Dual-band Directional MIMO Antenna for WLAN Application

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Abstract. In this paper, we propose a dual-band directional multiple input multiple output (MIMO) antenna, which covers 2.4 / 5.8 GHz frequency band for WLAN. The MIMO antenna consists of four monopoles with the same structure and orthogonal positions, and the port isolation between the monopoles is greater than 13 dB. The monopole antenna generates double-frequency radiation by L-shaped branches and adopts a CPW feed network to achieve broadband matching. Our simulation results show that the antenna has wide bandwidth and excellent radiation performance for indoor WLAN signal distribution.

1. Introduction

MIMO refers to the technology of spatial diversity by using multiple transmit and receive antennas. It uses independent multiple sub-antennas. Communication link can have a plurality of parallel non-interfering sub-channels, rather than a single channel. Therefore, the channel communication capacity is greatly improved [1, 2]. It can be used in autonomous driving, Unmanned Aerial Vehicle (UAV), 5G and other fields [3, 4, 5]. However, problems like mutual coupling between antenna elements, the impact of cell number and spacing on terminals, and miniaturization still remain in the MIMO antenna design. In recent years, MIMO technology makes a major breakthrough. A series of low-cost, miniaturized and multi-band MIMO antennas for WLAN have been proposed [6, 7, 8]. Sonkki et al. proposed a monopole MIMO antenna applied to 2.5 GHz to enhance the antenna isolation through slotting, and the antenna isolation reached about 40 dB [9]. Miers et al. designed multi-frequency resonance through enhancing the bandwidth of MIMO antenna which is based on the eigenmode theory [10].

In this paper, we propose a dual-frequency MIMO directional antenna for WLAN, which covers the 2.4 / 5.8 GHz dual-band. The antenna integrates four output ports, and the isolation between each port is greater than 10 dB. Double frequency radiation is generated by double inverted L-shaped branches. CPW feed is employed to realize broadband matching. The simulation results show that the return loss of the antenna is less than -10 dB in the 2.4 / 5.8 GHz band, which has a wide bandwidth and good radiation characteristics.
2. Design of antenna structure
The antenna is composed of four orthogonal monopoles. A metal reflecting plate with a diameter of 100mm is set under the antenna, and the height of the reflecting plate from the antenna is set to 5mm. The design of antenna structure is shown in Fig. 1.

![Antenna structure diagram](image)

**Figure 1.** Antenna structure diagram.  **Figure 2.** Structure size of monopole antenna.

The specific size of the monopole antenna is shown in Fig. 2. Monopole is printed on the FR4 dielectric substrate with a dielectric constant of 4.4, thickness of 1mm and size of 32mm × 25mm. Two inverted L-shaped monopole antennas are fed by coplanar waveguide, with a length of 15mm and a width of 2mm. The gap width between feeder and metal ground is 0.5mm, and the metal ground is composed of two rectangles with a size of 15mm × 11mm. The inverted L-type monopole is connected with the feeder, and the width of the Monopole Microstrip line is 1mm. Two groups of monopole antennas are printed on FR4 in parallel, as shown in Fig. 3. The distance width between two monopoles is 30mm, and the overall size of the FR4 dielectric substrate is 80mm × 32mm.

![Structure size of MIMO monopole antenna](image)

**Figure 3.** Structure size of MIMO monopole antenna.

3. Antenna optimization and result analysis
We employ three-dimensional electromagnetic simulation software to optimize the antenna. The influence of short L-shaped branch length \( L_7 \) on the frequency of 5.8 GHz and the CPW feeder width on the reflection coefficient of the antenna are shown in Fig. 4 and Fig. 5, respectively. It can be seen from Fig. 4 that the length of the short L-shaped branch mainly affects the low-frequency resonance point of the antenna. The larger the \( L_7 \) value is, the more the frequency shifts to the low-frequency. As can be seen from Fig. 5, the width of the CPW feeder determines the antenna impedance. When the width \( W_3 \) is 2.4 mm, the antenna matching at the high-frequency resonance point is poor. With the decrease of \( W_3 \), the antenna impedance matching becomes better. When \( W_3 \) is set to 2 mm, the impedance matching approaches the best. In this paper, we set \( L_7 = 10 \) mm and \( W_3 = 2 \) mm to meet the frequency requirements of WLAN antenna.
As can be seen from Fig. 6 that the bandwidth with the antenna reflection coefficient less than -10 dB is 2.23 ~ 2.89 GHz, 5.05 ~ 5.99 GHz, meeting the requirements of WLAN band 2.4 GHz and 5.8 GHz.

The isolation curve $S_{12}$ between ports is shown in Fig. 6. At 2.45 GHz and 5.4 GHz, the isolation values $S_{12}$ of ports are -13 dB and -18 dB respectively, meeting the isolation requirements of the MIMO antenna ($S_{12} > 10$ dB).

Fig. 7(a) and 7(b) shows the antenna pattern at 2.4 GHz and 5.8 GHz, respectively. The direction pattern of the antenna is directional at the low resonant frequency, the maximum gain of the antenna is 3.71 dBi, and the maximum gain of the antenna at the high resonant frequency is 4.78 dBi.
4. Conclusion
In this paper, we proposed a dual-frequency MIMO directional antenna for WLAN. The antenna covers the 2.4 / 5.8 GHz dual-band of WLAN. Four monopoles with the same structure and orthogonal position are adapted to form a 4-port MIMO antenna, which is fed by CPW to achieve high and low-frequency broadband matching. The impedance bandwidth of antenna -10 dB is 2.23 ~ 2.89 GHz, 5.05 ~ 5.99 GHz, and the isolation between ports exceeds 13 dB. The antenna has the characteristics of compact structure, wide frequency band, directional radiation and so on. It has an important guiding significance in indoor WLAN signal distribution.

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