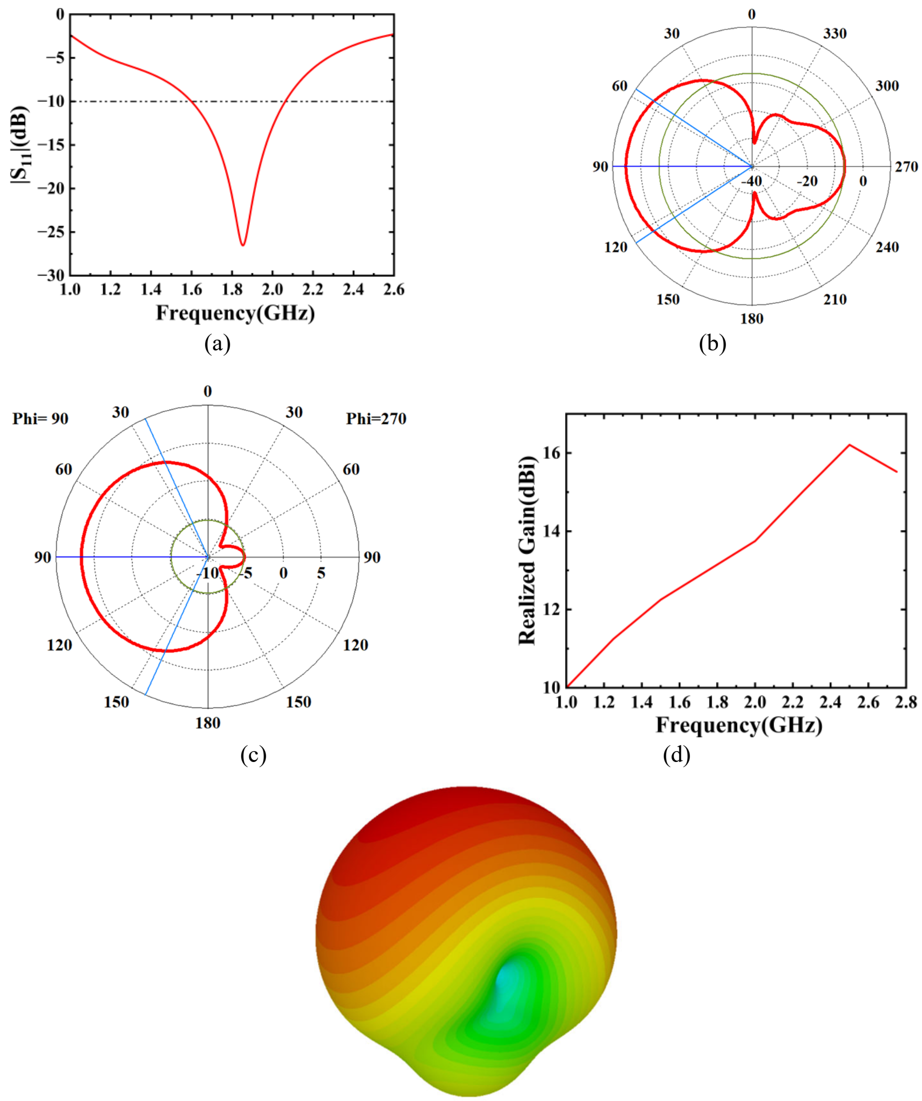
The optimized curved horn structure is selected as the array cell, and the dipole units are placed at a fixed distance of 20mm to form a 1×5 array, which is integrated on the ideal electromagnetic panel of 100mm×600mm. A bent panel with a certain angle alpha is added to two sides of the ideal electromagnetic panel to test its influence on the simulation results of the dipole array, as shown in Figure 5.



(a) (b)

Figure. 5 Antenna array (a) Three-dimensional diagram (b) Electric field distribution diagram

When alpha is 45° and the intermediate bending value, the simulation results of the array can be obtained, satisfying the frequency range |S11|≤-10, and the gain Figure is shown in Figure.6.



(a) (b) (c) (d) (e)

Figure. 6 When alpha is 45° (a)S parameter meets the design frequency range (b) Gain direction radar E diagram (c) Frequency gain diagram, the maximum gain is 16.12dB (d) Gain direction radar H diagram (e) Antenna array direction 3D diagram

In order to further verify the influence of the dipole patch's ruler parameters on the antenna operating frequency, parameters L and W are scanned. It can be found that when L=2mm and W=2mm, the widest bandwidth of the antenna is 1.24GHz-

2.38GHz, and the relative bandwidth is 76%. To explore the influence of bending panel angle on antenna array, alpha was optimized, and 8 different values of equal angle were separated within the range of 0°-90° for simulation analysis. Then, appropriate angles were selected from the set 8 values for simulation analysis again, and the results were shown in Figure. 7.

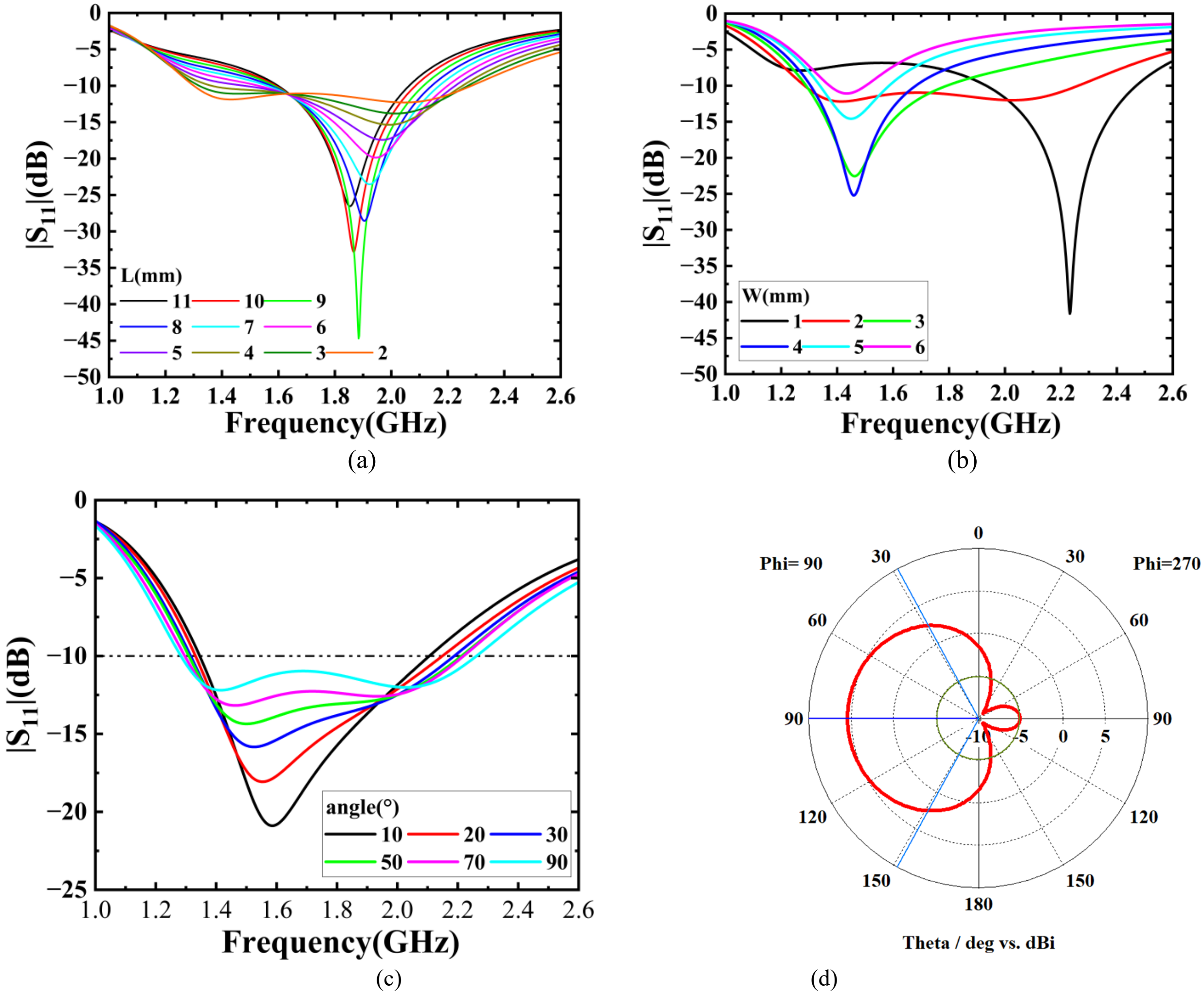


Figure. Parameter optimization (a) The influence of different values of L on $|S_{11}|$, (b) The influence of different values of W on $|S_{11}|$, (c) Influence of different angles of inclined plate on $|S_{11}|$ (d) The angle with the maximum gain was selected for radar diagram analysis

4. SUMMARY

The most basic linear horn dipole structure is designed, which is separated by a certain distance through the Teflon dielectric substrate, and the antenna element is smaller in size, more compact in structure and good mutual coupling compared with the traditional structure. Due to the bandwidth limitation, the shape of the dipole boom is changed into a curve-circular boom structure to obtain a wider frequency range and higher gain, which greatly improves the directivity of the dipole unit. The five dipole elements are integrated on the ideal electromagnetic surface, and the optimal 90° is obtained by changing the bending angle of the electromagnetic surface panel, which is the final dipole antenna array structure, which meets or even exceeds the design requirements. The frequency range is broadened to 1.352GHz-2.274GHz.

5. ACKNOWLEDGMENT

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