Compact Size Triple-band Monopole Antenna with Parasitic Element for WLAN/WiMAX Applications

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***Abstract* – A compact size (20 × 38.5 × 0.8 mm^3) coplanar waveguide (CPW) fed monopole antenna design with triple-band operation for WLAN (Wireless Local Area Network) and WiMAX (Worldwide Interoperability for Microwave Access) applications is proposed. The monopole design is a modified symmetrical U-shaped printed structure, and a parasitic element is attached behind this printed monopole. Good impedance matching is attained by loading two dissimilar notches separately into the two CPW ground planes. From the measured results, the 10-dB impedance bandwidths of the three operating bands (f_L, f_M, and f_H) are 17.6% (2.105–2.495 GHz), 28.7% (3.22–4.30 GHz), and 23.3% (4.895–6.125 GHz), respectively. Furthermore, the three operating bands have also yielded peak gain and radiation efficiency of more than 2.7 dBi and 65%.**

***Index Terms* — Monopole antenna, triple-band, WLAN, WiMAX, compact size, parasitic element.**

I. Introduction

The recent development of printed monopole antenna designs with triple-band operation for WLAN (2.4-2.483, 5.15-5.35, and 5.725-5.85 GHz) and WiMAX (2.5-2.69, 3.3-3.8, and 5.25-5.85 GHz) applications can be categorized into two main design types [1]-[4]. The first type is to load (or extend) multiple branch strips into the monopole antenna so that multiple quarter-wavelength resonant modes can be excited [1], [2]. The second type is to initially design a wideband antenna type, follow by introducing two band notches (rejection bands) into this wideband operation, so that triple operating bands can be yielded [3], [4]. Interestingly, the combination of these two techniques (branch strip and band notch) is also reported in [5], so that good triple-band operation can be attained for WLAN/WiMAX applications. Notably, such CPW-fed antenna design has exhibited a small size of 23 × 36.5 × 0.8 mm^3 [5], which is also smaller than those reported in [1]-[4].

In this investigation, a monopole antenna with triple-band operation for WLAN/WiMAX applications is proposed. To achieve size reduction to 20 × 38.5 × 0.8 mm^3, the technique of loading an additional parasitic element behind the monopole structure is introduced [6]. In this case, instead of improving the impedance matching of the proposed antenna [6], this parasitic element is used to induce an additional resonant mode at 3.38 GHz. Detail design of the proposed antenna will be discussed, and typical measurement results are also presented.

II. Antenna Design

The geometry of the proposed monopole antenna with total dimension of 20 × 38.5 × 0.8 mm^3 is shown in Fig. 1. The proposed antenna is printed on a thin 0.8 mm FR4 substrate. The modified symmetrical monopole structure is composed of two inverted L-shaped strips connected separately to the two open-ends of the U-shaped structure. To achieve impedance matching, two notches (notch 1 and notch 2) of dissimilar sizes are loaded separately into the two CPW ground planes. As for the symmetrical parasitic element loaded behind the monopole, it is comprised of a tapered structure and two C-shaped strips.

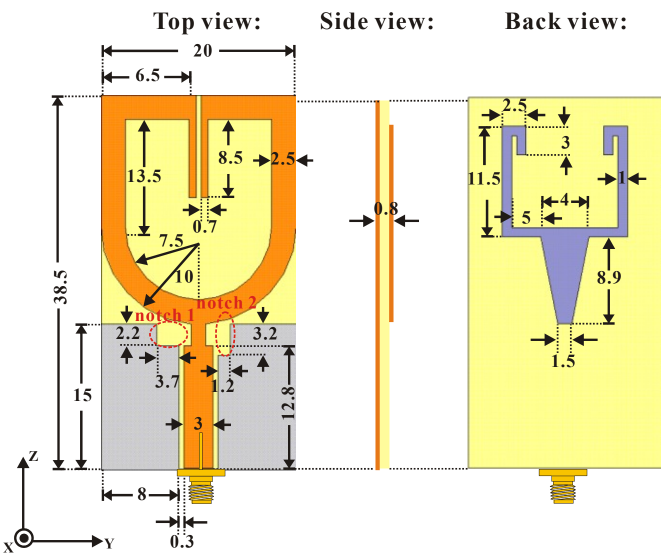

Fig. 1. Geometry of proposed antenna.

III. Results and Discussions

The simulated and measured return losses of the proposed antenna are shown in Fig. 2, and the two results validated well with each other. In this figure, four resonant modes were measured at 2.37 GHz (f_1), 3.38 GHz (f_2), 4.05 GHz (f_3), and 5.19 GHz (f_4). Here, the lower f_L and upper f_H operating frequencies are dependent on f_1 and f_4, respectively, while the middle operating frequency f_M is due to the combination of f_2 and f_3. The 10-dB impedance bandwidths of the three operating bands (f_L, f_M, and f_H) are 17.6% (2.105–2.495 GHz), 28.7% (3.22–4.30 GHz), and 23.3% (4.895–6.125 GHz), respectively.

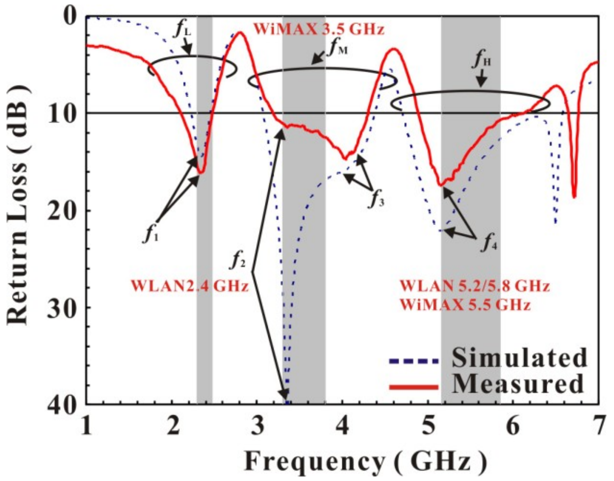

Fig. 2. Simulated and measured return losses of proposed antenna.

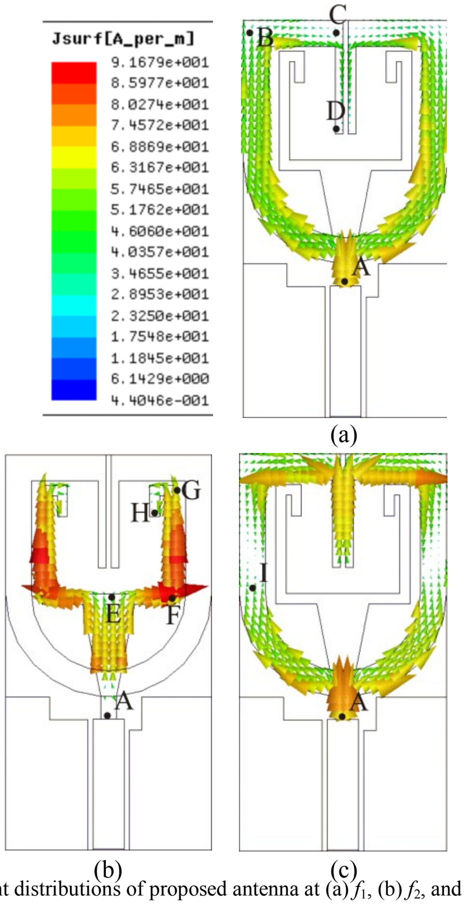

Fig. 3. Current distributions of proposed antenna at (a) f_1, (b) f_2, and (c) f_4. .

To further comprehend how the proposed antenna can excite multiple resonant modes, its corresponding simulated current distribution diagrams for f_1, f_2 and f_4 are presented in Fig. 3. For brevity, the current distribution diagram for f_3 is not shown in here. In this figure, it is obvious that f_1 and f_4 are excited via the modified U-shaped monopole structure (so does f_3) along the 1/4 wavelength distribution paths ABCD and AI, respectively. As for f_2, its corresponding distribution path AEFGH is mainly concentrated along the parasitic structure.

Fig. 3 shows the measured peak gain and radiation efficiency of the proposed antenna. In this figure, the WLAN 2.4 GHz operating band has exhibited a small gain and efficiency variation of 2.7–3.2 dBi and 70%–75%, respectively. As for the WiMAX 3.5 GHz operating band, slight increment in gain and efficiency of 3.1–3.5 dBi and 65%–73% were observed, respectively. Similar trend were also observed for the WLAN 5.2/5.8 GHz and WiMAX 5.5 GHz operating bands, in which a stable increment in gain and efficiency of 2.8–3.3 dBi and 77%–84% were measured.

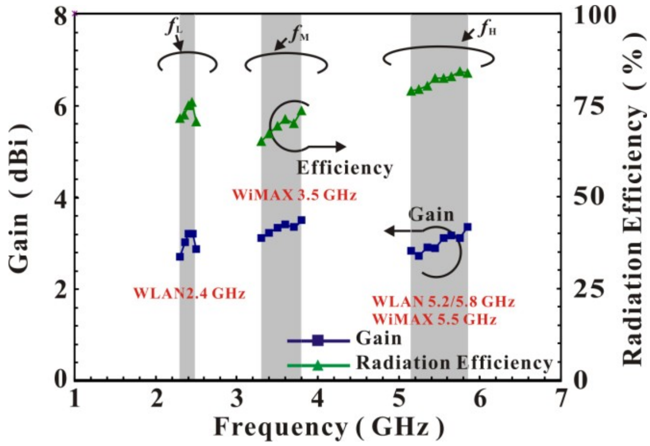

Fig. 3. Measured peak gain and radiation efficiency of proposed antenna.

IV. Conclusion

A small size CPW-fed monopole antenna with a modified U-shaped structure was successfully investigated. To allow the antenna to cover the entire WLAN/WIMAX operating bands, the technique of loading a symmetrical parasitic element behind the monopole and loading two notches into the CPW grounds were introduced to excite triple-band characteristics.

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