A Compact Triple Band Antenna for a Wireless USB Dongle

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Abstract

A compact monopole antenna possessing triple resonance (f_1, f_2, f_3) characteristics for (USB) dongle applications is presented. The resonance characteristic f_1 is determined by the overall length of the antenna. The monopole antenna acts as the main radiator for f_3 as well as the coupling feeding structure for the parasitic resonators in f_1, f_2 . The resonance characteristic f_2 is achieved by a combination of the capacitance formed by the coupling between the top and bottom parasitic substrate resonators and the inductance generated by a via bridging the two parasitic resonators.

Key words: Monopole Antenna, (USB) Dongle Application.

I . Introduction

Because of the rapid development of wireless communication technology, recent research has focused on compact multiband antennas. Among these structures, multiband antennas for USB dongles are of particular interest because they are portable and enable the easy exchange of information based on a simple plug and play interface. Accordingly, several triple band antennas for USB dongle applications have been studied [1]~[4]. In [1] and [2], the triple band is formed by a coupling between a monopole antenna and a parasitic resonator positioned on the bottom of the substrate. In [3], in order to cover the 2.4 GHz band, an inverted-F antenna is used; its ground uses two slots, one for the 3.5 GHz band and the other for the 5.5 GHz band. In [4], a structure that has various current paths obtains different resonances through two strips added to a rectangular radiating element fed asymmetrically by a trapezoidal ground plane. However, the size of these structures is not suitable for wireless USB dongle applications.

This paper presents a triple band monopole antenna for wireless USB dongle applications. The authors have previously presented a dual-band antenna resonating at 2.4/5.2/5.8 GHz for wireless USB dongle applications [5]. The design of the proposed antenna is based on the structure outlined in [5]. A parasitic resonator in the bottom of the substrate is added to the proposed antenna and is connected to the top parasitic resonator by a via,

which enables the 3.5 GHz band for WiMAX service to be added to our previous dual-band (f_1, f_3) antenna. In addition, because the top parasitic resonator is folded into a P-shape, the size of the proposed antenna is reduced by 50 % compared to the monopole antenna found in [5].

II . Antenna Geometry

As Fig. 1(a) shows, the proposed antenna is composed of a monopole antenna and a parasitic radiator. The monopole is bent down to the substrate with the aim of reducing the space occupied by the antenna and effectively controlling the coupling to the parasitic radiator. In addition, the top parasitic resonator is folded into a P-shape. In order to obtain 3.5 GHz resonance, a parasitic resonator is added to the bottom of the substrate and is connected to the top parasitic resonator by a via, unlike the structure found in [5]. Figs. 1(b) and (c) show top and bottom views of the antenna, respectively. The radiator, which is fabricated on a FR4 substrate with a thickness of 0.8 mm and a permittivity of 4.4, is designed as a non-GND that is equivalent to 20 mm×10 mm for efficient radiation; the antenna occupies an area equal to 10 mm×10 mm. The antenna is fed through a 50 Ω coaxial cable. The width of all the antenna lines except for W_1 is set at 0.9 mm in order to simplify the design. The distance between the monopole and the parasitic radiator is set at g . In this study,

Manuscript received February 16, 2012 ; Revised April 12, 2012 ; Accepted April 13, 2012. (ID No. 20120216-004J)
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Fig. 1. (a) 3D structure, (b) top view, (c) bottom view.

the optimized antenna has the following design parameters: $L_1=6.6$ mm, $L_2=6.6$ mm, $L_3=3.4$ mm, $W_1=3$ mm and $g=0.5$ mm. An Ansoft High Frequency Structure Simulator (HFSS V12) based on a finite element method FEM is used for the simulation.

III. Simulated and Measured Results

Fig. 2 shows the simulated and measured reflection coefficients of the proposed antenna. In this graph, the notation “without bottom parasitic resonator” indicates that the bottom parasitic resonator is removed from the proposed antenna and “without via” indicates that the via linking top and bottom parasitic resonators have been removed from the proposed antenna. Comparison of the

Fig. 2. Simulated and measured reflection coefficients of the proposed antenna.

(a) Variation in lengths L_1

(b) Variation in lengths L_2

Fig. 3. Simulated reflection coefficients of the proposed antenna with different lengths L_1 and L_2 .

reflection coefficients of these modified structures and the entire proposed antenna structure shows that f_2 is formed by the coupling capacitance and the via inductance between the top and bottom parasitic resonators. The comparison also shows that when f_1 decreases, f_3 increases by the bottom parasitic resonator. The measured results show that the antenna covers a 4.9 % bandwidth (2.38~2.5 GHz) at f_1 , an 8.5 % bandwidth (3.4~3.7 GHz) at f_2 , and a 17.86 % bandwidth (5.1~6.1 GHz) at f_3 , thus allowing WLAN/WiMAX service.

Fig. 3 shows the simulation results of the reflection coefficient as a function of the different parasitic resonator lengths L_1 and L_2 . The simulation results show that as L_1 and L_2 decrease, f_3 is only slightly influenced, whereas f_1 and f_2 increase. Fig. 4 shows the simulation results of the reflection coefficient as a function of the different parasitic resonator lengths L_3 . As the simu-

Fig. 4. Simulated reflection coefficients of the proposed antenna with different lengths L_3 .

lation results show, a decrease in L_3 affects f_3 more than f_1 and f_2 . However, f_1 and f_2 are hardly influenced when L_3 increases from 4.5 mm to 5.5 mm and 6.6 mm. At this time, the impedance matching deteriorates but the bandwidth increases from 10.19 % (5.68~6.29 GHz) to 18.67 % (5.05~6.09 GHz).

Fig. 5 shows the measured 2D radiation patterns of the proposed antenna at 2.44 GHz, 3.56 GHz, and 5.35 GHz, respectively. The radiation patterns are measured in the xy plane, the xz plane, and the yz plane. Omnidirectional radiation patterns are displayed in the azimuthal plane (xz plane) at 2.44 GHz, 3.56 GHz, and 5.35 GHz. The xy plane and yz plane at 2.44 GHz show that although the measured cross-pol is slightly higher than the simulated cross-pol, it has the same pattern as the monopole. Because the cross-pol supplements the co-pol well, the antenna has a completely omnidirectional radiation pattern. The measured maximum gains at 2.44 GHz, 3.56 GHz, and 5.35 GHz are 0.65 dBi, 1.82 dBi, and 3.1 dBi, respectively.

IV. Conclusion

This paper presents a compact monopole antenna for wireless USB dongle applications. The monopole antenna is coupled to the parasitic radiator, which enables its double resonance (f_1 , f_3) to be easily obtained at 2.4 GHz and 5.5 GHz. In order to produce a third 3.5 GHz band, a parasitic resonator is added to the bottom of the substrate and is connected to the parasitic resonator positioned on the top of the substrate through a via. In this manner, the proposed antenna covers the WiMAX (3,400~3,600 MHz) and WLAN IEEE 802.11 a/b/g/n (2,400~2,497 MHz, 5,150~5,350 MHz, 5,725~5,825 MHz) bands with a reflection level less than -10 dB.

Fig. 5. Measured radiation patterns of the proposed antenna.

The antenna occupies a 10 mm×10 mm area, and the total size of the substrate is 20 mm×50 mm. Therefore, it is appropriate for compact wireless USB dongle applications.

This work was supported by Kyonggi University Research under Grant 2011.

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