A Triple-band Monopole Antenna with Parasitic Elements for WLAN and WiMAX Application

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***Abstract* - In this paper, the simulation and measured results of a triple-band monopole antenna with parasitic elements for application in WLAN and WiMAX bands are presented. The triple-band monopole antenna with parasitic elements is fabricated on a FR4 substrate. The lower band is associated with the parasitic inverted-C shaped strip in the back side, the middle band is expected to be controlled by the length of monopole in the front side, while the higher band is associated with the two shorted parasitic strips in the ground. The proposed antenna has good agreement between the measured and the simulation results. The proposed antenna has a 10 dB return loss with bandwidth 150 MHz (2,370-2,520 MHz) in the lower band, 910 MHz (3,130-4,040 MHz) in the middle band, and 1,040 MHz (5,020-6,060 MHz) in the higher band. The proposed triple-band monopole antenna with parasitic elements covered the ISM, HIPERLAN, UNII, and WiMAX bands.**

***Index Terms* —inverted-E monopole, bandwidth, radiation, gain.**

I. INTRODUCTION

Many commercial applications, including mobile radio and wireless communications, use monopole. The monopole is used extensively because it is reasonably compact, good efficiency, and very simple [1]. Recently, multiband monopole antennas for application in WLAN (wireless local area network, 2.4-2.484 GHz), ISM (Industrial, Scientific, Medical) and Bluetooth at low band, HIPERLAN (high-performance radio local area network, 5.15-5.35 GHz) and UNII (Unlicensed National Information Infrastructure, 5.725-5.825 GHz) applied in the high band are implemented. Simultaneously, associating with the rapid development of WiMAX (worldwide interoperability for microwave access, 3.4-3.6 and 5.25-5.85 GHz), there is an increasing demand for antennas suitable for WLAN/WiMAX simultaneously. Multiband monopoles are realized by employing parasitic or shorted elements to the monopole [2-4]. Via holes are employed to connect the parasitic or shorted element on the front side to the ground plane on the back side of the substrate. However, this has increased the manufacturing cost and difficulty in fabricating.

In this paper, a triple-band monopole antenna with parasitic elements operated in ISM, HIPERLAN, UNII, and WiMAX bands, simultaneously, is proposed. The proposed antenna is simple in manufacturing because of single dielectric substrate, single metal layer, and without via holes. The proposed antenna is capable of operating in the ISM, HIPERLAN, UNII, and WiMAX bands. The design considerations and experimental results for the proposed antenna are presented and discussed.

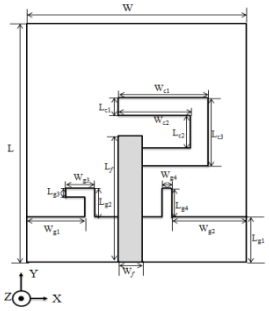

Fig. 1. The geometry of proposed triple-band monopole antenna

II. ANTENNA DESIGN

The geometry and parameters of a triple-band monopole with parasitic elements are shown in Fig. 1. The a triple-band monopole with parasitic elements is realized on a RF4 substrate of 1.6 mm in thickness, 4.4 in relative permittivity, and 0.024 in loss factor. A 50 ohm microstrip feedline is used to feed the triple-band monopole with parasitic elements. The proposed triple-band monopole with parasitic elements, which comprise a monopole in the front side, an inverted-C shaped radiating element in the back side, and two shorted radiating strips. The longer inverted-C shaped radiating element controls the lower band of the proposed antenna, the middle band is expected to be controlled by the length of monopole in the front side, while the two shorted strips together generate a wide operating band for the upper band. The effects of parameters on the resonant frequency are studied to understand the behavior of the triple-band monopole with parasitic elements. Fig. 2 (a), (b), (c,) and (d) show the simulation return losses of the triple-band monopole with parasitic elements with different lengths of W_{c1}, L_f, W_{g3}, and L_{g4}, respectively. The first resonant frequency in the lower band decreases from 2.74 to 2.24 GHz as the W_{c1} increases from 15.5 to 19.5 mm. The longer the W_{c1} enables the lower the first resonant frequency. The second resonant frequency in the middle band decreases from 3.82 to 3.21 GHz as L_f increases from and the forth resonant frequency decreases from 6.56 to 4.67 GHz as L_{g4} increases from 3.95 to 7.95 mm. However, the optimal parameters of triple-band mm,

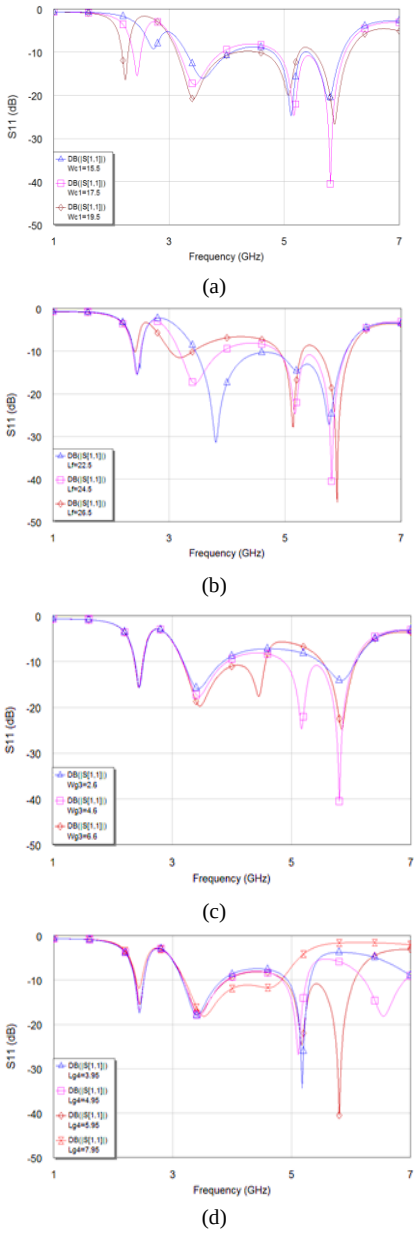

Fig. 2. The simulation return loss of the triple-band monopole with different lengths of (a) W_{c1} (b) L_f (c) W_{g3} (d)L_{g4}

W_f = 2.80 mm, L_{g1} = 10.50 mm, L_{g2} = 4.00 mm, L_{g3} =0.50 mm, L_{g4} = 5.95 mm,W_{g1} = 11.90 mm, W_{g2} = 13.00 mm, W_{g3} = 4.60 mm, W_{g4} = 0.70 mm, L_{c1}= 3.00 mm, L_{c2}= 5.00 mm, L_{c3}= 11.00 mm, W_{c1} = 17.50 mm, and W_{c2} = 15.10 mm.

III. Results

Fig. 3 shows the measured and simulation return loss of the proposed antenna. The measured resonant frequencies are 2.46, 3.46, 5.43, and 5.79 GHz. The measured resonant frequencies are close to the simulation resonant frequencies. The measured return losses are 14.2, 21.9, 20.0, and 13.4 dB at 2.46, 3.46, 5.43, and 5.79 GHz, respectively. Furthermore,

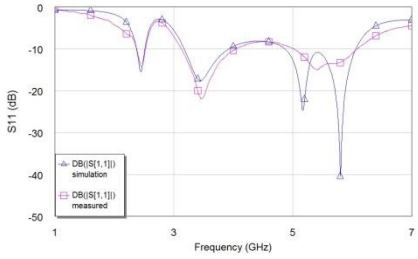

Fig. 3. The measured and simulation return loss of the proposed antenna.

there is a 10 dB return loss bandwidth of 150 MHz (2,370-2,520 MHz) in the lower band, 910 MHz (3,130-4,040 MHz) in the middle band, and 1,040 MHz (5,020-6,060 MHz) in the higher band. The bandwidth of the proposed antenna is sufficient for the ISM band from 2.40 to 2.484 GHz. It is also sufficient for the HIPERLAN, UNII, and WiMAX bands from 3.4 to 3.6 and from 5.15 to 5.85 GHz. The radiation patterns are similar to that of a monopole. The peak gains are about -1.8, -1.0, and 5.1 dBi in the lower, middle, and higher bands, respectively. The gain variations are 1.1, 1.0, and 6.6 dBi for frequencies within the lower, middle, and higher bands, respectively.

IV. Conclusions

A triple-band monopole antenna with parasitic elements for application in WLAN and WiMAX bands is successfully realized. The monopole is demonstrated to have smaller size compared with literatures. The structure of the proposed antenna is simple and easily manufactured. The proposed antenna has a 10 dB return loss with bandwidth 150, 910, and 1,040 MHz in the lower, middle, and higher bands, respectively. The 10 dB S_{11} bandwidth of the proposed antenna covered ISM, UNII, HIPERLAN, and WiMAX bands.

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