Small Size Uniplanar Monopole Antenna with Triple-band Operation

Chow-Yen-Desmond Sim, Chih-Husan Yeh, and Bo-Yu Chen
Department of Electrical Engineering, Feng Chia University, No. 100, Wenwha Rd., Seatwen, Taichung 40724, Taiwan

Abstract — A small size (15 × 35 × 0.8 mm²) 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 basic structure of this proposed design is a simple uniplanar C-shaped monopole loaded with two additional branch strips. From the measured results, the 10-dB impedance bandwidths of the three operating bands (f₁, f₃, and f₅) are 23.17% (2.175–2.745 GHz), 15.04% (3.32–3.86 GHz), and 37.91% (4.895–7.185 GHz), respectively. Furthermore, the three operating bands have also yielded peak gain and radiation efficiency of more than 0.69 dBi and 65%.

Index Terms — Uniplanar monopole antenna, triple-band, WLAN, WiMAX, small size.

I. INTRODUCTION

In recent years, two common design methods are introduced for the design of printed monopole antenna with triple-band operation that can cover both the 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) operating bands [1]-[4]. The first design method requires the loading of multiple branch strips into a monopole antenna so that multiple quarter-wavelength resonant modes can be excited [1], [2]. Therefore, such design method usually allows the antenna size to be compact, in which the antenna size of [1] and [2] are 10 × 52 × 1 mm³ and 17.5 × 40 × 0.8 mm³, respectively. The second design method is to introduce two rejection bands (or band notches) into a wideband antenna type, so that triple operating bands can be yielded [3], [4]. However, the overall size of [3] and [4] that used this second design method are 40 × 40 × 0.8 mm³ and 30 × 35 × 0.8 mm³, respectively, and in comparison with the two reported antennas [1], [2], that used the first design method, the latter method requires larger antenna size. Although the integration of these two design methods (branch strip and rejection band) can also achieve good triple-band operation for WLAN/WiMAX applications [5], however, such antenna design with an overall size of 23 × 36.5 × 0.8 mm³ is still larger than that of [1] and [2].

In this study, a CPW-fed uniplanar monopole antenna with triple-band operation for WLAN/WiMAX applications is proposed. To achieve size reduction to 15 × 35 × 0.8 mm³, a dual-band C-shaped monopole antenna type design is initially applied [6]. By further introducing two additional branch strips into this uniplanar C-shaped monopole, two additional quarter wavelength resonant modes are thus excited, and via the integration of the two lower resonant modes (f₁ and f₃) and the two upper resonant modes (f₂ and f₅), a triple operating bands (f₁, f₃, and f₅) monopole antenna is therefore achieved. Detail design of this monopole antenna will be discussed, and typical measurement results are also presented.

II. ANTENNA DESIGN

The geometry of the proposed uniplanar monopole antenna with planar dimension of 15 × 35 mm² is shown in Fig. 1, and it is printed on a thin 0.8 mm FR4 substrate. The main monopole structure is composed of a C-shaped structure with two open-ends of vertical length L₃ = 4.7 mm and L₄ = 8.2 mm. Here, a vertical branch strip of length L₂ = 13.7 mm is extended from the bottom section of the C-shaped monopole, and an L-shaped branch strip of length L₃ = 21 mm is extended from the right side of the C-shaped monopole. To achieve good impedance matching, the monopole antenna is located 2.8 mm above the CPW-ground.

Fig. 1. Geometry of proposed antenna. Unit: mm.
III. RESULTS AND DISCUSSIONS

The simulated and measured return losses of the proposed monopole antenna are shown in Fig. 2. The two results agreed well with each other. In this figure, five resonant modes were measured at 2.35 GHz ($f_1$), 2.63 GHz ($f_2$), 3.58 GHz ($f_3$), 5.36 GHz ($f_4$), and 6.55 GHz ($f_5$). Here, the lower operating frequency $f_1$ is dependent on the combination of $f_1$ and $f_2$, while the upper wide operating frequency $f_5$ is due to the integration between $f_4$ and $f_5$. Notably, the middle operating frequency $f_3$ is solely due to $f_3$. The measured 10-dB impedance bandwidths of the three operating bands ($f_1$, $f_3$, and $f_5$) were 23.17% (2.175–2.745 GHz), 15.04% (3.32–3.86 GHz), and 37.91% (4.895–7.185 GHz), respectively.

![Fig. 2. Simulated and measured return losses of proposed antenna.](image)

The corresponding simulated current distribution diagrams from $f_1$ to $f_5$ are presented in Fig. 3. Here, it is obvious that $f_1$ and $f_4$ are excited via the C-shaped structure, showing a 1/4 $\lambda_0$ distribution path along ABCD and AH1, respectively. As expected, both $f_2$ and $f_5$ are induced by the two additional branch strips, and their corresponding $1/4$ $\lambda_0$ distribution paths are along EF and AG, respectively. Lastly, the excitation of $f_3$ is mainly due to the 1/2 $\lambda_0$ distribution path JBCD along the upper section of the C-shaped structure.

Fig. 4 shows the measured peak gain and radiation efficiency of the proposed antenna. In this figure, the WLAN 2.4 GHz/WiMAX 2.5 GHz operating bands have exhibited a small gain and efficiency variation of 0.69–1.81 dBi and 65%–82%, respectively. As for the WiMAX 3.5 GHz operating band, slight increment in gain and efficiency of 0.92–2.19 dBi and 65%–88% were observed, respectively. Lastly, the WLAN 5.2/5.8 GHz and WiMAX 5.5 GHz operating bands have demonstrated a variation in gain of 3.5–4.59 dBi and efficiency of more than 85%.

![Fig. 4. Measured peak gain and radiation efficiency of proposed antenna.](image)

IV. CONCLUSION

A CPW-fed monopole antenna was successfully investigated. Here, the technique of loading two additional branch strips into a C-shaped monopole was introduced to excite five resonant modes, so that triple-band characteristics can be achieved to cover the entire WLAN/WiMAX operating bands. In comparison, the overall size of the proposed antenna was smaller than the reference ones.

REFERENCES