Printed Loop Antenna with an Inductively Coupled Branch Strip for Small-Size LTE/WWAN Tablet Computer Antenna

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***Abstract*-The technique of using an inductively coupled branch strip for bandwidth enhancement of a simple printed loop antenna to achieve small size yet multiband operation to cover the LTE/WWAN bands (704~960 and 1710~2690 MHz) in the tablet computer is presented. The antenna's metal pattern occupies a small area of 10 × 34.5 mm^2, and is printed on a thin FR4 substrate. The branch strip can cause an additional resonance and thereby greatly widens the antenna's low-band bandwidth to cover the 704~960 MHz band for the LTE700/GSM850/900 operations. While in the antenna's higher band, the chip inductor provides a high inductance and limits the excitation of the branch strip. In this case, with the printed loop antenna excited in the higher band, the antenna can generate two higher-order resonant modes to form a wide operating band for the GSM1800/1900/ UMTS/LTE2300/2500 operations (1710~2690 MHz).**

Keywords: mobile antennas, LTE/WWAN antennas, tablet computer antennas, inductively coupled branch strip, small-size antennas

I. Introduction

Owing to the very limited space inside the tablet computers, the embedded antennas having planar structure and small size for multiband operation are generally demanded. In this paper, we demonstrate that a quarter-wavelength printed loop antenna [1], [2] can be applied in achieving two wide operating bands for the LTE/WWAN operations. By applying an inductively coupled branch strip for bandwidth enhancement of the antenna's lower band to cover the LTE700/GSM850/900 operations in the 704~960 MHz band, the antenna's metal pattern occupies an area of 10 × 34.5 mm^2 only. A wide higher band contributed by two higher-order resonant modes of the printed loop antenna alone is also obtained to cover the GSM1800/1900/UMTS/LTE2300/2500 operations in the 1710~2690 MHz band. Design considerations and operating principle of the proposed antenna are described. A parametric study on the proposed antenna is also conducted, and results of a fabricated antenna are presented and discussed.

II. Proposed Antenna

Fig. 1 shows the geometry of the proposed LTE/WWAN tablet computer antenna. The antenna has a uniplanar structure and is printed on an FR4 substrate of thickness 0.8 mm. The antenna is mounted along an edge and at a corner of the device ground plane of size 150 × 200 mm^2, which is a reasonable size for the tablet computer with a 10-inch display panel. The antenna is formed by a loop strip configured into an inverted-L shape and a branch strip inductively coupled to the loop strip through a chip inductor (L_2) of 22 nH. The loop strip (section ADB) has a length of 64 mm (about 0.16λ at 750 MHz) only. Aided by a series chip capacitor (C) of 1.2 pF and a series chip inductor (L_1) of 5.6 nH, the loop antenna can generate a resonance at about 750 MHz, and the 750-MHz mode generation is mainly owing to the series chip capacitor added to compensate for the large inductive reactance around the lowest resonant mode or the quarter-wavelength mode of the printed loop antenna. In addition, it can be seen in Fig. 2 that two higher-order resonant mode are generated with good impedance matching, which is aided by the chip inductor L_1. In the proposed design, the antenna's higher band cover the desired 1710~2690 MHz band.

In order to achieve a wide lower band, a branch strip of length (t) 39 mm and width 0.3 mm is coupled to the loop strip through a chip inductor of 22 nH. A parallel resonance controlled by the additional inductance and capacitance occurs at about 1150 MHz (see the input impedance of the proposed antenna in Fig. 2). This parallel resonance causes the resonant mode owing to the loop strip shifted to be at about 750 MHz and having improved impedance matching. Further, an additional resonance at about 950 MHz is also generated, which greatly widens the bandwidth of the antenna's lower band to cover the desired 704~960 MHz band.

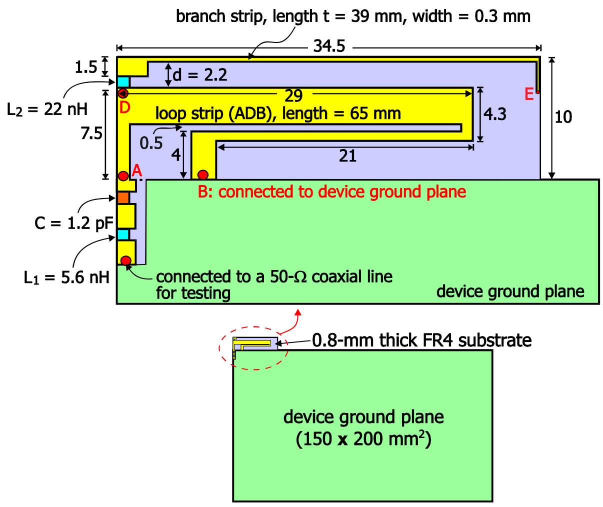

Figure 1. Geometry of the proposed LTE/WWAN antenna.

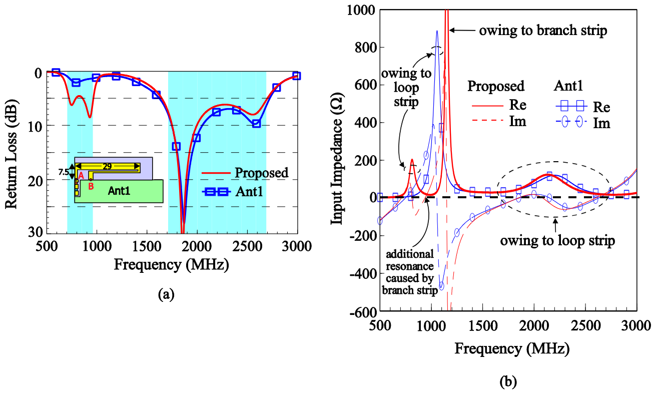

Figure 2. (a) Simulated return loss for the proposed antenna and the printed loop antenna only (Ant1). (b) Simulated input impedance.

III. PARAMETRIC STUDY

To further analyze the effects of the inductively coupled branch strip, Fig. 3 shows the simulated return loss as a function of the chip inductor. Results for the chip inductor with L_2 = 0, 7, 14, 22 nH are shown. For L_2 = 0, the added branch strip makes the proposed antenna operates more like a simple shorted strip antenna having a radiating strip of length about 49 mm (section ADE) and a shorting strip (section DB) of length about 57 mm. This explains the resonant mode excited at about 1.5 GHz, which is mainly owing to the radiating strip being about a quarter-wavelength at 1.5 GHz. In this case, the section ADB can still function as a loop antenna, and a resonant mode at about 750 MHz and two higher-order resonant modes in the higher band are still generated, with the first mode in the higher band being affected and shifted to higher frequencies. The simulated input impedance for the proposed antenna with L_2 = 0, 7 and 14 nH is also shown in Fig. 3 for comparison. It is seen that for L_2 = 7 and 14 nH, the resonances in the antenna's higher band are almost not affected. Furthermore, the lowest resonant mode of the printed loop antenna is also seen to be shifted to lower frequencies with the added L_2 having a larger inductance, and the impedance variations thereof become much smoother, thereby causing good excitation of the resonant mode at about 750 MHz when the chip inductor of 22 nH is used (the proposed antenna).

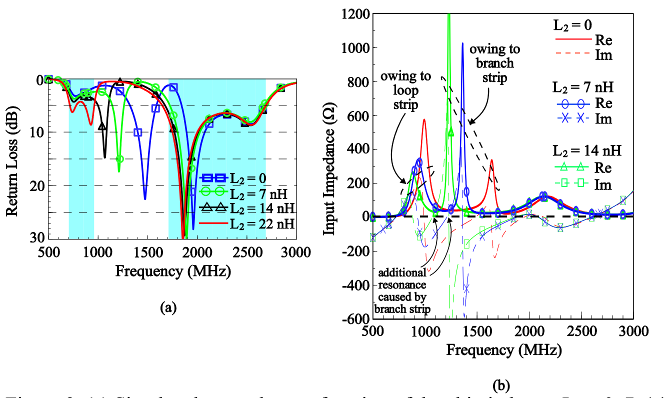

Figure 3. (a) Simulated return loss as function of the chip inductor L_2 = 0, 7, 14, 22 nH. (b) Simulated input impedance.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed antenna was fabricated and tested. A photo of the fabricated antenna mounted along an edge and at a corner of a 0.2-mm thick copper plate to simulate the device ground plane in Fig. 1 is shown in Fig. 4(a). Measured and HFSS simulated return loss of the proposed antenna is presented in Fig. 4(b). Good agreement between the measurement and simulation is seen. The measured antenna efficiency of the fabricated antenna is shown in Fig. 4(c). The antenna efficiency includes the mismatching loss and was measured in a far-field anechoic chamber. The antenna efficiency is about 40~62% and 64~92% in the lower and higher bands, respectively. The obtained antenna efficiency is acceptable for mobile communications.

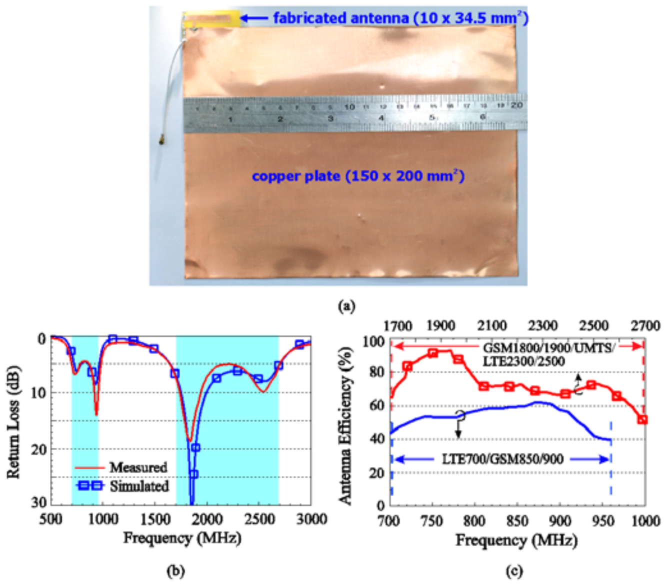

Figure 4. (a) Photo of the fabricated antenna. (b) Measured and simulated return loss. (c) Measured antenna efficiency.

V. CONCLUSION

A small-size, planar LTE/WWAN tablet computer antenna has been proposed. The antenna can provide two wide operating bands for the LTE/WWAN operations. The operating principle of the proposed antenna, especially the effects of the inductively coupled branch strip on the low-band bandwidth enhancement has been described. The proposed antenna is especially suitable for the LTE/WWAN operation in the slim tablet computer applications.

REFERENCES

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