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A Triple-band Monopole Antenna for WLAN and WiMAX Applications

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Abstract—In this paper, a triple-band monopole antenna for WLAN and WiMAX wireless communication applications is presented. The antenna has a simple structure designed for 2.4/5.2/5.8 GHz WLAN and 3.5/5.5 GHz WiMAX bands. The radiator is composed of just two branches and a short stub. The antenna is designed on a 40 × 40 × 0.8 mm³ substrate using computer simulation. For verification of simulation results, a prototype is fabricated and measured. Results show that the antenna can provide three impedance bandwidths, 2.35-2.58 GHz, 3.25-4 GHz and 4.95-5.9 GHz, for the WLAN and WiMAX applications. The simulated and measured radiation patterns, efficiencies and gains of the antenna are all presented.

I. INTRODUCTION

In modern wireless communication systems, multiband antennas for multiple communication standards have gained increasing interests. However, using a single compact antenna to provide multiple-band operations presents a considerable challenge. In literature, different techniques have been proposed for the designs of multiple-band antennas. In [1, 2], multiple-mode operations were obtained by modifying the radiators to form several multiple-current paths. In [3-5], approaches of using parasitic elements in the antennas to generate multiple resonances were reported. For the slot antennas reported in [6, 7], multi-band resonances were generated by adding stubs to the slots to excite other modes.

In this paper, the design of a monopole antenna operating at 2.4, 3.5, 5.2 and 5.8 GHz bands is presented. In the design, two branches are used to operate as quarter-wavelength structures at 2.4 and 3.5 GHz, and a short stub attached to the one of the branches excites an operating mode at around 5.5 GHz, covering the 5.2 and 5.8 GHz bands. The operating frequency bands of the antenna can be easily controlled by the lengths of the two branches and the short stub. The measured results show that the antenna has a good multiband characteristic to cover the 2.4/5.2/5.8 GHz WLAN and 3.5/5.5 GHz WiMAX bands.

II. ANTENNA DESIGN

Figure 1 shows the geometry of the proposed antenna, which is designed on a 40 (W) × 40 (L) mm² substrate with a thickness of 0.8 mm, a relative permittivity of 3.5 and a loss tangent of 0.02. The radiator of the antenna is composed of three elements, two branches and a short stub. In Fig. 1, the branches on the left and right have the lengths of \( L_4 + L_5 + W_4 + L_7 + W_7 \) and \( L_1 + L_2 + L_3 \) to generate the 2.4- and 3.5-GHz bands, respectively. The short stub with a length of \( L_6 \) attached to the branch on the left is used to excite a resonance at around 5.5 GHz to cover both the 5.2- and 5.8-GHz bands. These three lengths can be adjusted to control these frequency bands. The two branches are bent to make the antenna more compact. A 50-Ω microstrip line with a width of \( W_f \) is adopted for feeding the antenna. The antenna is optimized using the commercial EM simulation tool CST. The optimized parameters are: \( W = 40 \text{ mm} \), \( L = 40 \text{ mm} \), \( L_4 = 20 \text{ mm} \), \( g = 0.9 \text{ mm} \), \( L_1 = 13 \text{ mm} \), \( L_2 = 4 \text{ mm} \), \( L_3 = 5 \text{ mm} \), \( L_4 = 0.5 \text{ mm} \), \( L_5 = 6 \text{ mm} \), \( L_6 = 5 \text{ mm} \), \( L_7 = 11.7 \text{ mm} \), \( L_8 = 9 \text{ mm} \), \( W_1 = 3 \text{ mm} \), \( W_2 = 3.1 \text{ mm} \), \( W_3 = 1 \text{ mm} \), \( W_4 = 1.3 \text{ mm} \), \( W_5 = 1 \text{ mm} \) and \( W_6 = 1.5 \text{ mm} \).

III. SIMULATED AND MEASURED RESULTS

Based on the optimized parameters, a prototype of the antenna shown in Fig. 1 is fabricated and then measured using the antenna measurement equipment, Satimo Starlab. The simulated and measured S11 in Fig. 2 show a good agreement. The measured result exhibits three 10-dB impedance bandwidths of 230 MHz (2.35-2.58 GHz), 750 MHz (3.25-4 GHz) and 4.95-5.9 GHz, for the WLAN and WiMAX applications. The simulated and measured radiation patterns, efficiencies and gains of the antenna are all presented.
GHz) and 950 MHz (4.95-5.9 GHz), which can cover the frequency bands of 2.4-2.484 GHz, 5.15-5.35 GHz and 5.725-5.825 GHz for the WLAN standards, and of 3.3-3.6 GHz and 5.25-5.85 GHz for the WiMAX standards.

The radiation patterns in the x-y and x-z planes at 2.44, 3.5, 5.2 and 5.8 GHz shown in Figs. 3(a), 3(b), 3(c) and 3(d), respectively, demonstrate good performances. Figure 4 shows the simulated and measured results on radiation efficiency and peak gain of the antenna. The discrepancies between the measured and simulated results at lower frequencies are due to the effects of the measuring cable using in the antenna measurement system, as described in [8]. At the frequencies of 2.44, 3.5, 5.2 and 5.8 GHz, measured efficiency are 57%, 69%, 90% and 87% and the measured gains are -0.3, 0.9, 3.4 and 3.8 dBi, respectively.

The radiation patterns in the x-y and x-z planes at (a) 2.44, (b) 3.5, (c) 5.2 and (d) 5.8 GHz.

![Simulated and measured radiation patterns in x-y and x-z planes](image)

Fig. 3. Simulated and measured radiation patterns in x-y and x-z planes at (a) 2.44, (b) 3.5, (c) 5.2 and (d) 5.8 GHz.

Fig. 4. (a) Efficiencies and (b) peak gains

IV. CONCLUSIONS

The design of a triple-band antenna with microstrip-fed has been presented. Results have shown that the antenna can cover the WLAN (2.4/5.2/5.8 GHz) and WiMAX (3.5/5.5 GHz) frequency bands. The operating bands can be easily controlled by using the lengths of the two branches and the short stub in the antenna. The simple structure and good radiation performance of the antenna make it a very promising candidate for WLAN and WiMAX applications.

REFERENCES