

# Millimeter Wave Massive MIMO Array Design for 5g

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**Abstract:** with the Official Commercialization of the Fifth Generation Mobile Communication, the 5g-Oriented Massive MIMO Antenna System Plays an Important Role. the Mm-End is the Main Band for 5g Network Deployment Choices Due to Its Wide Frequency Band, Short Wavelength, High Resolution and High Precision. in View of This, This Paper First Analyzes the Main Features and Development Status of Massive MIMO, and Analyzes the Necessity of Optimizing the Millimeter Wave Massive MIMO Array Design. on This Basis, the Deployment of Massive MIMO Matrix is Further Carried out in Three Aspects: Network Planning, Network Operation and Maintenance, and Network Configuration. Finally, the Paper Designs a 5g Millimeter-Wave Massive MIMO Array and Performs Simulation Calculations. the Results Show That the Designed Array Can Effectively Achieve the Gain Effect.

## 1. Introduction

### 1.1 Literature Review

As a Further Extension of Traditional MIMO Technology, Massive MIMO Has Become a Research Hotspot of 5g Wireless Communication. Massive MIMO Technology Has Grown Rapidly in Recent Years. Yang Zhonghao, Wang Qiong and Others Pointed out That the Massive MIMO Technology Can Increase the Number of Antennas in a Large Amount, and the Time-Division Duplex Communication Mode is Also an Unprecedented Improvement in the Overall Performance of the System. on This Basis, Several Scholars Elaborated on the Current Status of 5g Communication and the Technical Characteristics of MIMO (Yang et al, 2015). Xu Yafeng and Others Pointed out That Massive MIMO Technology is Extremely Critical in 5g Mobile Communication, and Analyzes and Numerically Simulates Multi-User Systems and Point-to-Point Systems According to Specific Characteristics. the Test Results Show That the Increase in the Number of Antennas Will Cause the Small-Scale Fading of the Single-Antenna System to Disappear, and the Overall System Performance Will Be Significantly Improved (Xu et al, 2017). Wang Bo et al. Believe That the Application of 3d Beamforming Technology in Massive MIMO Antennas Can Achieve Accurate Coverage. Antenna Calibration Technology is Key to Ensuring the Effectiveness of the Characterization. on This Basis, Wang Bo et al. Further Explored the Calibration Method and Error-Causing Factors of 5g Antennas (Wang et al, 2019). Li Yanfen and Zhu Xuetian Pointed out That the Application of Massive MIMO Can Effectively Improve Spectrum Efficiency and Increase Network Capacity. However, the Specific Application of Massive MIMO Faces Many Challenges in Deployment and Operation and Maintenance. the Two Scholars Further Analyzed the Problems in the Application of Massive MIMO from the Perspectives of Network Operation and Maintenance Intelligence and Network Planning (Li and Yan, 2019). the Peak is Based on the Evolutionary Route and Key Technologies of 5g Technology, Focusing on the Structure of Large-Scale Array Antennas. on This Basis, Peak Proposes a 3d Coverage Optimization Algorithm and a New Evaluation Method for Massive MIMO Antenna Performance (Gao, 2017). Wang Changwei It is Believed That with the Popularization and Maturity of 5g Technology, Large-Scale Antennas Will Become the Future Development Direction of Antennas, and Massive MIMO Antenna Technology Will Play an Important Role in It (Wang, 2018).

## 1.2 Purpose of the Study

In August 2019, 5G technology was launched in the first batch of cities in China. Compared to 4G technology, 5G technology has all-round advantages, especially in millimeter wave, massive MIMO, beamforming and so on. It is foreseeable that in the future, 5G technology will have broad application prospects. As one of the key technologies of 5G, the millimeter-wave Massive MIMO array design is the same as the antenna that activates the number of terminals in the temple, which can significantly improve the spectrum coverage and network capacity. Therefore, its related research is very important. However, combing the existing literature shows that the research on multi-bias theory around millimeter wave Massive MIMO, or just analyzing its characteristics and development status, few studies on its array design, and good array design is the basis for improving the efficiency of Massive MIMO. In view of this, this paper carries out related research to make up for the gaps in related research fields.

## 2. Overview of Related Theory

Massive MIMO, also known as large-scale antenna technology, can significantly improve system capacity and spectrum utilization in 5G development. This technology was first proposed by Bell Labs in the United States. According to the experimental results, with the increase of the number of cell sites, the effects of Rayleigh fading and Gaussian white noise can be neglected. Correspondingly, the data transmission speed is improved. The specific reasons for improvement can be analyzed from two aspects. One is the increase in the number of antennas, and the other is the increase in the signal coverage dimension.

Massive MIMO has several advantages over traditional communication technologies. The first is high energy efficiency, and large-scale antenna technology systems can form narrow beams and concentrate radiation and small spaces. The energy transmission efficiency between the base station and the UE is extremely high and the loss is small. The second is the high spatial distribution rate, because of the robust performance of large-scale MIMO systems and the high number of antennas. The number of UEs makes the system highly resistant to interference and extremely high spatial freedom. The third is high multiplexing gain and diversity gain. Thanks to higher spatial resolution, Massive MIMO systems can dig deep into space resources. On the same time-frequency resource, multiple users can communicate with the spatial freedom provided by the user, and the spectrum resource multiplexing capability can be greatly improved, and the spectrum efficiency can be improved without increasing the bandwidth and the base station density. Although 5G technology, Massive MIMO is one of the important core technologies, it has many advantages, but it does not mean that this technology is fully mature. In fact, how to model 3D channels, how to calibrate antenna systems, how to combine them with FDD technology, and how to arrange antennas are urgent problems.

Although 5G technology can also use the 6GHz low frequency band, due to limited resources, 5G requirements cannot be met. Therefore, most 5G networks use high frequency bands, that is, the frequency bands in which millimeter waves are located. Unlike the low-middle band, the high-band beam is extremely narrow and cannot achieve omnidirectional transmission and reception. Therefore, it can only rely on Massive MIMO technology to design a multi-antenna array.

## 3. Millimeter Wave Massive MIMO Deployment for 5g

### 3.1 Network Planning

At this stage, the Massive MIMO device form is mainly divided into three types, namely 64TRX, 32TRX, and 16TRX. Among them, the 64TRX antenna has 8 rows and 8 columns, for a total of 64 dual-polarized antenna units. The antenna is divided into 4 groups of sub-modules. Each RF port is synthesized by three antenna elements. The dual-polarized attribute makes the number of ports the same as 64. Each sub-module is designed with a dedicated calibration port, which is calibrated in special scenarios such as channel recovery and cell reconstruction to achieve consistent phase and

amplitude of the transceiver channel. In theory, the physical gain of the Massive MIMO antenna is mainly related to the array group number and the array factor gain. For the 64TRX antenna, the antenna array gain is 15dBi and the 1TEX gain is 10dBi, so ideally 25 dBi can be achieved. In terms of capacity, 16TRX can only support one layer of vertical, 64TRX can support up to 4 layers of vertical, and the network capacity is further improved. In terms of interference, since 64TRX supports 4 layers of vertical dimension, adjacent users can be divided into multiple beams, so there is less interference in the adjacent area

### 3.2 Network Configuration

Eight fixed-band narrowbands are designed based on the 3GPP standard Sub 6GHz broadcast beam. At different time nodes, differentiated narrow beams are transmitted for cell beam coverage. The narrow beam is scanned by the terminal within 2 ms to obtain an optimal beam. The SSB beam used is a static beam, and the weight is manually selected by static for different coverage scenarios. Since there are more than ten kinds of SSB weights, only manual configuration will have greater subjectivity, and accurate matching cannot be achieved. Therefore, combining AI with Massive MIMO to achieve intelligent weight assignment is a major development trend. Obtain valid data through ports such as MR, and use machine learning classification algorithms to intelligently estimate and obtain optimal weights. At the same time, the scene monitoring learning is carried out, and the performance of the model is greatly improved, and the coverage effect is optimized.

### 3.3 Network Operation and Maintenance

Network operation and maintenance is also important for the effect of millimeter-wave Massive MIMO arrays. As a benchmark for network operations, reasonable antenna engineering parameter settings help reduce operating costs. In the traditional 4G phase, the application of AISG realizes the remote acquisition of data, and the intelligence of operation and maintenance is strengthened. Compared with the traditional base station antenna, the Massive MIMO array is extremely large, and the antenna is integrated with the RUU. While improving the performance of the base station, the maintenance difficulty of the device is also drastically increased. For the RUU part of Massive MIMO, a certain AISG port is set on the outer side. On the built-in side, the sensing unit is placed at the top of the Massive MIMO antenna. Overall, the integrated design of Massive MIMO has resulted in a significant increase in cost over traditional methods.

## 4. The Specific Array Design

### 4.1 Design Array Indicators

The main indicators of the array antenna designed in this paper are shown in Table 1.

Table 1 Required Array Indicators

index	Related instructions
Center frequency	28.5GHz
Scanning range	$\theta \leq \pm 60^\circ$
Bandwidth	8%
Polarization	Horizontal linear polarization
Active standing wave	VSWR<2

The antenna unit is a giant polarized antenna that feeds the microstrip. Compared with other antenna forms, the antenna designed in this paper has the following characteristics. First, the bandwidth is narrow, generally less than 5%; second, the feed structure is a plane, which is easy to integrate with the RF system; Third, if the grounded cascode waveguide transmission line of the upper and lower layers is not considered, the feed network is a single layer with high integration. .

### 4.2 Rule Array Design

In this paper, a 32-element rectangular array is chosen instead of a regular array of micro-band elements of a conventional grounded coplanar waveguide. Each unit is coaxially connected to the

underside via a probe, and each coaxial is responsible for the RF port. The input impedance is set to 50 ohms, the vertical spacing is 0.64 wavelengths, and the horizontal spacing is 0.42. According to the design specification of 28.5 GHz, the spacing of the array elements is the same as the spacing between the RF terminals.

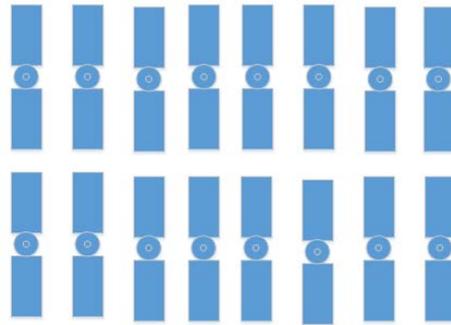


Fig.1 Cell Rule Array Structure

The minimum unit of the design interlaced array consists of two two units. The coaxial position is extremely RF port position with a vertical spacing of 7.3 mm and a horizontal spacing of 5.3 mm. For the convenience of processing, the four staggered line arrays are divided into four line arrays. The vertical distance between the two patch structures is shortened to 3.65 mm. The minimum period boundary size is 10.6 mm, and the vertical distance is equivalent to the RF port spacing.

The simulation results of the design array show that the active S parameters of any port are not high and -10dB between 24GHz and 28GHz. Among them, at the frequency of 24.50 GHz, the designed regular array gain is 20.09 dB. At the 25.75 GHz frequency, the designed regular array gain is 22.08 dB. At the 27.50 GHz frequency, the designed regular array gain is 20.86 dB.

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