Internal Penta-band Antenna Design For Laptop Computer

#Chia-Lun Tang [1], Jia-Yi Sze [2], Yi-Feng Wu [3]
[1] Technological Research Center, Auden Techno Corp.
No. 19, Lane 772, Ho Ping Road, Pa Te City, Taoyuan County, R.O.C., alantang@auden.com.tw
[2,3] Department of Electrical and Electronic Engineering, National Defense University
No. 190, Sanyuan 1st St., Dasi Township, Taoyuan County, Taiwan, R.O.C., szejy@ndu.edu.tw

Abstract

A new internal WWAN antenna design for laptop-computer applications has been presented in this article. The proposed penta-band antenna is a simple dual open-loop structure constituted by a meander strip, a metal plate, and a grounding strip while occupying a small volume of 60×4×8 mm^3. The antenna design has an enough VSWR < 3 impedance bandwidth which can easily support GSM850/GSM900/DCS/PCS/UMTS operations and has good radiation characteristics. Details of design considerations of the proposed design and experimental results of the constructed prototype are introduced and discussed.

Keywords : Penta-band antenna Laptop computer antenna WWAN antenna

1. Introduction

In recent years, wireless module is widely built in lap-top computers for wireless communications such as WWAN, WLAN etc. The WWAN antenna used in the wireless module is generally required to cover penta-bands for GSM 850 (824-894 MHz), GSM 900 (890-960 MHz), DCS (1710-1880 MHz), PCS (1850-1990 MHz) and UMTS (1920-2170 MHz) operations. To achieve convenient carrying, the size reduction of the laptop computers is required, which results in severe challenge in antenna design with abovementioned operating bands. The height and width of the WWAN antenna are required not more than of 10 mm and 60 mm, respectively. Some miniaturized multi-band antenna designs for WWAN applications in laptop computers have been proposed in literatures [1-7]. In [3, 5], the antenna designs with simple constructions can not only achieve impedance-bandwidth enhancement but also have small antenna widths. In this article, we propose an alternate design of penta-band antenna with a simple structure and a smaller occupied volume, which can make it become one of the promising candidates for laptop-computer applications.

2. Antenna Design and Results

The proposed antenna is constructed with an antenna radiator put on a top side of an antenna ground plane (with an area of 260 × 200 mm^2) set at the back of the display panel of lap-top computers. The antenna radiator has not only a small occupied volume of only 60×4×8 mm^3 but also a simple structure constituted by a meander strip, a metal plate, and an inverted L-shaped grounding strip shown in Figure 1. The meander strip (section ABB'CC') with a width and length of 0.4 mm and 30 mm, respectively, is printed on an FR4 substrate with a relative permittivity of 4.4, a thickness of 0.4 mm, and an area of 60 × 8 mm^2. The metal plate (section DEFGH) comprises a vertical copper plate and a rectangular patch. The vertical copper plate (section DEFG) with a width, height and thickness of 60 mm, 4 mm and 0.2 mm, respectively, is vertically set at the upper edge of the FR4 substrate, like a metal wall, and connected to a rectangular patch (section GH). The rectangular patch with a width and length of 4 mm and 8 mm, respectively, is printed on the same substrate as the meander strip and connected to the antenna ground at the H point. The inverted L-shaped grounding strip (section IJK) with a width of 1 mm is also printed on the same FR4 substrate as the meander strip and the rectangular patch. The grounding strip with a small gap of 0.5 mm away from the meander strip is connected to ground plane at the point K. The antenna feed is set at point A and connected to a 50-Ω coaxial cable.

Figure 2 shows the measured VSWR of Type 1 antenna to illustrate the antenna bandwidth affected by adding the metal plate or not. When only exists a meander strip only, the antenna can generate a resonant mode at about 2.1 GHz while one can obtain a new excited mode at about 960 MHz band by adding a metal plate. To excite the second mode in the lower band to enhance the impedance bandwidth to meet the bandwidth requirement for GSM 850/GSM 900, an inverted L-shaped grounding strip is placed on the right side of the meander strip to construct a Type 2 antenna. Figure 3 shows that the Type 2 antenna can excite the second mode at near 840 MHz, while having a poor impedance matching at about 960 MHz caused by the strong coupling between meander strip and grounding strip. To eliminate the coupling effect to obtain a good impedance match, the straight section AB' of the Type 2 antenna is bent to form two sections of AB and BB'. The measured VSWR of the proposed antenna (Type 3) plotted in Fig. 3, seen to agree reasonably well with the simulated data, indicates that two wide bandwidths can be obtained. The VSWR < 3 impedance bandwidth of the lower band is about 159 MHz (806–965 MHz) enough to support GSM 850 and GSM 900 operations. The bandwidth obtained of the upper band is about 645 MHz (1665–2310 MHz) which can cover the demanded bandwidth for the DCS, PCS and WCDMA operations. Figure 4 shows the measured radiation patterns (x-z, y-z, x-y plane) in dual wide resonant modes of the proposed antenna, which is also seen to agree reasonably well with the simulated data. In addition, the simulated and measured antenna gains are also presented in the Fig. 5. The ranges of the antenna gains in low-frequency and high-frequency bands are 1.3-2.0 dBi and 1.4-2.3 dBi, respectively.

3. Conclusions

In this article, a miniaturized dual open-loop antenna which can support penta-band operations of the GSM850/GSM900/DCS/PCS/UMTS (about 806-965 MHz and 1665-2310 MHz) embedded in the top side of laptop computers has been demonstrated. The antenna design comprises a simple radiator structure and occupies small dimensions of $60 \times 4 \times 8$ mm^3. Dual impedance bandwidths enough for WWAN operations and good radiation performances within the operating bands have also been observed. The abovementioned characteristics make the proposed antenna very suitable for the laptop-computer applications. More detailed results of the proposed design will be described in the presentation.

References

[1] K. L. Wong and L. C. Lee, "Multiband printed monopole slot antenna for WWAN operation in the laptop computer," *IEEE Trans. Antennas propagat.*, vol. 57, no. 2, pp. 324-330, Feb. 2009.

[2] K. L. Wong and S. J. Liao, "Uniplanar coupled-fed printed PIFA for WWAN operation in the laptop computer," *Microwave Opt. Technol. Lett.*, vol. 51, no. 2, pp. 549-554, Feb. 2009.

[3] K. L. Wong and F. H. Chu, "Internal planar WWAN laptop computer antenna using monopole slot elements," *Microwave Opt. Technol. Lett.*, vol. 51, no. 5, pp. 1274-1279, May 2009.

[4] X. Wang, W. Chen, and Z. Feng, "Multiband antenna with parasitic branches for laptop applications," *Electron. Lett.*, vol. 43, no. 19, pp. 1012-1013, Sep. 2007.

[5] K. L. Wong and C. H. Chang, "Internal coupled-fed shorted monopole antenna for GSM850/900/1800/1900/UMTS operation in the laptop computer," *IEEE Trans. Antennas propagat.*, vol. 56, no. 11, pp. 3600-3604, Nov. 2008.

[6] C. H. Kuo, K. L. Wong, and F. S. Chang, "Internal GSM/DCS dual-band open-loop antenna for laptop application," *Microwave Opt. Technol. Lett.*, vol. 49, no. 3, pp. 680-684, Mar. 2007.

[7] L. C. Chou and K. L. Wong, "Uni-planar dual-band monopole antenna for 2.4/5 GHz WLAN operation in the laptop computer," *IEEE Trans. Antennas propagat.*, vol. 55, no. 12, pp. 3739-3741, Dec. 2007.

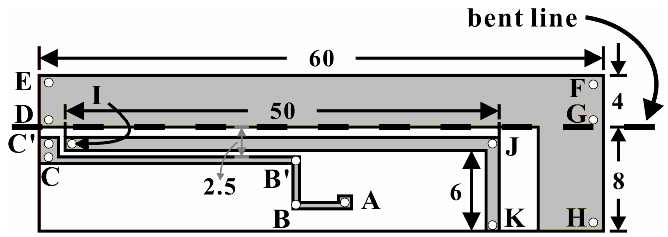

Fig. 1: Geometry of the proposed antenna

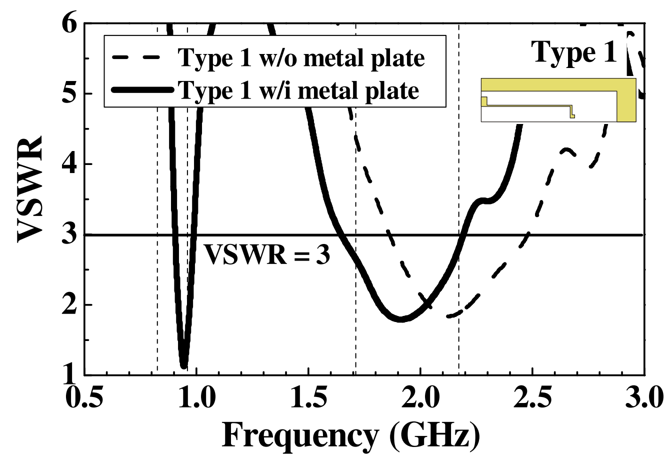

Fig. 2: Measured VSWRs of the Type 1 antenna with (without) the added metal plate

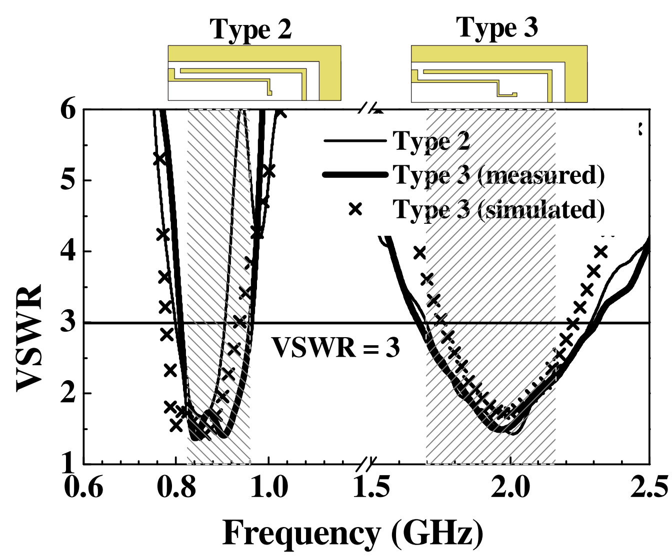

Fig. 3: Measured and simulated VSWRs of the Type 2 and Type 3 antenna

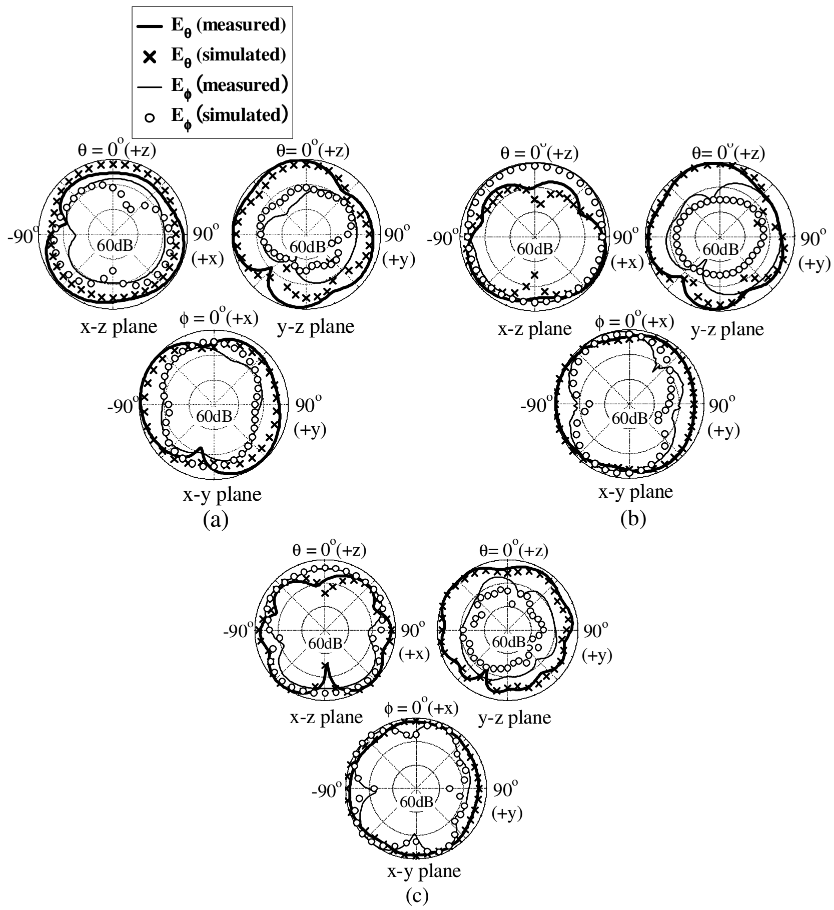

Fig. 4: Measured and simulated radiation patterns of the proposed antenna at (a) f = 850 MHz; (b) f = 900 MHz; (c) f = 1950 MHz.

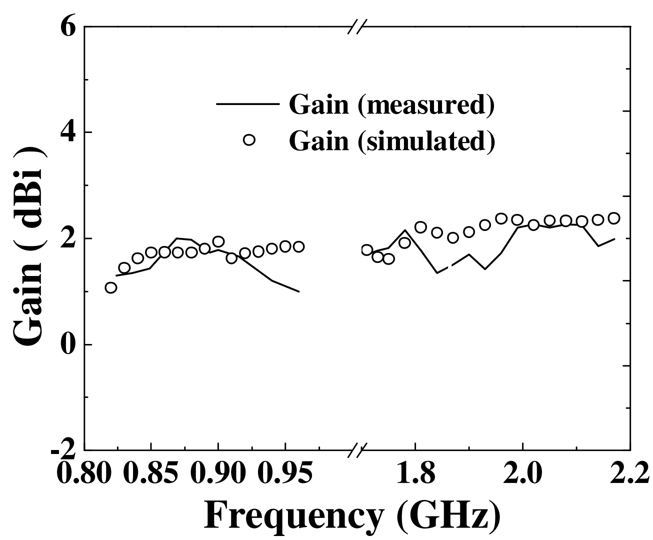

Fig. 5: Measured and simulated antenna gains of the proposed antenna