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A Novel High-Isolation Positive-and-Negative-45-Degree Dual-Polarization 5G mmWave Micro Base Station Antenna

Chao You, Yejun He*, Wenting Li, Long Zhang
State Key Laboratory of Radio Frequency Heterogeneous Integration
Sino-British Antennas and Propagation Joint Laboratory
Guangdong Engineering Research Center of Base Station Antennas and Propagation
Shenzhen Key Laboratory of Antennas and Propagation
College of Electronics and Information Engineering, Shenzhen University, Shenzhen, China
Email: heyejun@126.com

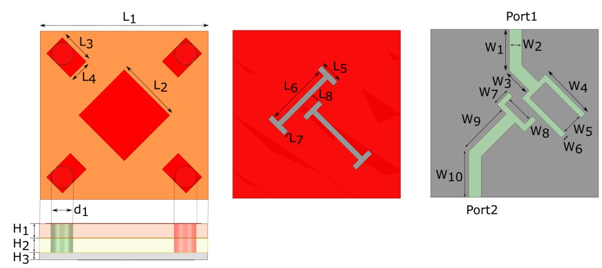
***Abstract*—In this paper, a slot-coupled dual-polarization micro base station antenna based on a vertical feed structure is proposed. The structural design of the double-layer patch allows the antenna to have two resonance points. When the resonance points are close to each other, the bandwidth of the antenna is increased. Four circular metal through-holes (or via holes) are used to improve the impedance matching of the antenna, resulting in an operating bandwidth of 24.14-29.08 GHz with voltage standing wave ratio (VSWR) of less than 1.5. The antenna also has a high isolation of less than -30 dB. In addition, the cross-polarization performance of the antenna exceeds 15 dB, which meets the standards of base station antennas. At the same time, the antenna has a low profile feature, with a thickness of 1.3 mm (about 0.11λ at 26 GHz) and a compact size of 6 mm $\times$ 6 mm (about 0.52λ $\times$ 0.52λ at 26 GHz). This antenna has the potential for large-scale multiple-input multiple-output (MIMO) applications.**

***Index Terms*—Millimeter wave antenna, dual-polarization, patch antenna, micro base station antenna.**

I. Introduction

In the development of communication systems from 1G to 4G, there are few spectral resources left [1], making it difficult to meet the requirements of contemporary people for data transmission rate. Therefore, millimeter wave technology [2] is a necessary technology for 5G millimeter wave base station antennas. At present, we mainly conduct research on millimeter wave base station antennas from three aspects: miniaturization, high isolation, and broadband. In [3], a broadband dual-polarized magnetoelectric dipole with a special T-shaped probe feeding structure, suitable for the millimeter wave band, was proposed. This antenna achieves a wider bandwidth than existing antennas. However, its structure is complex and difficult to form a large-scale array structure. In [4], a single-fed low-profile millimeter wave broadband circularly polarized spiral antenna array with an operating frequency range from 24.87 GHz to 31.82 GHz is proposed, where cross slots are used to ultimately achieve a port isolation of 15.8 dB.

In this paper, a broadband dual-polarization high isolation micro base station antenna is proposed. The antenna can operate in the bandwidth range of 24.14-29.08 GHz and maintain stable gain and high isolation. In addition, its simple structure is suitable for large-scale mmWave antenna array applications.



(a) (b) (c)

Fig. 1. Geometry of the proposed antenna.(a) Top view and side view. (b) Floor layer patch (c) Feed patch (Detailed antenna parameters: H_1 = 0.508 mm, H_2 = 0.508 mm, H_3 = 0.254 mm), L_1 = 6 mm, L_2 = 2.3 mm, L_3 = 1.2 mm, L_4 = 0.8 mm, L_5 = 0.8 mm, L_6 = 2.3 mm, L_7 = 0.2 mm, L_8 = 0.3 mm, d_1 = 0.8 mm, W_1 = 1.5 mm, W_2 = 0.45 mm, W_3 = 1 mm, W_4 = 2 mm, W_5 = 0.8 mm, W_6 = 0.2 mm, W_7 = 0.6 mm, W_8 = 1 mm, W_9 = 1.9 mm, W_{10} = 1.65 mm.

II. ANTENNA DESIGN

The geometric shape of the proposed antenna is shown in Fig. 1. The antenna consists of three layers of dielectric substrates, each of which uses Rogers4350b board with a dielectric constant of 3.66 and a loss tangent of 0.0037. The top layer dielectric substrate is etched with a square parasitic patch located in the center and four rectangular parasitic patches located in the corners. The upper surface of the intermediate dielectric substrate is etched with a square radiation patch at its center. The size of the radiation patch is the same as the top parasitic patch. In addition, four metal through-holes are designed at the corners of the upper and middle dielectric substrates. This metal through-hole will connect the middle floor structure and the top rectangular parasitic patch. During the debugging process of the antenna, it will act as an inductor to improve the impedance matching performance of the antenna.

The upper surface of the dielectric substrate at the bottom layer of the antenna serves as the floor structure of the antenna, and two mutually perpendicular H-shaped gaps are etched at its center. At the same time, a pair of U-shaped feeding structures are etched on its lower surface. The feeding structure couples energy to the radiation patch through the action of gaps, while the radiation patch continues to couple energy to the parasitic patch on the upper layer. After feeding port 1 and port 2, $\pm$ 45° polarization can be achieved respectively. The antenna was simulated and optimized in HFSS software.

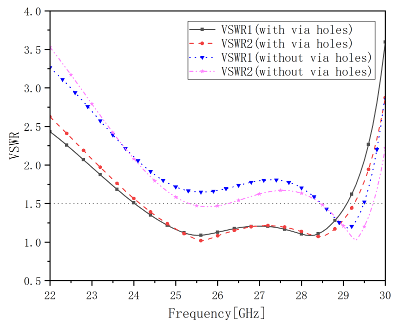


Fig. 2. Simulated VSWR of the proposed antenna.

The simulation results of the voltage standing wave ratio (VSWR) of the two antenna ports are shown in Fig. 2, and the effect of metal through-holes is analyzed. After adding a metal through-hole structure, the impedance matching of the antenna can be improved. In addition, a bandwidth of 24.02-29.08 GHz and a bandwidth of 24.14-29.26 GHz are achieved on Port 1 and Port 2, respectively. Over the operating bandwidth, the VSWR is less than 1.5.

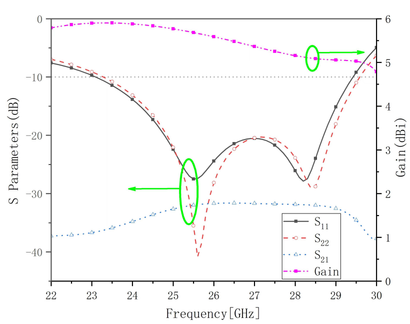


Fig. 3. Simulated scattering parameters and gain of the proposed antenna.

The simulation results of antenna scattering parameters and gain are shown in Fig. 3. The antenna can achieve a bandwidth range of 23.09-29.42 GHz on Port 1 and 23.28-29.59 GHz on Port 2 (S_{11}<-10 dB). Moreover, the isolation of the antenna is less than -30 dB within the bandwidth range. The gain of this antenna is greater than 5dBi and remain stable. As shown in Fig. 4, when only feeding port 1, the cross-polarization characteristics of the antenna at 24 GHz and 28 GHz on the xoz and yoz planes are shown. The cross-polarization discrimination rate of the antenna at 0° is greater than 30 dB.

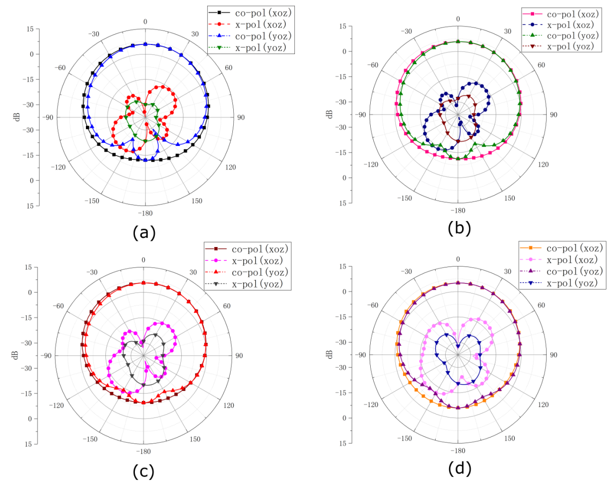


Fig. 4. Simulated radiation patterns of the proposed antenna. (a) 24 GHz , (b) 25 GHz, (c) 26 GHz , (d) 28 GHz .

III. CONCLUSION

This paper introduces a $\pm$ 45° dual-polarization slot coupled millimeter wave micro base station antenna. This antenna can achieve a bandwidth of 24.14-29.08 GHz (VSWR<1.5), with a relative bandwidth of 18.56%. At the same time, the antenna has a high isolation level that can be less than -30 dB, stable pattern performance and wide beam width. The antenna has a lower profile with a size of 6 mm $\times$ 6 mm $\times$ 1.3 mm (about 0.52λ $\times$ 0.52λ $\times$ 0.11λ at 26 GHz) .Therefore, this antenna has great potential as a candidate antenna for 5G micro base stations, which can be used for wide-angle beam scanning.

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