Design of Multi-band Circularly Polarized Microstrip Antenna

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Abstract. Design a multi-band circularly polarized microstrip antenna for ISM (2.4GHz, 5.8GHz) and WiMAX (3.3GHz-3.6GHz). Using Ansoft HFSS15.0 for the simulation analysis, the size of the resonance point and the resonance bandwidth are adjusted by opening four triangular grooves on four sides of the radiation patch. The simulation results show that the frequency band of the antenna's return loss below -10dB is 2.38GHz-2.52GHz, 3.37GHz-3.45GHz, and 5.6GHz-5.9GHz. The antenna meets the design requirements of multi-frequency and miniaturization.

Keywords: Circularly polarized microstrip antenna; Triangle groove; Multi-frequency.

1. Introduction

The antenna is one of the important components in the radio system, and its main function is to radiate and receive electromagnetic waves[1-3]. Radar, navigation, broadcasting, and television in communication systems all transmit information through electromagnetic waves[4-5]. With the rapid development of modern communication technology, miniaturization and multi-function have become people's continuous pursuit of various handheld devices[6], so a terminal device is required to be able to work in multiple frequency bands at the same time. The publicly used wireless frequency bands (ISM2.4GHz, ISM5.8GHz) and metropolitan area network bands (WiMAX) for wireless communication are important frequency bands for small multifunctional handheld devices. Therefore, it is of practical significance to design an antenna that can cover the above frequency band. In this paper, Design a multi-band circularly polarized microstrip antenna for ISM (2.4GHz, 5.8GHz) and WiMAX (3.3GHz-3.6GHz). The antenna meets the design requirements of multi-frequency and miniaturization[7-8].

2. Design of Antenna Model

Fig.1 is a detailed structural diagram of the antenna. FR4 is used as the dielectric substrate, the dielectric constant is 2.2, and the substrate size is 36.8mm*36.8mm*3mm. The position of the coaxial feed point is located at the diagonal of the radiation patch to ensure the circular polarization. The size of the radiation patch is 13mm*6.5mm. The four sides of the radiation patch have triangular slots to optimize circular polarization performance. The slot depth is 3.25mm and 1.63mm, and the included angle is 90°. Constant amplitude mode with 90° phase difference. Fig.2 is the antenna model. The (a) is Front of antenna and The (b) is Back of the antenn.
3. Simulation Optimization and Result Analysis
Using Ansoft HFSS15.0 for the simulation analysis, analyzing the antenna parameters, structure, and smith pattern. The simulation results are shown in Fig. 3, 4, 5, and 6.
Fig.3 is the standing wave ratio of each resonance point after parameter optimization.
Fig.4 shows the return loss curve when the triangular patch is not opened on the four sides of the radiation patch.
Fig.5 is the return loss curve when the triangular patch is opened on the four sides of the triangular patch.

Fig.3 shows the standing wave ratios of the three resonance points are all below 1.5 at 2.4 GHz, 3.4 GHz, and 5.8 GHz.
Comparing the results of Fig.4 and Fig.5 shows that the frequency position is improved. The branches can realize the design of multi-frequency and miniaturization of the antenna. Fig.6 shows the smith pattern of the antenna at three resonance points at 2.4 GHz, 3.4 GHz, and 5.8 GHz.

4. Measured Results and Analysis
The physical picture of the antenna is shown in Fig.7.
The antenna was connected to a vector screen instrument (Agilent Technologies E5071C 300 MHz ~ 20 GHz) through a SMA connector for testing. The test results are shown in Fig.8.

![Antenna measurement results.](image)

**Figure 8.** Antenna measurement results.

Fig.8 shows the frequency band of antenna return loss below -10dB is 2.37GHz-2.6GHz, 3.35GHz-3.44GHz, 5.65GHz-5.9GHz. Compared with the simulation results, the 5.8GHz resonance frequency point in the antenna test results is slightly Backward shift. At 2.4GHz and 3.4GHz, the test bandwidth is improved compared to the simulation bandwidth. This is mainly due to errors in materials and manufacturing processes. Within the error tolerance range, the actual measurement results are consistent with the simulation results.

5. Conclusion

In this paper, Design a multi-band circularly polarized microstrip antenna for the ISM (2.4GHz, 5.8GHz) and WiMAX (3.3GHz-3.6GHz). Through simulation and test results, the bandwidths of its resonance points are 5.7% (2.38-2.52GHz), 2.4% (3.37–3.45 GHz), and 5.2% (5.6–5.9 GHz). The measured results are in good agreement with the simulated ones, indicating that the antenna has multiple operating frequency bands. $S_{11}$ are all less than -10dB, and the matching, gain and radiation characteristics of the antenna are relatively good, and they can be widely used in modern wireless communication and mobile communication systems.

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Reference

[1] Gaurav Kumar, Mahender Singh, Sarita Ahiawat, Rajveer S. Yaduvanshi. Design of Stacked Rectangular Dielectric Resonator Antenna for Wideband Applications[J]. Wireless Personal Communications, 2019, Vol.109 (3):1661-1672.

[2] Jaiverdhan, Ashok Kumar, Mahendra Mohan Sharma, et al. Dual wideband circular polarized CPW-fed strip and slots loaded compact square slot antenna for wireless and satellite applications[J]. AEUE - International Journal of Electronics and Communications, 2019, 108.

[3] Hongyan Tang, Ke Wang, Runmiao Wu, et al. A Novel Broadband Circularly Polarized Monopole Antenna Based on C-Shaped Radiator[J]. IEEE Antennas and Wireless Propagation Letters, 2017, 16:964-967.

[4] Lakoju Bhanu Pratap, Akhilesh Mohan. Microstrip-Fed Broadband Circularly Polarized Antenna for Lower UWB[J]. Wireless Personal Communications, 2017, Vol.96 (3):4167-4175.

[5] Hongyan Tang, Ke Wang, Runmiao Wu, et al. Compact Triple-Band Circularly Polarized Monopole Antenna for WLAN and WiMAX Applications[J]. Microwave and Optical Technology Letters, 2017, 59(8): 1901-1908.
[6] M. S. Ellis, Z. Zhao, J. Wu, et al. A novel simple and compact microstrip-fed circularly polarized wide slot antenna with wide axial ratio bandwidth for C-band applications[J]. IEEE Transactions on Antennas and Propagation, 2016, 64(4): 1552-1555.

[7] K. K. So, H. Wong, K. M. Luk, et al. Miniaturized circularly polarized patch antenna with low back radiation for GPS satellite communications[M]. IEEE Transactions On Antennas And Propagation, 2015, 63(12): 5934-5938.

[8] C. Y. D. Sim, H. D. Chen, L. Zuo, et al. CPW-fed square ring slot antenna with circular polarization radiation for Wi MAX/WLAN applications[J]. Microwave and Optical Technology Letters, 2015, 57(4): 886-891.