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A Dual-Polarized 5G mmWave Micro Base Station Antenna Based on Differential Feed Structure

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***Abstract*—In this paper, a dual polarization multilayer patch micro base station antenna based on a differential feed structure is proposed. The antenna is designed with a three-layer radiation patch structure, with the first layer connected to the feed network through metal through holes, and the second and third layers also connected through metal through holes. Two differential feed networks were designed corresponding to their two polarization modes. The stacked structure of multi-layer radiation patches increases the bandwidth of the antenna from 23.21 to 29.60 GHz, with S_{11} less than -10 dB. And a square ring is added around the first layer of the radiation patch to improve the isolation of the antenna, which can achieve greater than 20 dB. At the same time, the antenna has a stable gain and directional pattern effect, and the gain can achieve a size greater than 7 dBi within the bandwidth range. Therefore, this antenna array has the potential to be a candidate antenna for large-scale millimeter wave array applications.**

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

I. Introduction

In recent years, due to our continuous improvement in communication quality requirements, the 5th generation communication technology (5G technology) has begun to enter our lives. Millimeter wave has a Transmission delay as low as 1 ms and a higher signal transmission rate, which enables it to meet our requirements for current communication quality. Patch antennas have many advantages such as lightweight, easy processing, and low cost, but they have the natural disadvantage of small bandwidth [1]. [2] proposes a wideband substrate integrated waveguide (SIW) back cavity slot antenna. On its top wide wall, there is a U-shaped groove and a rectangular groove, which generate multiple resonances and effectively expand the operating bandwidth. The antenna operates in the frequency range of 7.8 GHz to 12.1 GHz. In [3], a broadband circularly polarized magneto electric dipole antenna array is proposed. The antenna is coupled and fed through gaps, ultimately achieving a relative bandwidth of 32%. And designed an 8 × 8 array structure, with a peak gain of up to 22 dBi. But it's just a single polarized antenna. A dual polarization filtering antenna was proposed in [4], but it is difficult to form an array structure.A low profile, broadband, dual line polarized millimeter wave antenna array is proposed in [5]. The total thickness of the antenna is 1.57 mm, exhibiting a 21.8% impedance bandwidth and mutual coupling below -41 dB.

In this article, a dual polarization millimeter wave antenna based on differential feeding structure is proposed. The antenna achieves dual polarization through differential feeding. And the antenna has a wide bandwidth, with a gain of over 7 dBi.

II. Antenna Design

The structural diagram of the antenna is shown in Fig. 1. The antenna uses Rogers 5880 board with a dielectric constant of 2.2 and a loss tangent of 0.0009 for all three dielectric substrates.The centers of the upper and lower surfaces of the dielectric substrate 4 are etched with two equally sized square patches, which are connected through four metal through-holes.The upper surface of dielectric substrate 2 is etched with four equally sized diamond patch structures, and symmetrical triangles of equal size are dug out at its center. And, a square circular ring structure is etched around the four diamond-shaped patches which are connected to the underlying feed network through four metal through-holes. Differential feeding network structures corresponding to two polarizations were etched on the bottom layer of dielectric substrate 1.The proposed antenna is simulated and analyzed in HFSS software.

As shown in Fig. 2, after adding the upper ring, the isolation of the antenna at high frequencies can be better improved, making it less than -20 dB within the bandwidth range.

The simulation results of the scattering parameters and gain of the antenna are presented in Fig. 3. The antenna can operate in the bandwidth range of 23.25-29.68 GHz in Port 1 and 23.25-29.60 GHz in Port 2 (S_{11}<-10 dB). In addition, the gain of the antenna during operation can be greater than 7 dBi, and the out of band gain will rapidly decrease, which can prevent the influence of out of band signals. When exciting antenna port 1, Figure 4 shows the directional patterns of the antenna in the horizontal and vertical planes at 24 GHz, 25 GHz, 26 GHz, and 27.5 GHz. The antenna maintains stable main polarization patterns at all frequency points, with axial

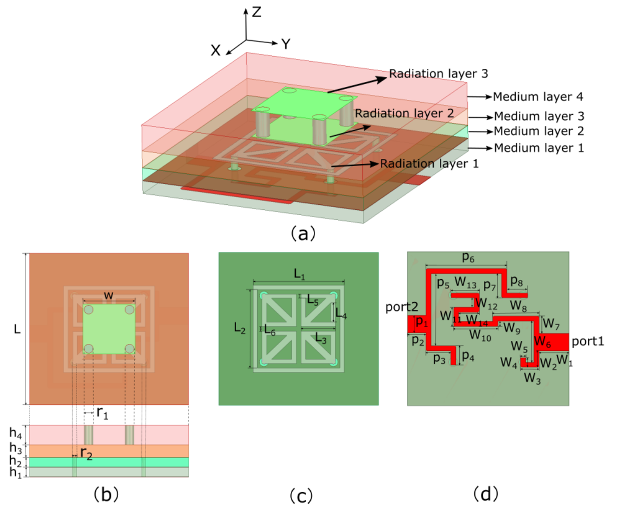

Fig. 1. Geometry of the proposed antenna.(a) 3D View (b) Top view and side view. (c) Radiation patch (d) Feed patch (Detailed antenna parameters:L = 7 mm, W = 2.3 mm, h_1 = 0.381 mm, h_2 = 0.381 mm, h_3 = 0.508 mm, h_4 = 0.787 mm, r_1 = 0.4 mm, r_2 = 0.2 mm, L_1 = 4 mm, L_2 = 3.6 mm, L_3 = 1.5 mm, L_4 = 0.88 mm, L_5 = 0.2 mm, L_6 = 0.21 mm, W_1 = 1.3 mm, W_2 = 0.745 mm, W_3 = 0.8 mm, W_4 = 0.42 mm, W_5 = 0.22mm, W_6 = 1.88 mm, W_7 = 0.785 mm, W_8 = 2 mm, W_9 = 0.25 mm, W_{10} = 1.92 mm, W_{11} = 1.92 mm, W_{12} = 0.43 mm, W_{13} = 1.22 mm, W_{14} = 0.89 mm, P_1 = 0.79 mm, P_2 = 0.8 mm, P_3 = 1.08 mm, P_4 = 0.87 mm, P_5 = 3.28 mm, P_6 = 3.5 mm, P_7 = 1.1 mm, P_8 = 0.9 mm.

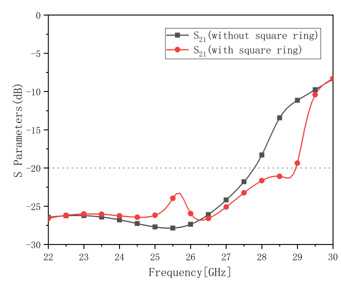

Fig. 2. Simulated S_{21} of the proposed antenna.

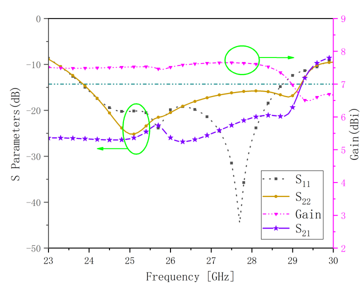

Fig. 3. Simulated scattering parameters and gain of the proposed antenna.

cross polarization discrimination rates higher than 20 dB and half power beam widths greater than 75°.

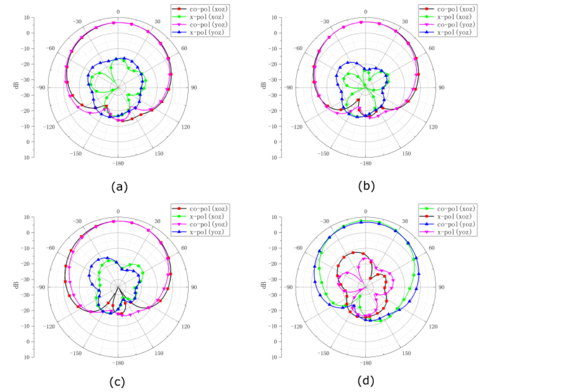

Fig. 4. Simulated radiation pattern of antenna at different frequency points. (a) 24 GHz , (b) 25 GHz, (c) 26 GHz , (d) 27.5 GHz .

III. CONCLUSION

In this article, a ± 45° dual-polarization millimeter wave micro base station antenna based on differential feeding structure is proposed. The antenna operates within the bandwidth range of 23.25-29.60 GHz (S_{11}<-10 dB), with a relative bandwidth of 24%. And the antenna can achieve a gain of over 7 dBi and an isolation degree of over 20 dB within the working bandwidth. In addition, it has a good cross-polarization effect and a wider lobe width. Therefore, this antenna meets the design requirements of millimeter wave micro base station antennas and has the potential to be a candidate antenna for mmWave large-scale array design.

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REFERENCES

[1] H. Al-Saedi, J. K. Ali, W. M. Abdel-Wahab, S. Gigoyan and S. Safavi-Naeini, "A Dual Circularly Polarized Patch Antenna for Broadband Millimeter Wave (MMW) Communication Systems," in *Proc. 2016 IEEE International Symposium on Antennas and Propagation (APSURSI)*, 2016, pp. 593-594.

[2] Z. Zhang, X. Cao, J. Gao, S. Li and J. Han, "Broadband SIW Cavity-Backed Slot Antenna for Endfire Applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 17, no. 7, pp. 1271-1275, July 2018.

[3] Q. Tan, K. Fan, W. Yu, W. Wang, L. Liu and G. Q. Luo,"A Circularly Polarized Magneto-Electric Dipole Antenna Array With Wide AR and Impedance Bandwidth for Millimeter-Wave Applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 22, no. 9, pp. 2250-2254, Sept. 2023.

[4] K. Huang and Y. Zhang, "Analysis and Design of Dual-Polarized Millimeter-Wave Filtering Magneto-Electric Dipole Antenna,"*IEEE Transactions on Antennas and Propagation,"*, vol. 71, no. 8, pp. 6947-6952, Aug. 2023.

[5] X. Tong, Z. H. Jiang, C. Yu, F. Wu, X. Xu and W. Hong, "Low-Profile, Broadband, Dual-Linearly Polarized, and Wide-Angle Millimeter-Wave Antenna Arrays for Ka-Band 5G Applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 20, no. 10, pp. 2038-2042, Oct. 2021.