A Compact Triple-band Monopole Antenna for WLAN/WIMAX Application

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***Abstract*-A compact triple-band monopole antenna is proposed to cover the frequency band for WLAN/WIMAX application in this paper. The triple-band monopole antenna proposed in this letter has the advantage of compact size and relatively wide bandwidth. The proposed antenna consists of a modified E- shaped radiation patch and slotted ground plane. It has a compact size of only 15×30×1.2 mm^3. The compactness of the triple-band antenna is achieved by adding slots on the ground plane. The triple-band antenna has three operation bands, ranging from 2.4 GHz to 2.493 GHz, 3.01 GHz to 3.84 GHz and 4.89 GHz to 6 GHz, which can apply for 2.4/5.2/5.8 GHz WLAN bands (2.4-2.484 GHz, 5.15-5.35 Hz, and 5.725-5.825 GHz) and 3.5/5.5 GHz WIMAX (3.3-3.79 GHz and 5.25-5.85 GHz) band. The operating mechanism and the effect for parameters on the antenna performance are studied. Experimental results show that the antenna gives omnidirectional radiation patterns and good antenna gains in the operating bands.**

I. INTRODUCTIN

Wireless communication systems have experienced enormous growth over the last decade. Wireless local area network (WLAN) and the Worldwide Interoperability for Microwave Access (WiMAX) technology have extensively been used in commercial, medical, and industrial applications. The WLAN has a lower frequency band 2.4–2.484 GHz for the 802.11b/g standards, and two higher frequency bands 5.15–5.35 GHz and 5.725–5.825 GHz for the 802.11a standard. The WIMAX has a lower frequency band 3.3-3.79 GHz and a higher frequency band 5.25-5.85 GHz for the 802.16 standard. The multiband antenna must have simple structure, small size, light weight, low cost, and easily integrated with RF circuits. So far, numerous antennas have been proposed to reduce size, enhance bandwidth for WLAN application [1-14]. Different shapes of monopole antenna used to apply for WLAN application, such as G-shaped, F-shaped, 9-shaped, T-shaped and L-shaped [10]–[13]. However, the sizes of most antennas are large. For WLAN and WIMAX application, the smaller size of antenna for 2.4/3.5/5.2/5.8 GHz wireless applications is 22 × 29 mm^2 [14], which is still larger than our proposed antenna of only size 15×30 mm^2.

In this paper, a compact dual-band monopole antenna is proposed to cover the frequency band for 2.4/3.5/5/2/5.8 GHz for WLAN and WIMAX application. The designed antenna has wider bandwidth for WIMAX application compared to antenna [6]. In the mean time, it has a compact size of 15×30×2 mm^3, which is smaller than the antenna [14]. The triple-band antenna has three operation bands, ranging from 2.40 GHz to 2.493 GHz, 3.01 GHz to 3.84GHz and 4.89 GHz to 6 GHz which can apply for 2.4/5.2/5.8 GHz WLAN bands (2.4-2.484 GHz, 5.15-5.35 GHz, and 5.725-5.825 GHz) and 3.5/5.5 GHz WIMAX (3.3-3.79 GHz and 5.25-5.85GHz) band. The operating mechanism and the effect for parameters on the antenna performance are studied. The triple-band antenna is fabricated and experimental results are presented. Experimental results show that the antenna gives omnidirectional radiation patterns and good antenna gains over the operating bands. The design of antenna and operating mechanism are shown in Section II. Experimental results are shown in Section III. The conclusion is in Section IV.

Fig.1 Geometry of the p

II. ANTENNA DESIGN

A. Antenna Configuration

The geometry of the proposed antenna is shown in Fig. 1 and the parameters are given in Table I. The antenna is constructed on the FR-4 substrate with dielectric constant of 4.4, loss tangent 0.02, thickness of 1.2 mm. The antenna has a compact size of 15×30 mm^2. The antenna consists of a modified E-shaped radiation patch on the top side of the substrate and slots on the ground plane. The point A is used to excite the resonant modes at 5.55 GHz, and the point B and the point C on the slotted ground excite the resonant modes for 3.3 GHz and 2.45 GHz, respectively.

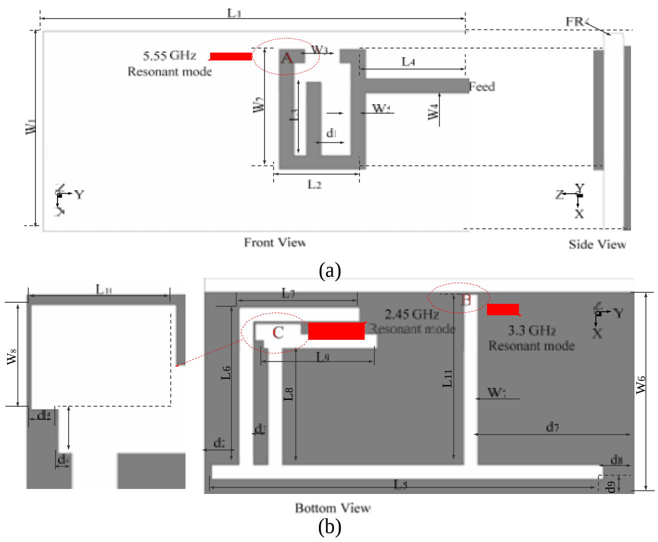

Fig.1 Geometry of the proposed antenna (a) Front view and Side View (b) Bottom View

TABLE I

PARAMETERS OF THE PROPOSED ANTENNA (UNITS: MM)

W_1	L_1	W_2	L_2	W_3	L_3	d_1
15	30	9	6	2.5	5.5	2.1
W_4	L_4	W_5	d_2	d_3	d_4	d_5
1.2	7.5	1	2.4	1	0.3	0.6
d_6	d_7	d_8	d_9	W_6	W_7	W_8
0.4	11	2.3	1.1	14	1	1.2
L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}
27.2	10.9	8.4	8.1	7.9	3.2	11.8

B. *Current Distribution analysis of the antenna*

To further examining the mechanism of the proposed antenna, the surface current distributions on both the radiator and the ground is studied. Fig. 2 shows the current distributions for the three resonant frequencies at 5.55, 3.3, and 2.45 GHz. At 5.55 GHz, the current is mainly distributed along the point A of modified E-shaped patch, as is shown in Fig.2 (a). At 3.3 GHz, the current is mainly distributed along the point B of slot L_{11}, as is shown in Fig. 2 (b). At 2.45 GHz, the current was mainly distributed along the point A of slots L_9 and L_{10}, as is shown in Fig. 2 (b).

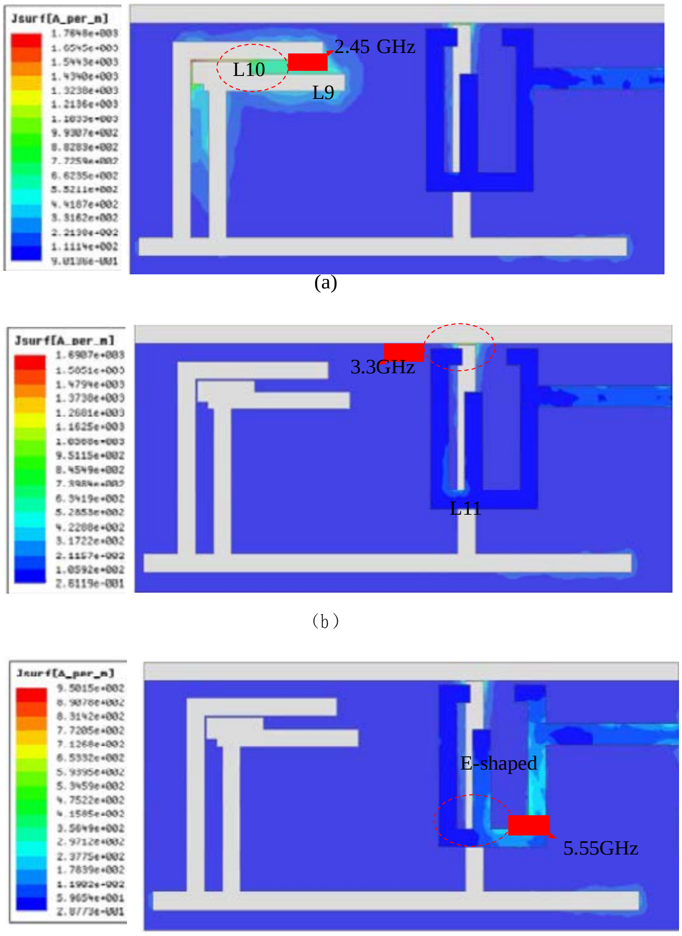

Fig.2 Simulated current distribution at (a) 2.45 GHz (b) 3.3 GHz (c) 5.55 GHz.

C. *Simulated and measured Reflection Coefficient*

The compact triple-band monopole antenna for WLAN / WI-MAX application is simulated by High-Frequency System Simulation software. The prototype of the proposed antenna is fabricated and measured. Fig. 3 is the prototype of the antenna. The simulated and measured S11 for the antenna is shown in Fig. 4.The S11 of the compact antenna is measured by using an Advantest R3770 network analyzer. It is observed that the proposed triple-band antenna has three operation bands, ranging from 2.4 GHz to 2.493 GHz, 3.01 GHz to 3.84 GHz and 4.89 GHz to 6 GHz. The discrepancy between the measured and simulated results is due to fabrication and measurement deviation.

D. *Parametric Analysis*

The parameter effects on the impedance are shown in Fig.5 (a)-(c). First, for modified E-shaped patch, the influence of L_3 is shown in Fig. 5 (a). L_3 for E-shaped patch only affects the higher frequency at 5.55 GHz. The resonant mode moves towards lower frequency with the increasing of L_3. Second, for the slots, Fig. 5 (b) presents the effect for the slot L_9.The lower frequency at 2.45 GHz moves down with L_9 increasing, but the resonant modes at higher frequency don't change. Third, the influence for the slot L_{11} is also observed in Fig. 5 (c). With L_{11} decreasing, the band of the higher frequency 3.3 GHz and 5.55GHz go narrower. It is observed that the resonant mode at 2.45GHz is affected by slot L_9, the resonant mode at 3.3 GHz is affected by slots L_5 and L_{11}, and the resonant mode at 5.55GHz is affected by the branch L_3 of the modified E-shaped patch and slots L_5, L_9, and L_{11}.

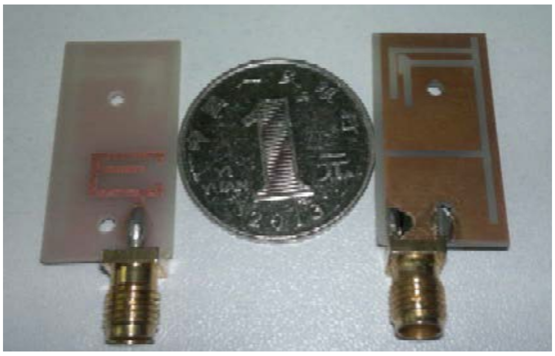

Fig.3 The fabricated antenna.

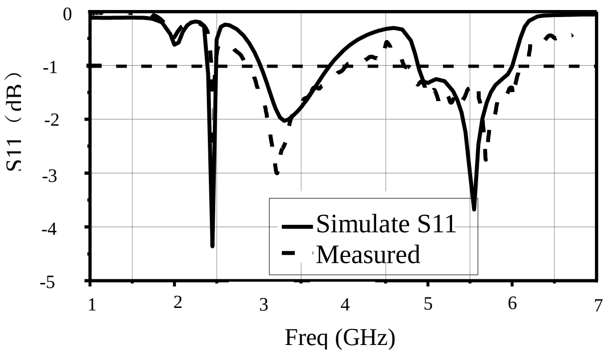

Fig.4 Simulated and measured S11 of the proposed antenna

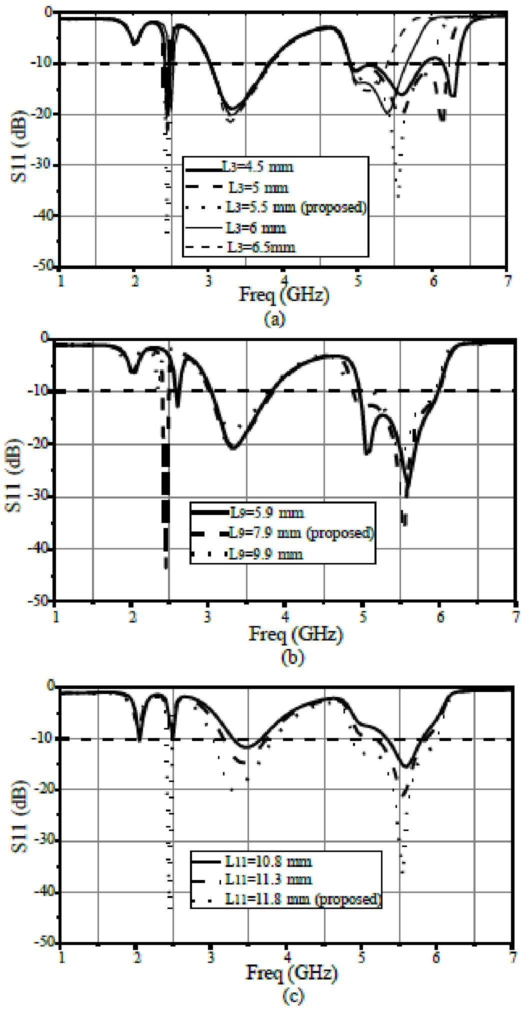

Fig.5 Parameters studies of the antenna (a) L_3 (b) L_9 (c) L_{11}

III. Experimental Results

The radiation characteristics such as radiation pattern and peak gain across the three operating bands for the proposed antenna have been measured. The simulated and measured radiation patterns including the vertical (E_θ) and horizontal (E_ψ) polarization in the x-z plane and y-z plane for the antenna at the three resonant modes of 2.45, 3.3, and 5.55 GHz are shown in Fig. 6 (a)–(c), respectively. First, the radition patterns are nearly omnidirectional in the x-z plane which is similar to monopole-like radiation pattern and nearly dumbbell in the y-z plane. The radiation patterns are quite stable throughout the WLAN and WiMAX bands. Second, the average peak gain for the triple band at 2.45, 3.3, and 5.55 GHz are about -8.45, 1.83, and 1.12 dBi, and the average radiation efficiency of the compact dual-band monopole antenna is almost 85%. Considering the small size of the antenna, the efficiency and gain values are acceptable.

IV. Conclusion

A compact triple-band monopole antenna for WLAN/ WIMAX application is proposed, analyzed and measured. The triple-band monopole antenna proposed in this letter has the advantage of compact size $15\times30\times1.2$ mm^3 and relatively wide bandwidth. The compactness of the triple-band antenna is achieved by adding slots on the ground plane. The operating mechanism and the effect for parameters on the antenna performance are studied. By controlling the parameters of the antenna, the operation bands can be changed. The triple- band antenna is fabricated, and experimental results are presented. Experimental results show that the compact triple-band antenna gives omnidirectional radiation patterns and good antenna gains over the operating bands.

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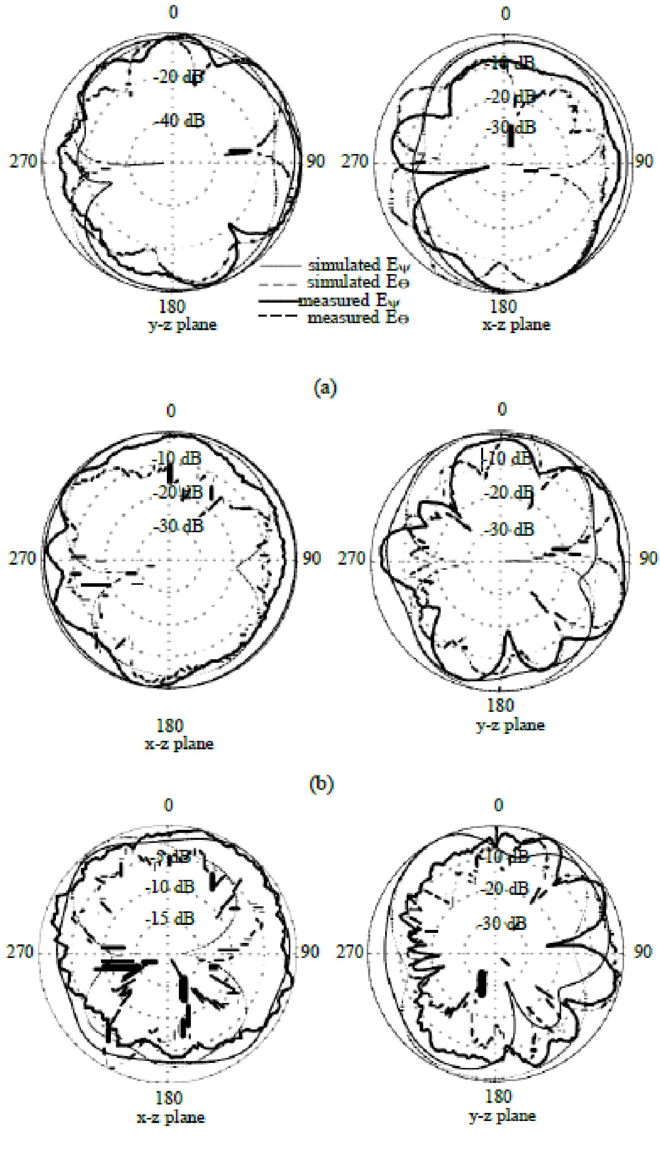

(c)
Fig.6 Simulated and measured radiation patterns of the antenna (a) 2.45 GHz (b) 3.3 GHz (c) 5.55 GHz.

References

[1] Y. J. Wu, B. H. Sun, J. F. Li, and Q. Z. Liu "Triple-band omni-directional antenna for WLAN application," Progress Electromagn. Res.,vol.76, pp. 477–484, 2007.

[2] X. L. Quan, R. L. Li, Y. H. Cui, and M. M. Tentzeris, "Analysis and Design of a Compact Dual-Band Directional Antenna," IEEE Antennas Wireless Propag. Lett. ,vol. 11, pp. 547-550,2012

[3] P. L. Shu, and Q. Y. Feng, "Design of a compact quad- band hybrid antenna for Compass/WIMAX/WLAN application," Progress Electromagn. Res.,vol.138, pp. 585–598,2013.

[4] J. R. Panda and R. S. Kshetrimayum, "A printed 2.4 GHz/5.8 GHz dual-band monopole antenna with a protruding stub in the ground plane for WLAN and RFID," Progress Electromagn. Res.,vol.117, pp. 425–434, 2011.

[5] C. S. Chuang, B. S. Yang, "Compact dual broadband planar slot antenna for wireless LAN application," IEEE International Conference Electrical and Electronics Engineering (ELECO), PP. 223-225, 2011.

[6] W. C. Liu, C. M. Wu, and Y. Dai, "Design of triple- frequency microstrip-fed monopole antenna using defected ground structure," IEEE Trans. Antennas Propag., vol. 59, no.7, pp. 2457-2463, Jul. 2011.

[7] X. L. Sun, L. Liu, S. W. Cheung, and T. I. Yuk, "Dual- band antenna with compact radiator for 2.4/5.2/5.8 GHz WLAN applications," IEEE Trans. Antennas Propag., vol. 60, no. 12, pp. 5924-5931, Dec. 2012.

[8] H. F. Abutarboush, H. Nasif, R. Nilavalan and S. W. Cheung, "Multiband and wideband monopole antennafor GSM900 and other wireless applications," IEEE Antennas Wireless Propag. Lett. , vol. 11, pp. 539-542, 2012.

[9] D. Yu, Z. H. Zhang, W. L. Liu, B. Yang, "Dual-band miniaturized printed antenna for WLAN applications," IEEE International Conference on Microwave and Millimeter Wave Technology (ICMMT), vol. 3, pp. 1-4, 2012.

[10] W. C. Liu, "Optimal design of dualband CPW-feed G- shaped monopole antenna for WLAN application Application," Progress Electromagn. Res.,vol.74, pp. 21–38, 2007.

[11] S. H. Huang. Yeh and K. L. Wong, "Dual-band F-shaped monopole antenna for 2.4 /5.2 GHz WLAN application," IEEE Antennas and Propagation Society International Symposium (APSURSI), vol.4, pp. 72-75, July. 2002.

[12] A. S. R. Saladi, J. R. Panda and R. S. Kshetrimayum, "A Compact printed 9-shaped dual-band monopole antenna for WLAN and RFID applications," IEEE International Conference on Computing Communication and Networking Technologies (ICCCNT), pp. 1-4, Jul. 2010.

[13] E. Debono, A. Muscat and C. J. Debono, "Dual frequency 2.4 GHz T-shaped and 5.2 GHz L-shaped nonopole antenna for WLAN applications," IEEE International Conference on Microwaves, Radar & Wireless Communications, pp. 1015-1018, May. 2006.

[14] A. Mehdipour, A. Sebak, W. Trueman and T. A. Denidni, "Compact multiband planar antenna for 2.4/3.5/5.2/5.8-GHz wireless applications," IEEE Antennas Wireless Propag. Lett. , vol. 11, pp. 144-177,Jan. 20