

A millimeter-wave MIMO antenna applied to the n260 frequency band

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Abstract. In order to effectively alleviate the current situation of low-frequency spectrum congestion and meet people's demand for high-speed communication, a four element multiple input multiple output (MIMO) millimeter wave antenna was designed for the n260 frequency band (37-40GHz), with an overall size of 10mm×12mm× 0.508mm. This antenna is based on a dipole broadband millimeter wave unit antenna and adopts a coplanar waveguide feeding method. The four element antenna is placed orthogonally to improve the isolation of the antenna. The operating bandwidth is 36.76-41.73GHz, fully covering the n260 frequency band of 5G, with a relative bandwidth of 12.7%. The simulation results show that the impedance bandwidth of each port of the antenna covers this frequency band, and the isolation degree between each antenna unit port is less than -15dB. The envelope correlation coefficient (ECC) is less than 0.05, and has good radiation characteristics, which meets the performance requirements of MIMO antenna and can ensure the normal operation of the antenna.

Keywords: millimeter wave antenna, n260 Frequency-band, 5G communication, MIMO

1. Introduction

In order to meet the capacity demand of 5G network, the millimeter-wave communication system has attracted great attention. The millimeter wave frequency band is not too accurately defined, usually the 30-200 MHz frequency electromagnetic wave, become the millimeter wave[1]. Compared with the current 2G/3G/4G/5G band, millimeter wave band has a large number of available spectrum resources, which can effectively alleviate the low frequency spectrum crowding, so as to meet people's demand for high-speed communication, so millimeter wave technology has become a research hotspot. In [2] proposed a new type of high-performance millimeter-wave antenna with differential patch low cross-polarization, high aperture efficiency and high gain characteristics. The bandwidth can be extended to 60GHz and achieve 5 dBi higher than the general patch antenna; In [3] proposed a low-cost high-order mode cavity backslot array antenna using empty substrate integrated waveguide, which is applied to the n260 band of 5G. The slot array is excited by an empty substrate integrated waveguide cavity covering

the n260 frequency band range and achieves high gain effect[4]; In [5]proposed a method to achieve a millimeter-wave antenna covering the n257 frequency band through gap coupling, but its small size is not suitable for application to cellular mobile devices. At present, the surface of the antenna is etched, slotted and gradually tted Structure, multi-layer coupling feeding and other technologies are important technologies to improve the isolation degree[6]. In [7]is orthogonal, making the isolation in the working bandwidth below-15dB; Therefore, millimeter wave technology combined with MIMO technology makes ultra-high-speed wireless communication possible, and the design of millimeter wave MIMO antenna has certain significance.

This paper presents a four-unit MIMO millimeter-wave antenna oriented to the 5G n260 frequency band. The size of the antenna is 10mm×5mm×0.508mm, and the working bandwidth of the antenna is 36.76-41.33GHz. By placing each antenna unit and adding floor branches vertically, the isolation degree of each port is below-20dB, the envelope correlation coefficient (ECC) of the antenna is less than 0.02, and the total reflection coefficient(TARC)is less than 0, satisfying the working performance of MIMO antenna.

2. Antenna design

2.1. Antenna unit design

The cell structure diagram of the antenna is shown in Figure Figure 1. The antenna is composed of three parts of feed micro strip line, radiation unit and medium substrate, using the feeding mode of the coplanar waveguide is adopted the substrate is the design of millimeter wave antenna high quality substrate material, radiation unit is obtained by the rectangular shear transformation, the overall size of the antenna unit is 5mm×5mm×0.508mm, meet the conditions of antenna miniaturization.

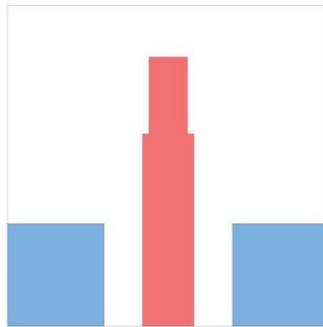


Figure 1. Structure diagram of the antenna unit

By optimizing the various parameters of the antenna, it is found that the patch and the center feed distance W_1 will affect the bandwidth of the antenna. The antenna simulation results are shown in Figure 2. As can be seen from the figure, when $W_1=1.5\text{mm}$, the reflection coefficient of the antenna is less than -10dB working bandwidth is 36.54-40.73GHz), fully covering the 5G communication n260 frequency band.

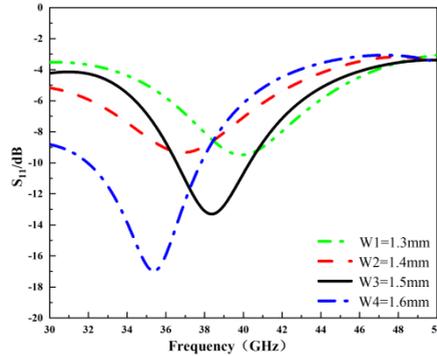


Figure 2. Simulation diagram of S_{11} changing with W_1

2.2. Binary antenna structure design

The design idea of the binary MIMO antenna is shown in Figure 3. First, the two antenna units placed in parallel as shown in figure 3 (a), the antenna size is $26\text{mm} \times 5\text{mm} \times 0.508\text{mm}$, antenna working bandwidth is 35.83-40.23GHz, adjacent isolation is -14dB, the effect can not meet the performance requirements of MIMO antenna, therefore, in order to reduce the isolation, reduce the coupling between the two antennas, the two antennas orthogonally vertical, as shown in Figure 3 (b), the time of the antenna size is $10\text{mm} \times 10\text{mm} \times 0.508\text{mm}$, the working bandwidth is 35.2-40.27GHz, isolated at less than -16dB.

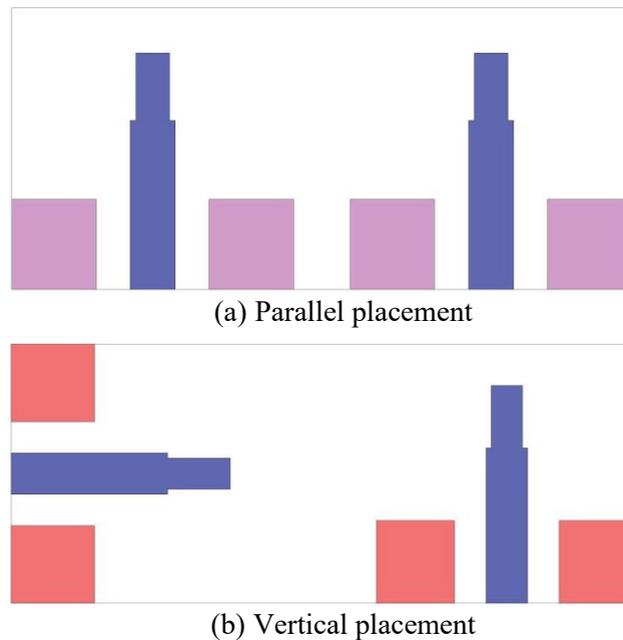


Figure 3. Structural diagram of the binary antenna MIMO

The simulation optimization results are shown in Figure 4, although the vertical placement mode makes the working bandwidth of the antenna to change, it can also cover the 5G n260 frequency band range, and improve the antenna isolation degree, which meets the better performance of MIMO antenna.

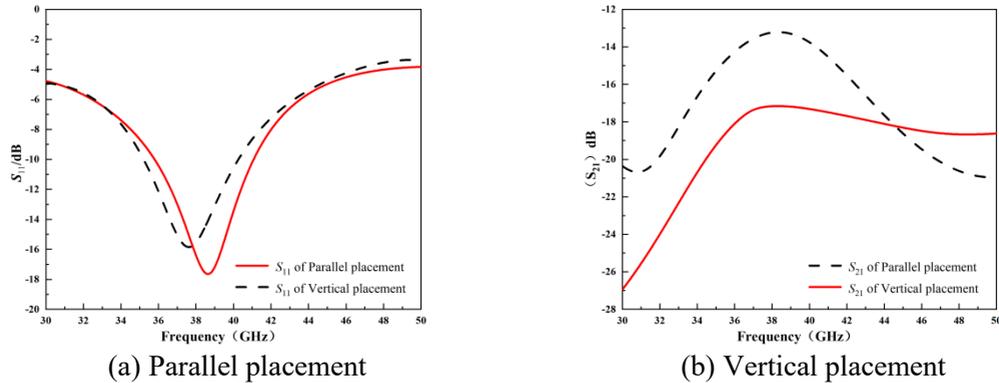


Figure 4. The effect of two different placement modes on the S -parameters

2.3. Design of the quelement antenna structurally

On the basis of the binary MIMO antenna, the antenna array is further expanded to design a four-element MIMO antenna structure. The antenna still adopts the Rogers4352 plate with relative dielectric constant of 3.2 and loss angle tangent of 0.0018, which is consistent with the medium substrate material of the unit antenna. The antenna design idea is shown in Figure 5.

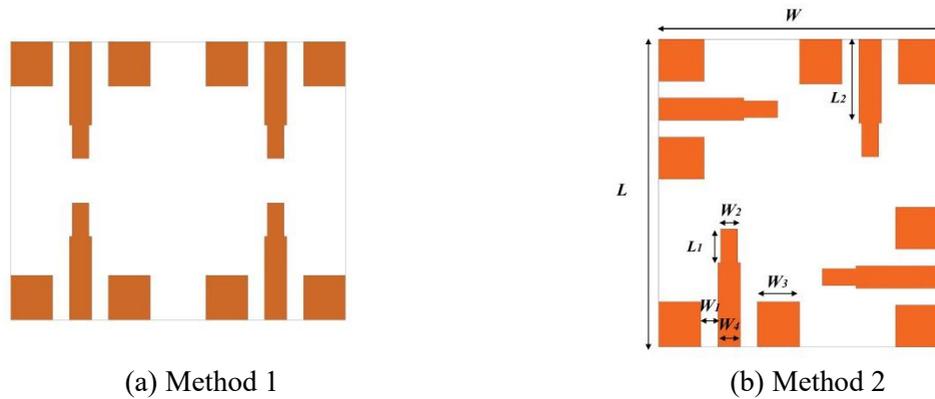


Figure 5. Four-element MIMO antenna structure

In order to further reduce the interference between antennas and improve the isolation degree, the placement form of the quad antenna is changed. The antenna structure and antenna dimension are shown in Figure 5 (b), and the reference value of the size is shown in Table 1. Figure 6 (b) shows the S parameter of the antenna after orthogonal placement. It can be seen from the figure, the working bandwidth range of the orthogonal imitation antenna is 36.76-41.33GHz. When the antenna still fully covers the n260 frequency band, the isolation degree of each port of the antenna is below -15dB.

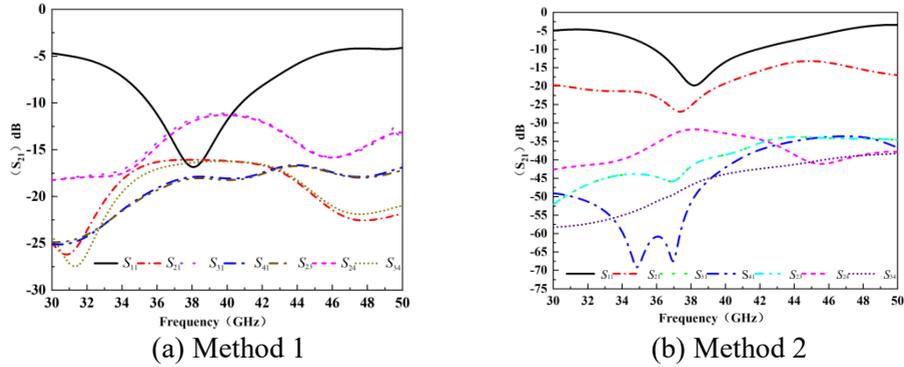


Figure 6. Two kinds of arrangement S -parameters of the quad-element MIMO antenna

Table 1. MIMO antenna size parameter (mm)

L	10	W_1	0.6
W	12	W_2	0.6
L_1	1.2	W_3	1.5
L_2	3	W_4	0.8

3. Analysis of the results of the simulation experiments

3.1. Radiation direction diagram

Figure 7 shows the simulation direction diagram of the far-field E and H planes at the central frequency 38.4GHz of the antenna. It can be seen from the figure that the radiation characteristics of the antenna in the n260 frequency band range are good. It can be seen that the E surface is approximately "8" and the H surface is approximately round, indicating that the antenna has certain omnidirectional radiation characteristics.

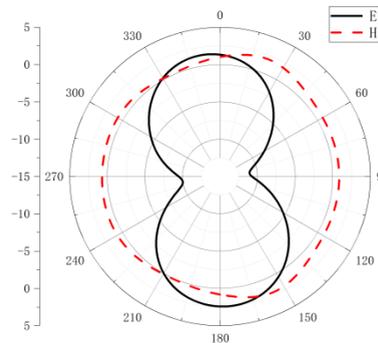


Figure 7. Radiation direction plot at the central frequency

3.2. Diversity characterization

To ensure channel correlation in MIMO communication, we quantified the performance of antenna diversity using the envelope correlation coefficient (ECC) As specified, the MIMO antenna elements must meet the $ECC < 0.5$ criteria to achieve a higher diversity between the MIMO antenna elements.

For the dual-port MIMO antennas, the ECC can be represented by the following formula:

$$ECC = \frac{|S_{12}^* S_{12} + S_{21}^* S_{22}|^2}{(1 - |S_{11}|^2 - |S_{21}|^2)(1 - |S_{22}|^2 - |S_{12}|^2)} \quad (1)$$

Moreover, the ECC value of the antenna is shown in Figure 8, which is less than 0.05 in the working frequency band and meets the standard requirement of less than 0.5.

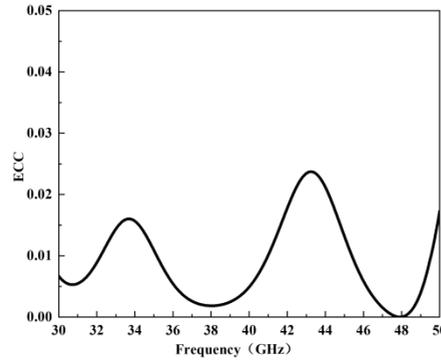


Figure 8. Simulated results of ECC

The proposed MIMO antennas are comprehensively compared with several antennas previously reported in Table 2 in terms of size, isolation, operating frequency, and ECC.

Table 2. A slightly more complex table with a narrow caption.

Ref.	Bandwidth(GHz)	Isolation(dB)	Size(mm ³)
[5]	24-68.6	-19	10.1×12
[6]	33.7-36.5	-40	40×40
[7]	23.1-35	-19	13×13
Proposed	36.76-41.73	-20	10×12

4. Conclusion

The antenna feeding method designed in this article is a coplanar waveguide method, which has the advantage of smaller size; Based on the traditional unit antenna, an antenna suitable for the n260 frequency band is generated, and then transformed into a binary and quaternary MIMO antenna on this basis, so that its working bandwidth fully covers the 5G n260 frequency band, with a relative bandwidth of 12.7% and a working range of 36.76-41.73GHz. By changing the placement of the quaternary antenna, the isolation degree of each port of the antenna is ultimately below -20dB, and good directionality is maintained, Suitable for the application and expansion of MIMO antennas.

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Acknowledgments

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