Small-Size Triple-Wideband LTE Tablet Device Antenna with Circuit-Based Wideband Feed Structure

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***Abstract* - A small-size tablet device antenna with three wide operating bands of 698~960 MHz, 1710~2690 MHz and 3400~3800 MHz for the LTE operation is presented. The antenna occupies a small ground clearance of 10 × 30 mm^2 and has a thin thickness of 3 mm in the tablet device. The antenna comprises three radiating branches and a circuit-based wideband feed structure formed by the integrated matching network. The integrated matching network can cause dual-resonance of the three resonant modes contributed by the three branches, thereby greatly enhancing the bandwidths to cover the desired bands. Results are presented and discussed.**

***Index Terms* — Mobile antennas, tablet device antennas, LTE antennas, triple-wideband, small-size, wideband feed structure.**

I. INTRODUCTION

For 4G communications, the tablet mobile devices are required to support the LTE operation (698~960/1710~2170/2300~2400/2500~2690/3400~3800 MHz). Although there have been many LTE antennas reported recently for mobile devices, they mainly covers two wide operating bands of 698~960 and 1710~2690 MHz only [1]-[5]. There are very few reported antennas that can support three wide operating bands of 698~960, 1710~2690 and 3400~3800 MHz. In this paper, we present an LTE antenna using a novel wideband feed structure to result in dual-resonance excitation of the three resonant modes generated by three radiating branches thereof. The antenna requires a small ground clearance of 10 × 30 mm^2 and a thin thickness of 3 mm in the tablet device. The antenna can provide a triple-wideband operation to cover 698~960, 1710~2690 and 3400~3800 MHz bands.

II. PROPOSED ANTENNA

Fig. 1 shows the proposed antenna. The antenna comprises a printed metal pattern and a bent metal plate. The printed metal pattern is fabricated on a 0.8-mm thick FR4 substrate. The bent metal plate is cut from a 0.2-mm thick copper plate and connected to the printed metal pattern on the FR4 substrate. The antenna's total volume is 10 × 30 × 3 mm^3 only. The antenna is mounted along the top edge of the device ground plane. The ground plane is selected to have a size of 200 × 150 mm^2, about the size of a 9.7-inch tablet device.

Detailed dimensions of the printed metal pattern are presented in Fig. 2. The antenna comprises three radiating branches, which are branch 1, branch 2 and branch 3. Branch 1 (section AB) has a length of about 47 mm, which is close to 0.25 wavelength at about 1.7 GHz and generate a resonant mode in the middle band. Branch 2 is the bent metal plate, which is connected to point D and E to be fixed to the FR4 substrate. At point D, branch 2 is also connected to branch 1 through a chip inductor L_1 of 8.2 nH. Owing to the inductor L_1, branch 2 has small effects on the generated resonant mode in the middle band controlled by branch 1. Furthermore, the inductor L_1 contributes additional inductance at lower frequencies. This leads to a resonant mode generated in the low band. A third resonant mode is controlled by branch 3 (section AF) and occurs at frequencies in the high band.

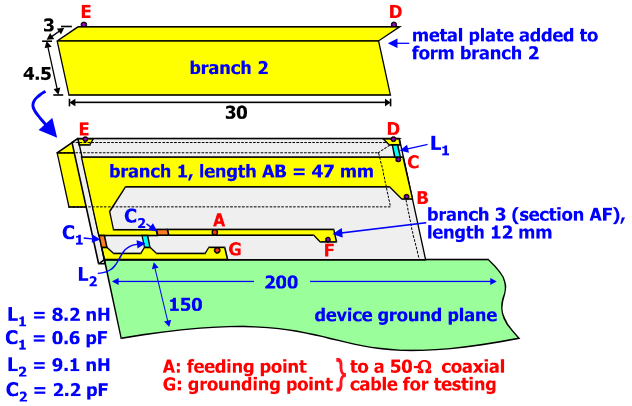


Fig. 1. Geometry of the triple-wideband LTE antenna.

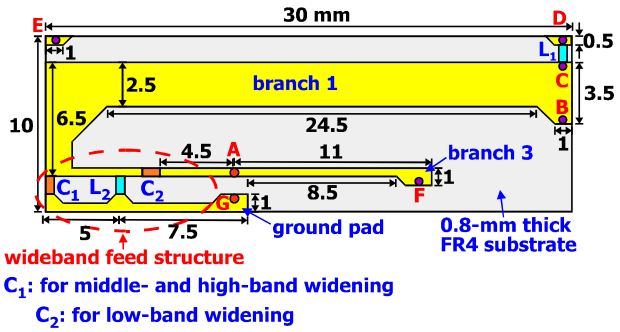


Fig. 2. Dimensions of antenna's printed metal pattern.

The wideband feed structure is also disposed on the FR4 substrate, and its equivalent circuit model is shown in Fig. 3. The wideband feed structure is formed by the integrated matching network, which comprises a shunt chip capacitor C_1 (0.6 pF), a shunt chip inductor L_2 (9.1 nH) and a series chip

capacitor C_2 (2.2 pF). The shunt capacitor C_1 can lead to dual-resonance for the antenna's second and third resonant modes, such that the antenna's middle-band and high-band bandwidths are greatly increased to cover the desired 1710~2690 and 3400~3800 MHz bands. In addition, the shunt capacitor C_1 has small effects on the antenna's low-band performance. That is, the shunt capacitor C_1 functions like a low-pass matching circuit. On the other hand, the shunt inductor L_2 and series capacitor C_2 form like a high-pass matching circuit to cause dual-resonance for the antenna's low band, with relatively small effects on the antenna's middle- and high-band performance. In this case, the antenna's low-band bandwidth can also be greatly increased to cover the desired 698~960 MHz band.

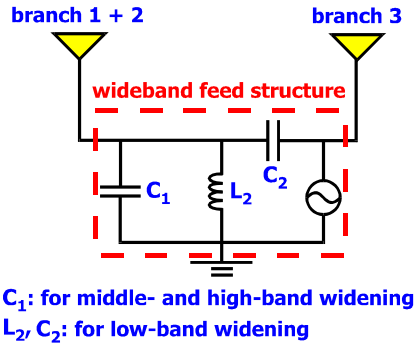


Fig. 3. Equivalent circuit model of the wideband feed structure.

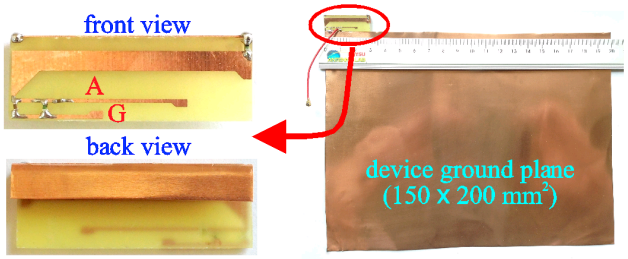
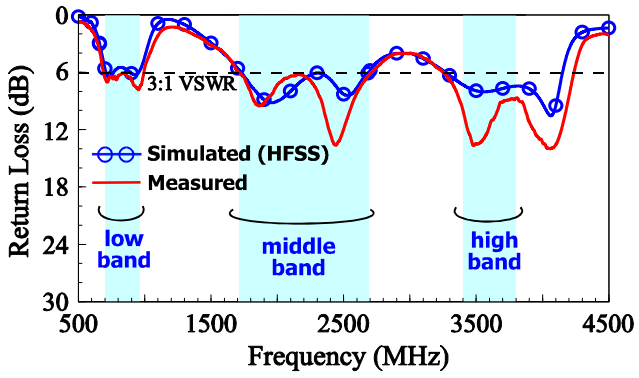


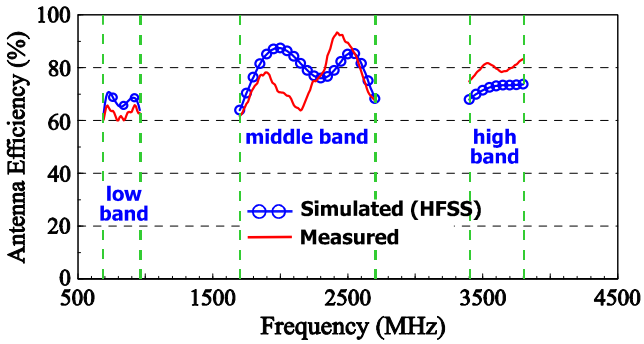
Fig. 4. Photo of the fabricated prototype of proposed antenna.

III. Experimental Studies And Discussion

In Fig. 4, the antenna is mounted at the top edge of the device ground plane for experimental testing. In Fig. 5(a), agreement between the simulated results and measured data is seen. The antenna shows a triple-wideband operation covering the 698~960, 1710~2690 and 3400~3800 MHz for the LTE operation. Results of the measured and simulated antenna efficiency are presented in Fig. 5(b). The antenna efficiency includes the mismatching loss. The measured antenna efficiency reaches about 60~66%, 62~92% and 75~82% for frequencies in the low, middle and high bands, respectively. The results are acceptable for mobile communication applications.



(a)



(b)

Fig. 5. (a) Measured and simulated return loss and (b) antenna efficiency.

IV. Conclusion

A triple-wideband LTE antenna with a small occupied ground clearance in the tablet device has been proposed. The triple-wideband operation in the low band (698~960 MHz), middle band (1710~2690 MHz) and high band (3400~3800 MHz) is achieved by embedding a wideband feed structure to the antenna. Good radiation characteristics for frequencies in the three wide operating bands have been observed. The antenna is promising for slim tablet device applications.

References

[1] K. L. Wong and T. J. Wu, "Small-size LTE/WWAN coupled-fed loop antenna with band-stop matching circuit for tablet computer," *Microwave Opt. Technol. Lett.*, vol. 54, pp. 1189-1193, May 2012.

[2] K. L. Wong, H. J. Jiang and T. W. Weng, "Small-size planar LTE/WWAN antenna and antenna array formed by the same for tablet computer application," *Microwave Opt. Technol. Lett.*, vol. 55, pp. 1928-1934, Aug. 2013.

[3] K. L. Wong and T. W. Weng, "Small-size triple-wideband LTE/WWAN tablet device antenna," *IEEE Antennas Wireless Propaga. Lett.*, vol. 12, pp. 1516-1519, Dec. 2013.

[4] K. L. Wong and M. T. Chen, "Small-size LTE/WWAN printed loop antenna with an inductively coupled branch strip for bandwidth enhancement in the tablet computer," *IEEE Trans. Antennas Propagat.*, vol. 61, pp. 6144-6151, Dec. 2013.

[5] K. L. Wong and T. W. Weng, "Coupled-fed shorted strip antenna with an inductively coupled branch strip for low-profile, small-size LTE/WWAN tablet computer antenna," *Microwave Opt. Technol. Lett.*, vol. 56, pp. 1041-1049, May 2014.