Planar Compact Tablet Monopole Antenna for LTE/WWAN System

Jui-Han Lu, Yi-Shiang Wang and Feng-Chuan Tsai
Department of Electronic Communication Engineering, National Kaohsiung Marine University, Kaohsiung, Taiwan

***Abstract* - This work describes a compact tablet monopole antenna with eight-band LTE/WWAN operation by introducing a G-shaped driven monopole strip. The obtained impedance bandwidths across dual operating bands approach 264 / 1046 MHz at the LTE and WWAN bands, respectively. Given that the overall antenna size is only 35 × 10 × 0.8 mm^3, the proposed planar monopole antenna provides more than 40% reduction in antenna size over that of the conventional ones. Additionally, the measured peak gains and antenna efficiencies are approximately 3.6 / 5.2 dBi and 67 / 70 % for the LTE/WWAN bands, respectively.**

***Index Terms* —Monopole antenna, long-term evolution (LTE), wireless wide area network (WWAN).**

I. INTRODUCTION

Due to the tremendous development of modern mobile communication, the long term evolution (LTE) system with three operating bands in the LTE700 (698 ~ 787 MHz), LTE2300 (2300 ~ 2400 MHz) and LTE2500 (2500 ~ 2690 MHz) [1] has received great interest for use in 4G wireless wide area network (WWAN) systems. Moreover, to fulfill the bandwidth specifications of the 4G system and be embedded into a limited space, a compact multi-band antenna is the most promising means of providing commercial broadband coverage in the 698–960 / 1710–2690 MHz bands in LTE/WWAN environments. The applications of several planar monopole antennas (MAs) developed for LTE/WWAN operations include tablet computers [2-9]. However, those antenna designs are limited by a larger antenna size for the above MAs with a greater planar dimension [2-6] or insufficient operating bandwidth [7-9] for LTE/WWAN operations in tablet computers. Several designs have been presented by using the lumped LC matching circuit [9] to enhance the operating bandwidth or adding a chip component [6, 8] to make the antenna dimensions more compact. However, the lumped element in the external matching circuit also incurs additional losses, possibly decreasing the total efficiency of the antenna [6, 8-9]. To overcome this limitation, this article proposes a G-shaped driven monopole strip to excite dual resonant modes in the upper (1710–2690 MHz) band of the desired antenna. An inverted L-shaped shorting strip is then introduced as the parasitic element to generate dual 0.25-wavelength resonant modes at approximately 750/940 MHz bands in order to cover the LTE700/GSM850/900 operating bandwidth. Additionally, as for the overall antenna volume, the proposed antenna with a small size of 35 × 10 × 0.8 mm^3 (280 mm^3) has an antenna size at least 40 % less than that of the smallest LTE/WWAN internal antenna with a dimension of 40 × 15 × 0.8 mm^3 [2] for a tablet computer.

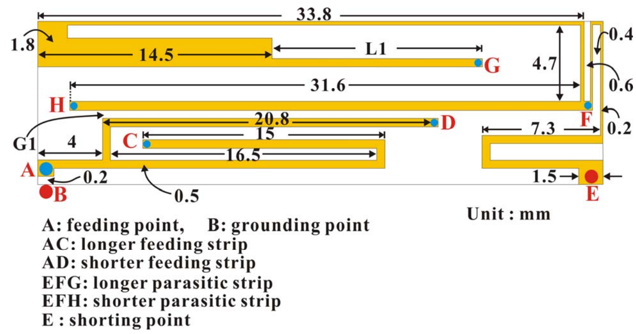


Fig. 1. Geometry of the proposed compact uniplanar printed antenna with the G-shaped driven monopole strip for tablet computer application.

II. ANTENNA DESIGN AND EXPERIMENTAL RESULTS

Fig. 1 shows the geometry of the proposed planar compact multiband antenna for LTE/WWAN operations in a tablet computer. The proposed MA is printed on the same side of an FR4 substrate with the dimensions of 35 × 10 × 0.8 mm^3 and mounted on the top-right corner of a display ground with a distance of 37.15 mm to the center line of the ground plane of 200 × 150 mm^2. The proposed small-size monopole antenna (MA) consists of a G-shaped driven monopole and an inverted L-shaped parasitic strip shorted at point E. A 50-Ω mini coaxial line is connected to the feeding point (point A) of the G-shaped driven monopole and the display grounding point (point B) to excite this monopole antenna. First, the upper meandered arm of the inverted L-shaped parasitic shorted strip (i.e. section EFG) contributes to its fundamental (0.25-wavelength) resonant mode at around 750 MHz with a higher-order resonant mode at approximately 2460 MHz. Then, to widen the impedance bandwidth for the lower operating band (LTE700/GSM900 MHz), another inverted L-shaped parasitic shorted strip (section EFH) is introduced and coupled by the G-shaped feeding strip with the gap of G1 to generate the fundamental (0.25-wavelength) resonant mode at approximately 940 MHz band. Next, by introducing the lower / upper strips (section AC and AD) of the G-shaped driven monopole, 1695 / 2148 MHz modes are then excited as the first and second operating modes of the upper band. Additionally, based on the above guidelines, the proposed MA is optimized by using Ansoft HFSS, a commercially available software package based on the finite element method [10].

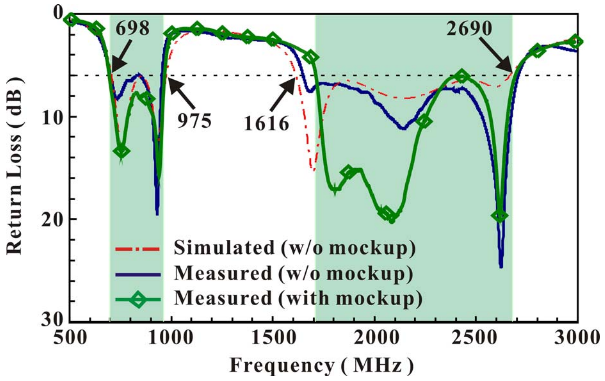
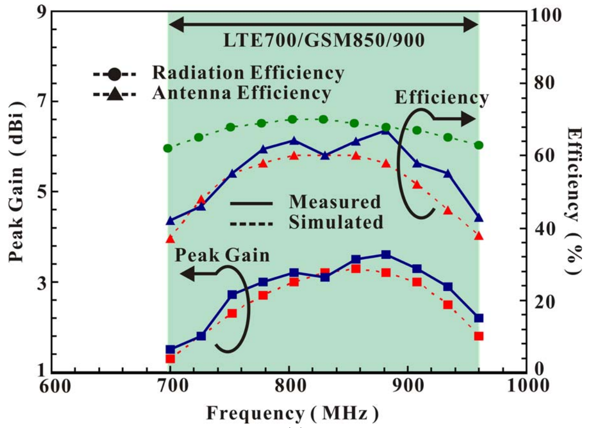
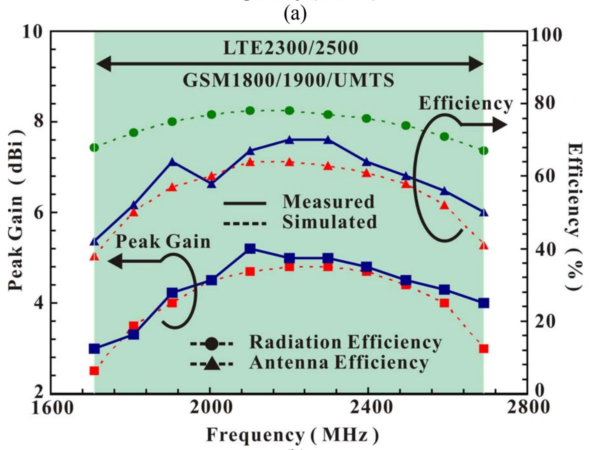


Fig. 2. Simulated and measured results against frequency for the proposed compact MA with a mockup or not.



(a)



(b)

Fig. 3. Measured and simulated antenna gain and efficiency for the proposed compact printed MA studied in Fig. 2.

Fig. 2 shows the simulation and experimental return loss in the proposed MA with or without a mockup. The proposed MA provides the measured 3:1 VSWR (6-dB return loss) bandwidth of 264 MHz (698–962 MHz) and 1046 MHz (1650–2696 MHz) for the lower and higher operating bands, respectively. Dual wide bands can meet with the bandwidth requirements of the desired eight-band LTE/WWAN (LTE700/GSM850/900/GSM1800/1900/UMTS/LTE2300/2500) operations. Additionally, the proposed internal antenna is embedded with the plastic mockup a relative permittivity of 3.0 and loss tangent of 0.02. This finding suggests that the loading effect caused by the substrate of the casing is slight. Figure 3 illustrates the measured antenna gain and efficiency for the proposed compact multiband antenna. For frequencies over the LTE700/GSM850/900 bands, the measured antenna gain and efficiency are approximately 1.5 ~ 3.5 dBi and 42 ~ 67 %. Meanwhile, those for the GSM1800/1900/UMTS/LTE2300/2500 bands range from approximately 3.0 to 5.2 dBi and 42 ~ 70 %, respectively.

III. CONCLUSIONS

The proposed uniplanar monopole antenna reduces the antenna size by more than 40% since the overall antenna size is only 35 × 10 × 0.8 mm^3. The proposed small-size monopole antenna provides eight-band LTE/WWAN operations for tablet computers by using the inverted L-shaped parasitic shorted strip and a novel G-shaped driven monopole. The impedance bandwidth across the operating bands can reach approximately 264 / 1046 MHz at the LTE / WWAN bands, respectively. The measured peak gains and antenna efficiencies are approximately 3.5 / 5.2 dBi and 67 / 70 % for the LTE and WWAN bands, respectively.

ACKNOWLEDGMENT

This paper was supported by the Ministry of Science and Technology (MOST), Taiwan, R.O.C., under Grant NSC97-2221-E-022-005-MY3.

REFERENCES

[1] LTE Advanced The 3rd Generation Partnership Project, 2011. Available: http://www.3gpp.org/LTE-Advanced.

[2] J. H. Lu and Y. S. Wang, "Internal uniplanar antenna for LTE/WWAN operation in a tablet computer", *IEEE Trans. Antennas Propagat.*, vol. 61, pp. 2841-2846, May 2013.

[3] J. H. Lu and Z. W. Lin, "Planar compact LTE/WWAN monopole antenna for tablet computer application", *IEEE Antennas and Wireless Propagation Letters*, vol. 12, pp. 147-150, 2013.

[4] J. H. Lu and F. C. Tsai, "Planar Internal LTE/WWAN Monopole Antenna for Tablet Computer Application", *IEEE Trans. Antennas Propagat.*, vol. 61, pp. 4358-4363, Aug. 2013.

[5] K. L. Wong, W. J. Wei and L. C. Chou, ''WWAN/LTE printed loop tablet computer antenna and its body SAR analysis'', *Micro. Opt. Technol. Lett.*, vol. 53, pp. 2912-2919, Dec. 2011.

[6] S. H. Chang and W. J. Liao, ''A broadband LTE/WWAN antenna design for tablet PC'', *IEEE Trans. Antennas Propagat.*, vol. 60, pp. 4354-4359, Sep. 2012.

[7] K. L. Wong, C. A. Lyu and L. C. Chou, ''Small-size multiband planar antenna for LTE700/2300/2500 operation in the tablet computer'', *Micro. Opt. Technol. Lett.*, vol. 54, pp. 81-86, Jan. 2012.

[8] Z. Chen, Y. Ban, S. Sun and J. L. W. Li, ''Printed antenna for penta-band WWAN tablet computer application using embedded parallel resonant structure'', *Progress in Electromagnetics Research*, vol. 136, pp. 725-737, Jan. 2013.

[9] K. L. Wong and P. J. Ma, ''Small-size WWAN monopole slot antenna with dual-band band-stop matching circuit for tablet computer application'', *Micro. Opt. Technol. Lett.*, vol. 54, pp. 875-879, April 2012.

[10] http://www.ansoft.com/products/hf/hfss, Ansoft Corporation HFSS.