Small Embedded LTE/WWAN Antenna for a Laptop Computer

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***Abstract* - A small embedded long-term evolution/wireless wide area network (LTE/WWAN) antenna integrated with the keyboard ground plane in a laptop computer is presented. The antenna is installed on a notched region (40 mm × 8 mm) of the keyboard ground plane. This antenna can not only be configured to have a compact configuration but also be designed to excite several resonant modes of the hinge slot between the display ground plane and the keyboard ground plane. The proposed antenna comprises a hook-shaped strip and a shorted strip, which together form a coupled-fed loop that not only has a compact size when printed on a 0.8-mm-thick FR4 substrate 40 mm × 8 mm in size but also provides eight-band LTE/WWAN operation. The proposed antenna can cover LTE/WWAN operation in the 698–960 and 1710-2690 MHz bands. The measured antenna efficiency was approximately 45%–80% in the lower band and approximately 52%–75% in the upper band.**

***Index Terms* —LTE/WWAN antennas, hinge slot antennas, coupled loop antennas, computer antennas.**

1. Introduction

In general, most of laptop computer antennas are arranged at the top edge of the display ground plane and have a height exceeding 10 mm [1]. Moreover, with the development of laptop computers with metal covers, the positioning of the antennas at the top edge of the display ground plane is not appropriate. Therefore, printed planar antennas covering the LTE/WWAN operating bands for wireless universal serial bus (USB) dongle applications have been developed [2, 3]. However, users may forget carry the additional belongings that make some troubles and inconvenient, which render USB dongle devices unpopular and unattractive.

In this present, we successfully designed an embedded coupled-fed loop antenna integrated with the keyboard ground plane in a laptop computer. The proposed antenna is installed on a notched region (size 40 × 8 mm^2) of the keyboard ground plane at a distance of 10 mm from the laptop computer hinge. The location can be plugged into a USB dongle device. The proposed antenna comprises a hook-shaped strip and a shorted strip, which together form a coupled-fed loop that not only has a compact size when printed on a 0.8-mm-thick FR4 substrate 40 mm × 8 mm in but also provides eight-band LTE/WWAN operation.

2. Proposed Antenna

The proposed coupled-fed loop antenna was installed on a notched region (40 mm × 8 mm) of the keyboard ground plane, and it is shown in Fig. 1. A laptop computer with an angle of 120° between its upper metal cover and its base metal cover was considered, and both covers were joined by two metal hinges. The two metal hinges were placed symmetrically at the two edges of a side of the metal covers to form a hinge slot (yellow region). The proposed coupled-fed loop antenna has a simple structure that can be easily printed on a 0.8-mm-thick FR4 substrate. The proposed antenna was installed on a notched region (40 mm × 8 mm) of the keyboard ground plane at a distance of 10 mm from the laptop computer hinge. The location is probably plugged into a USB dongle device. The coupled-fed loop comprised a hook-shaped strip and a shorted strip. The hook-shaped strip and shorted strip had a width of 0.5 mm, a length of 57.5 mm, and 100 mm, respectively. A coupling gap of 0.5 mm was designed to provide sufficient capacitive coupling between the two strips for achieving good excitation of the quarter-wavelength coupled-fed loop mode. A small coupling gap of 0.3 mm was maintained between the hook-shaped strip and the keyboard ground plane to provide a coupling current for exciting the resonant modes of the hinge slot.

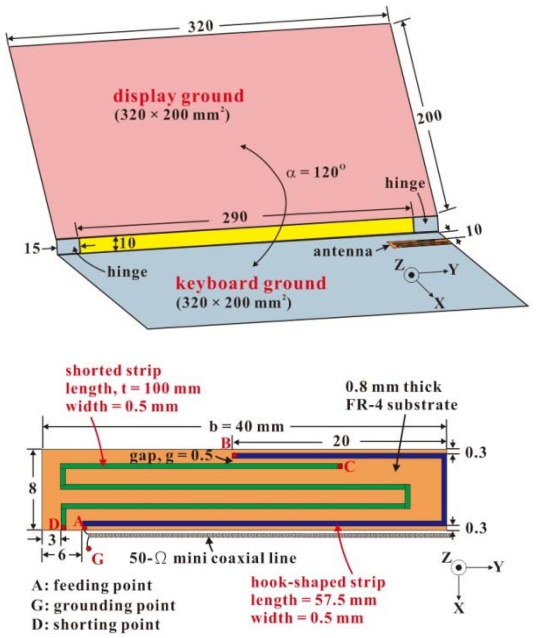

Fig. 1. Geometry of the proposed coupled-fed loop antenna for use in a laptop computer.

3. Results and Discussion

The measured and simulated return losses of the antenna are presented in Fig. 3. The measured results accord with the simulated results. The simulated results were obtained using the full-wave electromagnetic field simulator HFSS[4]. The proposed antenna could operate in two wide operating bands covering the LTE700/GSM850/900 and GSM1800/1900/ UMTS/LTE2300/2500 bands. These two wide operating bands consist of six resonant modes corresponding to the coupled-fed loop and the hinge slot. Modes 1, 3, and 5 correspond to the coupled-fed loop, and Modes 2, 4, and 6 correspond to the hinge slot.

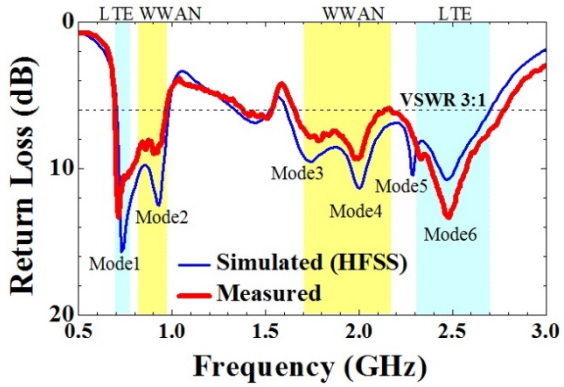

Fig. 2. Measured and simulated return loss of the proposed antenna.

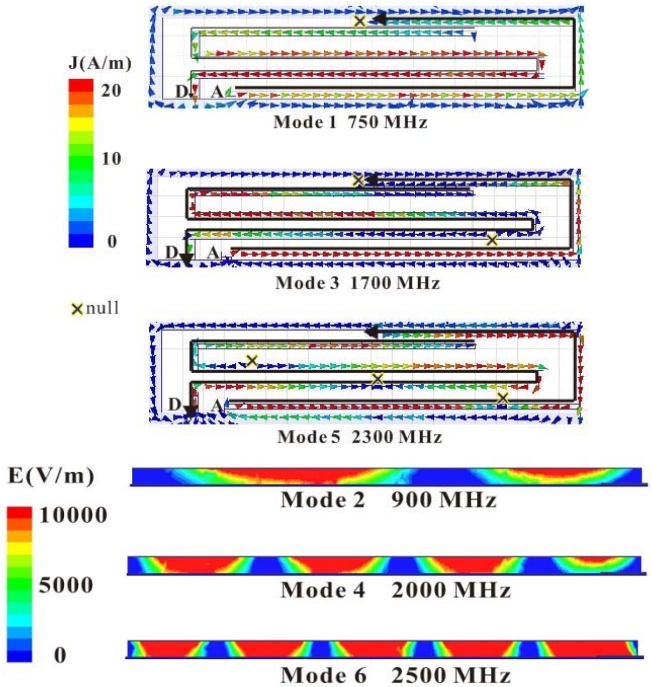

Fig. 3. Simulated surface current and electric field distributions for the proposed antenna.

To further identify the contribution of each excited mode, the simulated surface current distributions in the metal strip at 750, 1700, and 2300 MHzand electric field distributions in the hinge slot at 900, 2000, and 2500 MHz were examined for the proposed antenna (Fig. 3). Clearly, at 900 MHz, the quarter-wavelength mode of the coupled-fed loop is excited. At 2000 and 2500 MHz, the higher-order resonant modes of the coupled-fed loop are excited. Furthermore, at 900 MHz, the half-wavelength mode of the hinge slot (see the strong electric fields in the middle section of the closed slot) is excited. At 2000 and 2500 MHz, the electric field distributions show the excitation of higher-ordered modes of the hinge slot. These excitations confirm that Modes 1, 3, and 5 correspond to the coupled-fed loop, and Modes 2, 4, and 6 correspond to the hinge slot.

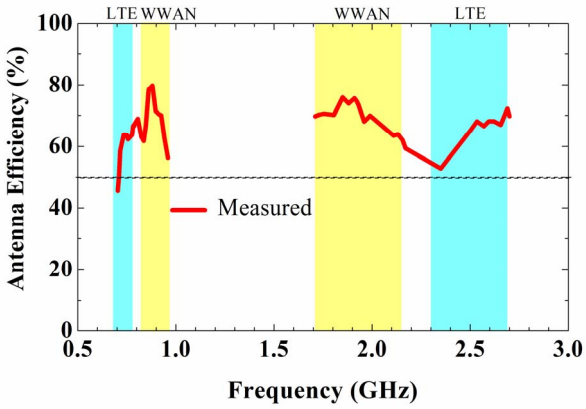

Fig. 4. Measured antenna efficiency, including the mismatch loss.

The measured antenna efficiency, which includes the mismatch loss, is shown in Fig. 4. The measured antenna efficiency in a far-field anechoic chamber reached approximately 45%–80% in the lower band and approximately 52%–75% in the upper band, and these efficiencies are acceptable in mobile communication applications.

4. Conclusion

A novel small coupled-fed loop antenna integrated with the surrounding keyboard ground plane in a laptop computer is proposed. The antenna achieves LTE/WWAN dual-wideband operation in the 698–960 and 1710–2690 MHz bands with good antenna efficiency. Moreover, the proposed antenna can not only be integrated with the surrounding keyboard ground plane but also excite several resonant modes of the hinge slot to widen the operating bandwidths. The proposed antenna has a compact size when printed on a 0.8-mm-thick FR4 substrate 40 mm × 8 mm in size.

References

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