

# A Compact Tri-Band Antenna for WLAN and WiMAX Applications

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**Abstract**—A compact tri-band antenna is proposed in this paper. The tri-band operation and bandwidth enhancement are achieved through the introduction of curved branches to a coplanar waveguide(CPW) fed monopole and L-shaped slots into the ground plane. Simulation results show that the lower band (2.32 - 2.58 GHz) of the proposed antenna covers the 2.4 GHz WLAN band, the middle band (3.38 - 3.81 GHz) covers the 3.5 GHz WiMAX band, and the upper band (4.39 - 6.93 GHz) covers the 5.2/5.8 GHz WLAN and 5.5 GHz WiMAX bands. Furthermore, the antenna is rather compact, with a size of only  $0.21 \times 0.28 \times 0.01 \lambda_0^3$ , where  $\lambda_0$  is the freespace wavelength at the central frequency of the lower band.

**Index Terms**—Planar monopole, tri-band antenna, WLAN antenna

## I. INTRODUCTION

The rapid evolution of modern wireless communication technologies leads to the proliferation of various communication standards, requiring commercial terminal devices to accommodate different spectrum. The demand of multi-band coverage has spurred the development of various multi-band antennas in recent years [1]-[4]. Antennas printed on single-layer substrate, among all types of multi-band antennas, offer advantages such as low cost, simple structure, and easy for integration, thus exhibiting significant potential for various wireless systems [5],[6]. However, these antennas remain limited by their relatively narrow bandwidth.

This paper proposes a compact single-layer CPW-fed antenna. Through the etching of slots and the introduction of extra branches, the proposed antenna realizes tri-band operation with an improved bandwidth, suitable for WLAN and WiMAX applications.

## II. ANTENNA DESIGN AND RESULTS

As depicted in Fig.1, the proposed tri-band antenna is designed atop an FR4 substrate with a dielectric constant of 4.4, occupying dimensions of  $25 \times 34 \times 1.6 \text{ mm}^3$ . The design includes a ground plane etched with two L-shaped slots and a monopole element featuring two curved branches.

Fig.2 depicts the evolutionary process of the antenna design. Initially, Antenna 1, a monopole antenna with an end-loaded disk, exhibits a single resonance and operates within the frequency range of 3.22 - 4.94 GHz. Antenna

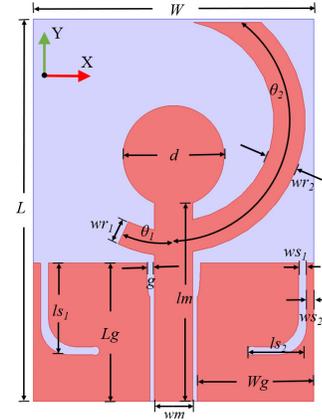


Fig. 1. Geometry of the proposed antenna [ $W = 25\text{mm}$ ,  $L = 34\text{mm}$ ,  $Lg = 12.3\text{mm}$ ,  $Wg = 10.4\text{mm}$ ,  $ls_1 = 7.8\text{mm}$ ,  $ls_2 = 4.5\text{mm}$ ,  $ws_1 = 0.7\text{mm}$ ,  $ws_2 = 0.65\text{mm}$ ,  $wm = 3.4\text{mm}$ ,  $lm = 17.6\text{mm}$ ,  $g = 0.7\text{mm}$ ,  $d = 9\text{mm}$ ,  $wr_1 = 2.2\text{mm}$ ,  $wr_2 = 2.8\text{mm}$ ,  $\theta_1 = 25\text{deg}$ ,  $\theta_2 = 150\text{deg}$ ]

2 introduces an additional resonant mode to Antenna 1 by etching two L-shaped slots on the ground plane, facilitating a current mode along the slot and enabling dual-band operation. As shown in Fig.3, the resonant frequency of the slot mode is located at 3.4 GHz, and the introduction of the slot shifts the monopole mode's resonant frequency to higher values. To achieve the tri-band operation and improve impedance matching, two unequal curved branches are added to the monopole of Antenna 2. The longer curved branch introduces two additional resonances, and the shorter curved branch effectively improves the antenna impedance matching. As shown in Fig.3, the proposed antenna exhibits four distinct resonances: the first and fourth resonances are due to the longer curved branch, the second arises from the L-shaped slot on the ground plane, and the third stems from the monopole.

As can be seen from Fig. 3, the proposed antenna operates across three frequency bands: 2.32 - 2.58 GHz, 3.38 - 3.81 GHz, and 4.39 - 6.93 GHz. Moreover, the meticulously tuned antenna features a wideband characteristic in the upper band, with a relative bandwidth reaching up to 44.9%.

Fig.4 depicts the current density distributions at four resonant frequencies. In the lower band, surface currents predominantly concentrate around the longer curved branch.

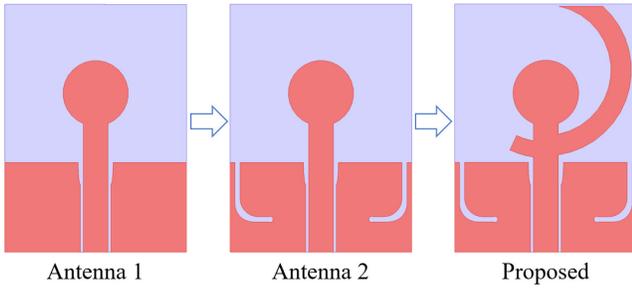


Fig. 2. Design evolution of the proposed antenna

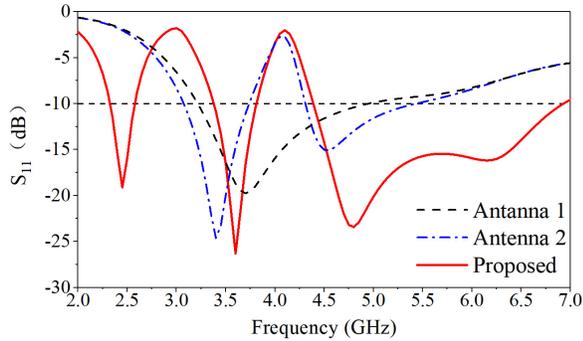


Fig. 3. Simulated  $|S_{11}|$  of various antennas involved in Fig. 2

In the middle band, currents converge near the slots etched on the ground plane. When operating at the third resonant frequency, the monopole exhibits the strongest current distribution. Additionally, at the fourth resonant point, currents are concentrated on the longer branch. However, unlike the lower frequency, the current on the curved branches is discontinuous and features a null, indicating the presence of anti-phase currents at 6.2 GHz on the curved branch and the existence of a higher-order mode operation.

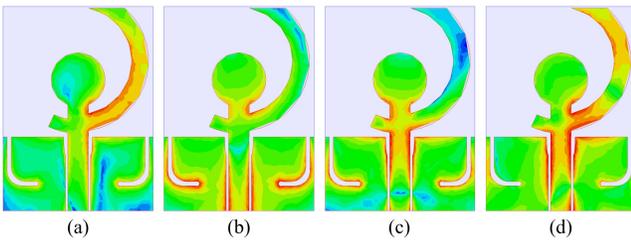


Fig. 4. Simulated surface current distributions of the proposed antenna at (a) 2.5, (b) 3.6, (c) 4.8, and (d) 6.2 GHz

The radiation patterns of the proposed antenna at the four resonant frequencies are depicted in Fig.5.

### III. CONCLUSION

This paper presents a compact CPW-fed antenna. By etching two L-shaped slots on the ground plane and incorporating curved branches on the monopole, the antenna achieves three operating frequency bands, with the third

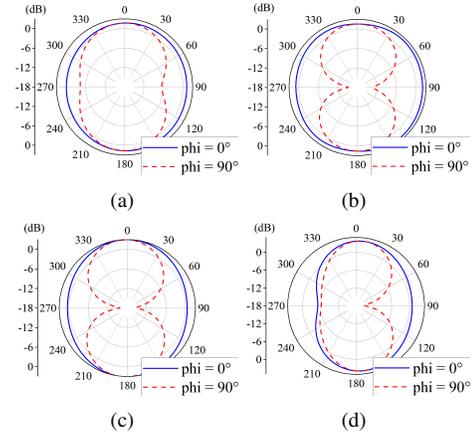


Fig. 5. Radiation patterns of the proposed antenna at (a) 2.5, (b) 3.6, (c) 4.8, and (d) 6.2 GHz.

band exhibiting a relative bandwidth of 44.9%. The antenna fully covers the 2.4/5.2/5.8 GHz WLAN bands and the 3.5/5.5 GHz WiMAX bands. Characterized by its low cost, compact structure, tri-band operation, and wide bandwidth, this antenna holds significant potential for WLAN and WiMax applications.

### ACKNOWLEDGMENT

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