A Multiband Antenna Based on a CRLH Structure for Mobile Handsets

RongLin Li and Liang Zheng
School of Electronic and Information Engineering
South China University of Technology
Guangzhou 510641, China
lirl@scut.edu.cn

***Abstract* - A compact multiband planar antenna is proposed for LTE/GSM/UMTS/WLAN/WiMAX mobile handsets. The multiband antenna is designed based on a composite right/left handed (CRLH) structure and a slot structure. The impedance bandwidths achieved are 120% (0.67-2.74 GHz) for LTE700/GSM850/900/1800/1900/UMTS/WLAN2450/LTE2300/2500 bands, 20% (3.15-3.84 GHz) for WiMAX3500 band, and 27% (4.9-6.4 GHz) for WLAN5200/5800 bands. The measured peak gains and antenna efficiencies are about 2.5-7.5 dBi and 50%-80%, respectively.**

***Index Terms* —Multiband antenna, planar antenna, composite right/left handed structure, mobile handset.**

1. Introduction

Nowadays antennas for wireless applications need to operate in a wideband/multiband mode. Antennas for traditional mobile handsets need to provide two wide operating bands of 824-960 and 1710-2170 MHz, covering five GSM/UMTS bands (GSM850/900/1800/1900/UMTS). With the introduction of the long term evolution (LTE) operation for 4G mobile phones services, mobile phone antennas also need to operate on three LTE bands (LTE700/2300/2500 in the 698-787/2300-2400/2500-2690 MHz bands). The wireless access services such as WLAN and WiMAX (2.4-2.5 GHz, 3.4-3.6 GHz and 5.1-5.9 GHz) are also a necessity for multifunctional "smart phones". Therefore it is desirable for a mobile phone antenna to cover the LTE/GSM/UMTS/WLAN/WiMAX frequency bands simultaneously. On the other hand, there is an increasing demand for compact antennas to be properly embedded in the thin/light devices. Several promising LTE/GSM/UMTS internal antennas have been reported in [1]–[3]. However, these antennas are unable to cover all the frequency bands mentioned above, especially the WLAN/WiMAX frequency bands. In this paper, we propose a multi-broadband planar antenna based on a composite right/left handed (CRLH) structure and a slot structure, covering all the LTE/GSM/UMTS/WLAN/WiMAX frequency bands (0.685-2.74 GHz, 3.15-3.84 GHz and 4.9-6.1 GHz).

2. Antenna Configuration

The configuration of the proposed multiband planar antenna is shown in Fig. 1. The design of the antenna is based on an FR-4 substrate (120 × 52 mm) which has a dielectric constant of ε_r = 4.4 and a thickness of 2.4 mm. There are two rectangle patches ($w_1 \times h_1$) on the backside of the substrate. On the front side of the substrate, two meander lines have the same total length of M. The antenna is fed by a coplanar waveguide (CPW) which can increase the bandwidth. According to the theory of CRLH transmission lines, the antenna can be equivalent to a two-units-cell CRLH structure. Two meander lines is equivalent to a shunt inductor (L_L) of each unit. The right patch on the backside is coupled to the feed line on the front side, which is equivalent to a series capacitor (C_L). Series inductor (L_R) normally exists in the feed line and the patches. And the parasitic capacitor between the feed line and the ground plane is equivalent to a shunt capacitor (C_R). The resonant frequencies in 0.7-1 GHz and 2-GHz are determined by the resonance of the left-handed mode while the resonant frequencies in 5.5-GHz are determined by the resonance of the right-handed mode. These resonant frequencies are controlled by the CRLH parameters which are independent of the size of the antenna. So we can design the antenna with a more compact size. Besides, we embed a slot in the feed line to generate a resonance around 3.4 GHz. The length of the slot is about a quarter wavelengths of 3.4 GHz in FR-4 substrate. We can realize the antenna miniaturization and wideband/multiband operation by combining the CRLH and slot structures.

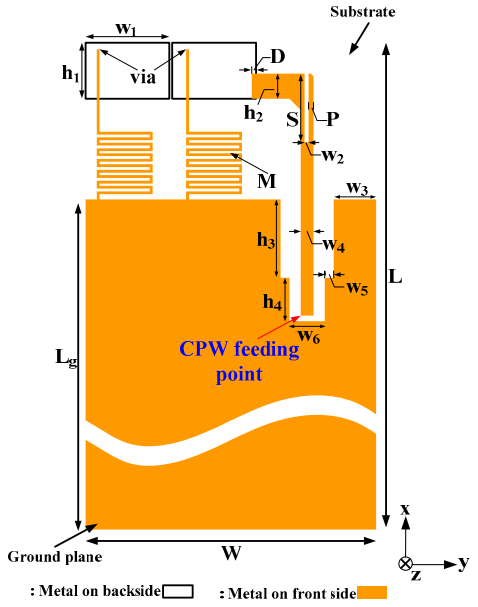
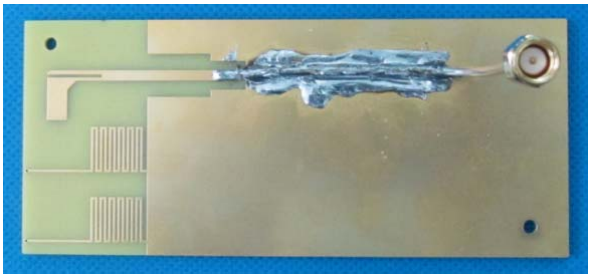


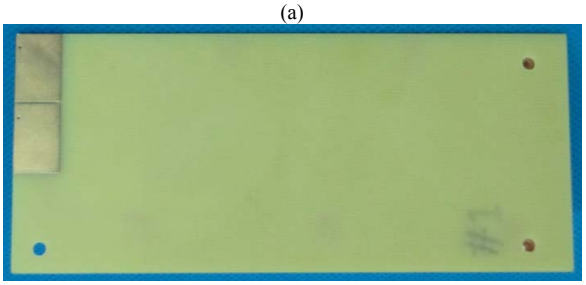
Fig. 1. Configuration of the proposed multiband antenna.

3. Experimental Results

To verify the broadband/multiband performance of the proposed antenna, a prototype was fabricated and measured. The photos of the fabricated antenna are shown in Fig. 2. The measured return loss of the proposed antenna is compared with the simulated result in Fig. 3. Agreement is observed. There are three wide frequency bands for 3:1 VSWR (6-dB return loss), covering bandwidths of 2.07 GHz (0.67-2.74 GHz), 0.69 GHz (3.15-3.84 GHz), and 1.2 GHz (4.9-6.1 GHz). Fig. 4 shows the radiation patterns measured at 0.9 GHz, 2.2 GHz, 3.5 GHz, and 5.5 GHz with the simulated results. All radiation patterns show nearly omnidirectional in the y-z plane, suitable for an environment of mobile communications.



(a)



(b)

Fig. 2. A prototype of the proposed multiband antenna: (a) Front view; (b) Back view.

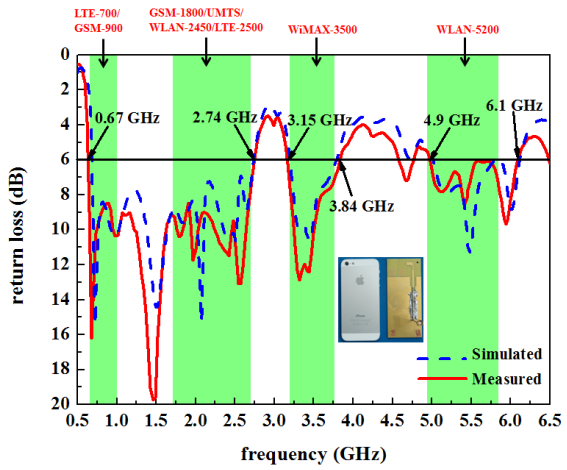
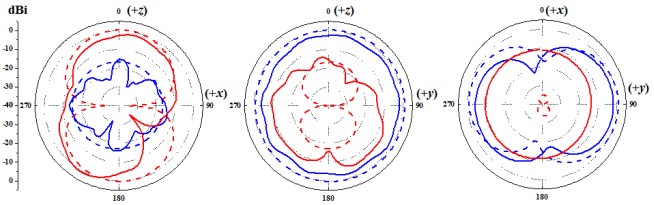


Fig. 3. Simulated and measured results for return loss of the proposed antenna.



(a)

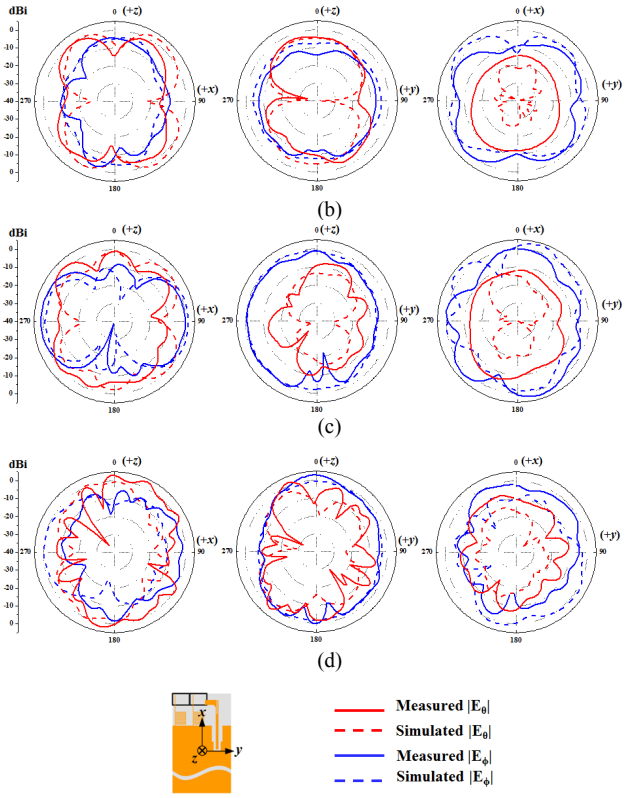


Fig. 4. Radiation patterns of the proposed antenna at (a) 0.9 GHz, (b) 2.2 GHz, (c) 3.5 GHz, and (d) 5.5 GHz.

4. Conclusion

A multiband/broadband planar antenna has been developed for mobile handsets in GSM/UMTS/LTE and WLAN/WiMAX applications. The antenna design is inspired from a CRLH structure The multiband antenna covers the three broad frequency bands with a bandwidth of 120% (0.67-2.74 GHz) for LTE700/GSM850/900/1800/1900/ UMTS/WLAN2450/ LTE2300/2500 bands, 20% (3.15-3.84 GHz) for WiMAX3500 band, and 27% (4.9-6.4 GHz) for WLAN5200/5800 bands.

Acknowledgment

The work is supported in part by the National Natural Science Foundation of China under Grant 61372009 and in part by the GDSTC under Grant 2014A010103011.

References

[1] Y.-L. Ban, J.-H. Chen, J. L.-W. Li, and Y. Wu, "Small-size printed coupled-fed antenna for eight-band LTE/GSM/UMTS wireless wide area network operation in an internal mobile handset," *IET Microw. Antenna Propag.*, vol. 7, no. 6, pp. 399–407, Feb. 2013.

[2] Y.L. Ban, Y.F. Qiang, Z. Chen, K. Kang, J.L.W. Li, "Low-profile narrow-frame antenna for seven-Band WWAN/LTE smartphone applications," *IEEE Antennas Wireless Propag. Lett.*, vol. 13, pp. 463–466, 2014.

[3] Y.-L. Ban, Y.-F. Qiang, Z. Chen, K. Kang, and J.-H. Guo, "A dual-loop antenna design for hepta-band WWAN/LTE Metal-rimmed smartphone applications," *IEEE Trans. Antennas Propag.*, vol. 63, no. 1, pp.48–58., Jan. 2015.