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Compact triple-band monopole antenna for WLAN/WiMAX applications

You Zheng[a)], **Peng Wang, Minjie Hua, and Peng Gao**
Research Institute of Electronic Science and Technology, University of Electronic Science and Technology of China, Chengdu 611731, China
a) *zy90_80@163.com*

Abstract: A novel compact monopole antenna for WLAN and WiMAX applications is presented. By properly etching two open-ended inverted L-shaped slots on the radiation patch, three separated resonances with effective bandwidth enhancement can be obtained. The overall dimension of the proposed antenna is only 29 (L) × 10 (W) × 1.6 (H) mm^3. Experimental results show that the antenna provides three impedance bandwidth of 80 MHz (2.4–2.48 GHz), 420 MHz (3.28–3.7 GHz) and 600 MHz (5.23–5.83 GHz). Good radiation patterns and applicable gains are also obtained across the operating bands. The proposed antenna is thus suitable for wireless communications systems.

Keywords: monopole antenna, slot, triple-band, WLAN, WiMAX
Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

In recent years, the rapid development of wireless communication has urged a wide demand for antennas having compact size and multiband operations such as WLAN and WiMAX standards. Various antennas have been developed to achieve multiband function. For example, the microstrip slot antenna was presented for WLAN and WiMAX applications [1]. The triple-band antenna with three circular-arc-shaped strips was proposed to create multiband functions [2]. [3] proposed a trident-shaped dual-band

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CPW-fed antenna. Utilizing the coupling between the parasitic patch and the main patch, the hybrid monopole antenna achieves dual resonant modes [4]. However, the antennas mentioned above have either complex structure or large size, which are not suitable for the portable wireless terminals with limited space. Broadband antenna covering multiple bands is also a choice, but it may cause interference with other existing communication systems [5, 6].

In this letter, a novel compact monopole antenna for triple-band WLAN and WiMAX applications is presented. The proposed antenna composed of a microstrip feed line, a rectangular patch and a modified ground plane. Using two open-ended inverted L-shaped slots, good impedance matching is achieved in three bands. Measurements show that the antenna provides three impedance bandwidth of 80 MHz (2.4–2.48 GHz), 400 MHz (3.28–3.7 GHz) and 600 MHz (5.23–5.83 GHz), which cover the 3.5/5.5 GHz WiMAX bands and 2.4/5.5/5.8 GHz WLAN bands. Good radiation patterns and stable gains are also obtained across the working band. Details of the design and experimental results are presented and discussed.

2 Antenna design

Fig. 1 shows the configuration with design parameters of the triple-band monopole antenna. The proposed antenna is fabricated on a 1.6mm-thick FR-4 substrate with relative permittivity of 4.4 and loss tangent of 0.02. The main radiation patch and the microstrip feedline are printed on the top of the substrate. The ground plane is printed below the microstrip feedline on the other side of the substrate. Asymmetric microstrip feeding is employed in this design so that the overall size of triple-band antenna is reduced. The feedline width W_f is calculated and fixed as 3 mm for 50 Ω characteristic impedance. The bottom of the radiating patch and the top of the ground plane adopt staircase edges for bandwidth enhancement. Two open-ended inverted L-shaped slots are etched on the radiation patch to excite lowest and highest frequencies. For design convenience, the width of the slots is chosen to be the same as 0.4 mm.

The design evolution process and its corresponding return loss are

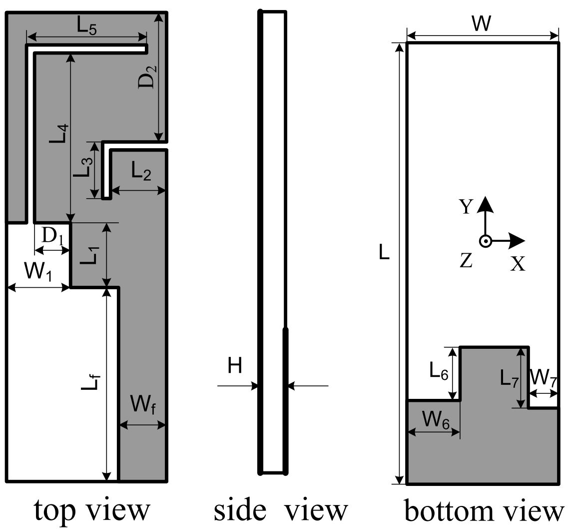

Fig. 1. Geometry of the proposed antenna.

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presented in Figure 2. Antenna 1 without slot is the basic modified monopole antenna. This design determines the middle resonant mode near 3.5 GHz WiMAX frequency band. To excite the lower and higher resonant modes, two open-ended inverted L-shaped slot 1 and slot 2 are orderly embedded in antenna 1 (denoted as antenna 2 and antenna 3). Antenna 3 with triple operation bands is the proposed antenna.

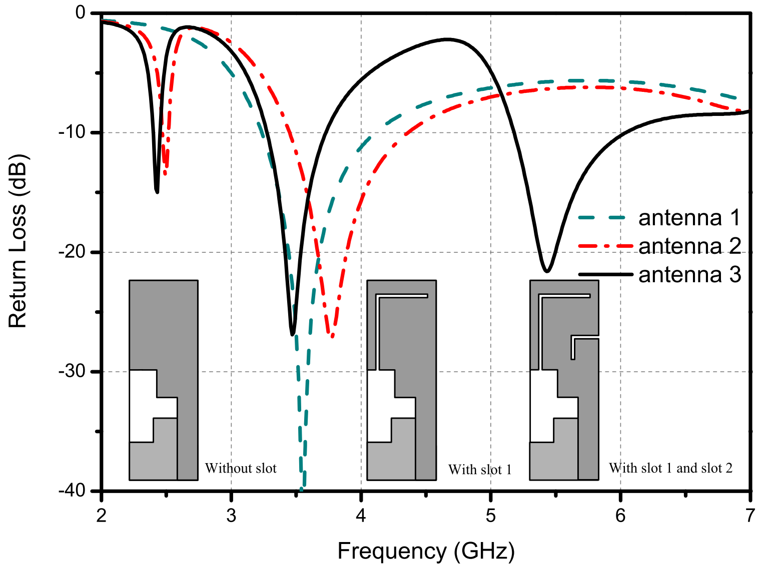

Fig. 2. Simulated return loss of the different structures.

To further study the excitation mechanism of the proposed antenna, the simulated surface current distributions at different frequencies are presented in Fig 3. From the figure, it is show that surface current density is mainly concentrated along the edge of slot 1 at 2.4 GHz, whereas for the 5.5 GHz excitation, the current distribution is observed along the edge of slot 2. For the median frequency excitation at 3.5 GHz, the current density is concentrated along both slot 1 and slot 2. It is indicated that the lower resonant mode is mainly determined by slot1 and the higher resonant mode is produced by slot 2. And both of the slot 1 and slot 2 will affect the medial resonant mode.

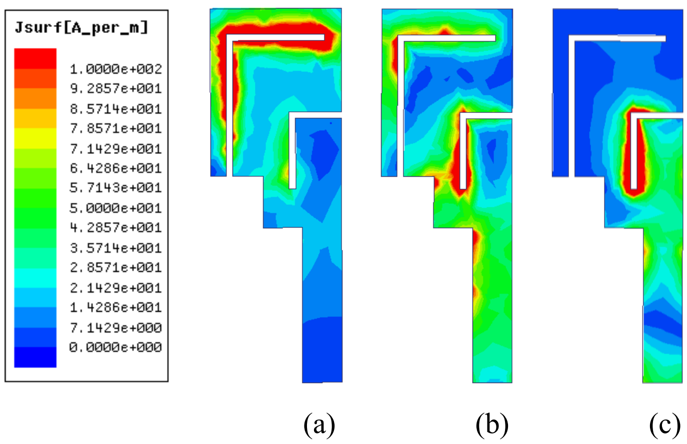

Fig. 3. Simulated surface current distribution of the proposed antenna at (a) 2.4 GHz, (b) 3.5 GHz, and (c) 5.5 GHz.

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Based on the above ideas, the final design is obtained by further optimization of dimensions. Ansoft High Frequency Structure Simulator (HFSS) is used to investigate and optimize the proposed antenna configuration. The parameters optimized of the proposed antenna are: $W = 10\,mm$, $L = 29\,mm$, $L_1 = 4\,mm$, $W_1 = 4\,mm$, $L_2 = 4\,mm$, $L_3 = 6.5\,mm$, $L_4 = 10.5\,mm$, $L_5 = 7.5\,mm$, $L_6 = 3.5\,mm$, $W_6 = 3.5\,mm$, $L_7 = 4\,mm$, $W_7 = 2\,mm$, $D_1 = 2.3\,mm$, $D_2 = 8\,mm$, $W_f = 3\,mm$, $L_f = 12\,mm$.

3 Experimental results

Based on the optimized design dimensions, a prototype of the proposed antenna is fabricated and measured. The measurement is carried out by using Agilent E8363B vector network analyzer. The simulated and measured return losses for the proposed antenna are shown in Fig 4. The measured bandwidths with 10-dB return loss are about 80 MHz (2.4–2.48 GHz), 420 MHz (3.28–3.7 GHz) and 600 MHz (5.23–5.83 GHz), which covers the 3.5/5.5 GHz WiMAX bands and 2.4/5.5/5.8 GHz WLAN bands. The measured results show good agreement with the simulated one.

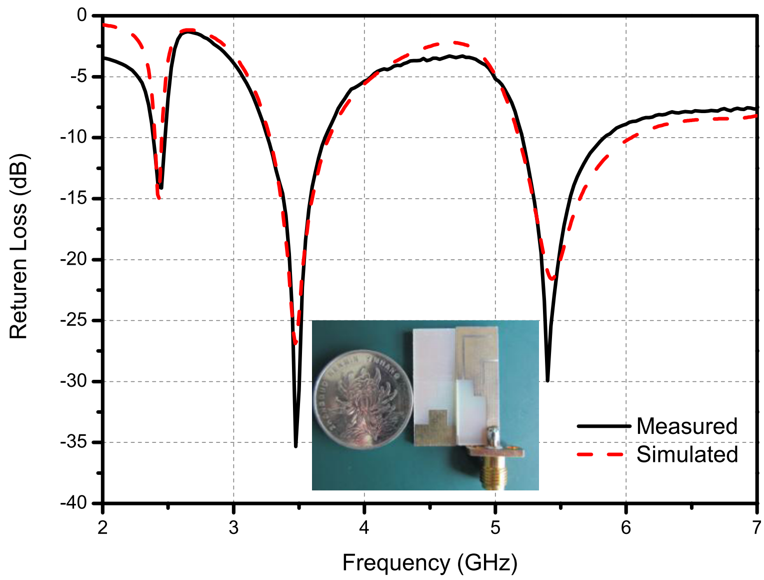

Fig. 4. Simulated and Measured return loss of the proposed antenna.

The measured far field radiation patterns in the H-plane (XZ-plane) and E-plane (YZ-plane) at 2.4, 3.5, and 5.5 GHz are shown in Fig. 5. Nearly omnidirectional radiation patterns in the H-plane and monopole-like radiation patterns in the E-plane are observed in the three operation bands. Fig. 6 indicates the measured peak gain against the frequencies for the antenna. The peak gains are about 1.85 dBi at 2.45 GHz, 1.94 dBi at 3.45 GHz, 2.35 dBi and at 5.5 GHz, respectively. It can be seen that the antenna exhibits stable gain at the working bands.

4 Conclusion

A novel compact monopole triple-band antenna has been investigated. With the embedment of two open-ended inverted L-shaped slots, the

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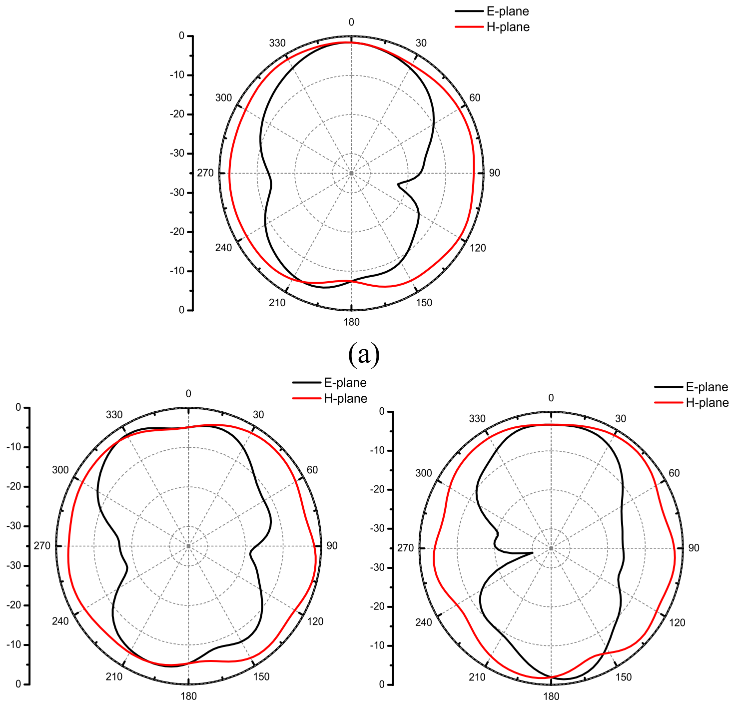

Fig. 5. Measured radiation patterns of the proposed antenna at (a) 2.4 GHz, (b) 3.5 GHz, and (c) 5.5 GHz.

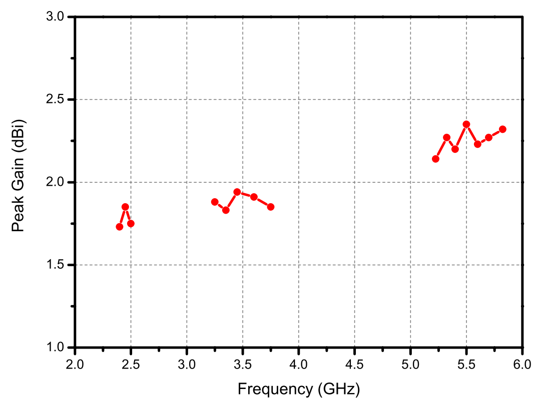

Fig. 6. Measured peak gains of the proposed antenna.

proposed antenna can provide sufficient impedance bandwidth and suitable radiation performance for WiMAX/WLAN operations, and is only 29 (L) × 10 (W) × 1.6 (H) mm^3 in overall size. Because of the good electromagnetic property and compact size, the antenna is a competitive candidate for multimode wireless communication applications.

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