Design of an Internal Antenna for USB dongle Application

Yeonsik Yu, Uisheon Kim, Youngki Lee and #Jaehoon Choi
Division of Electronics and Computer Engineering, Hanyang University
17 Haengdang-Dong, Sungdong-Gu, Seoul, 133-791, Korea
E-mail: choijh@hanyang.ac.kr
#corresponding author
Tel. +82-2-2220-0376, Fax. +82-2-2293-0377

1. Introduction

Demand for various digital devices with access to multimedia or wireless internet services has increased in recent years. However it is impossible that a single digital device covers all the emerging new services. The conventional universal serial bus (USB) dongles [1] are attractive for providing the plug-and-play function in digital devices such as mobile phone, PMP, PDA, laptop etc.. For that reason, using USB dongle with various services, we do not have to worry about buying new digital devices again.

To provide multiple services using a single terminal, multiband or wideband antenna technologies need to be applied. In addition, the use of an internal antenna is the overwhelming trend for digital devices. Recently, USB dongle antenna providing various communication services such as mobile communications [2] and ultra-wideband (UWB) [3-5] were reported. However, reported antennas are not suitable for USB dongle application because of their large antenna volume and ground size, which can not be incorporated within the limited space available for USB dongle application.

In this paper, we propose an internal inverted-F antenna having enough bandwidth to cover future wireless communication services. Additionally, it is promising that the proposed antenna can be embedded into the case of USB dongle as an internal antenna.

2. Antenna Design

Figure 1 shows the configuration of the proposed internal antenna for USB dongle. The proposed antenna consists of an inverted-F antenna element with four stubs and a small system ground. As shown in Figure 1, the designed antenna with a compact size of 19 mm × 3 mm is printed on both sides of the substrate. The stub-1 near the longest arm of antenna element is L-shaped. The stub-2 which is folded near feed point is introduced on the back side of the substrate. The L-shaped stub-3 and I-shaped stub-4 are located along the short edge. The antenna element and all stubs have a fixed width of 1 mm. It is printed on a FR4 substrate with a volume of 19 mm × 45 mm × 1 mm. The antenna is fed by a 50 Ω line which is connected across the feed gap (1 mm) between the antenna and system ground. The system ground plane of the USB dongle is chosen to have the width of 19 mm and the length of 40 mm, which are reasonable dimensions for general USB dongle.

The dual resonances near 2.3 GHz and 5.6 GHz are generated by the inverted-F antenna element. To enhance the impedance bandwidth, various shaped stubs are added. Figure 2 demonstrates the simulated return loss characteristics to investigate the effect of stub-1 and stub-2 in lower band. By adding stub-1 and stub-2, the first resonant frequency is lowered and impedance bandwidth is widened. Figure 3 shows the tuning capability for upper band resonance frequency. The change in L_{sh} and the existence of stub-3 and stub-4 make the higher resonant frequency lowered and the impedance bandwidth widened. The designed antenna provides independent tuning capability for each band.

The proposed antenna is designed and analyzed using the Ansoft High-Frequency Structure Simulator (HFSS V11) [6]. The final dimensions of an internal inverted-F antenna are as follow: L_{st1} = 14.5 mm, L_{st2} = 15 mm, L_{st3} = L_{st4} =1.5 mm, L_{sh} = 16.5 mm.

3. Result

Figure 4 shows simulated and measured return loss characteristics of the implemented antenna. The proposed antenna simultaneously satisfies the 10 dB return loss requirement for Wibro (2.3 GHz – 2.39 GHz), WLAN (2.4 GHz – 2.483 GHz and 5.15 GHz – 5.825 GHz), WiMAX (2.5 GHz – 2.7 GHz) and S-DMB (2.605 GHz – 2.655 GHz) bands. Figure 5 shows the radiation patterns for the designed antenna at 2.3 GHz, 2.4 GHz, 2.5 GHz and 5.6 GHz. The measured radiation patterns are close to omni-directional radiation patterns in all bands. Figure 6 shows the measured antenna gain against frequency. The antenna gain is varying from about 2.74 to 3.96 dBi across the service bands.

4. Conclusion

A compact internal inverted-F antenna is proposed. The antenna has wide bandwidth covering WiBro, WLAN, WiMAX and S-DMB bands. It is observed that the wide impedance bandwidth is obtained by adding stubs to the radiating element. Since the size of the designed antenna is small enough to satisfy the constraint imposed on the USB dongle application and independent tuning is possible for each band, it can be a good candidate for future wireless applications.

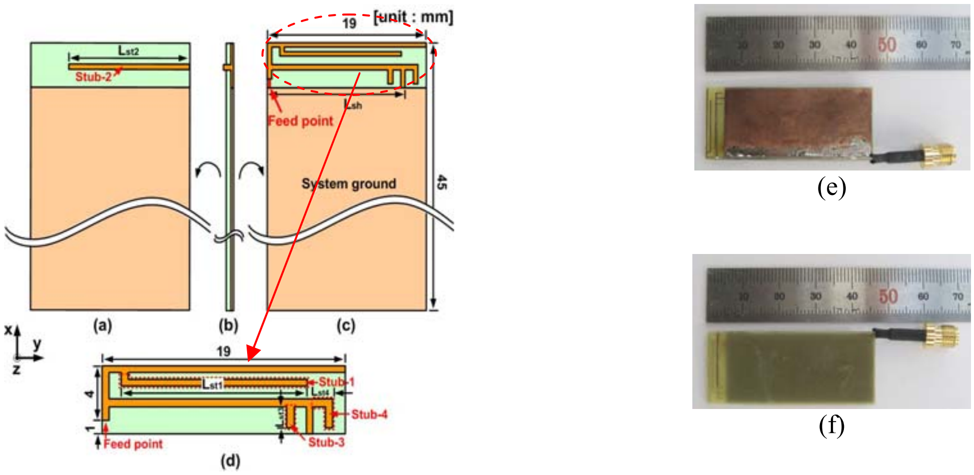


Figure 1: Geometry of the proposed antenna (a) bottom view, (b) side view, (c) top view, (d) antenna view and photograph of the fabricated antenna (e) front view, (f) back view

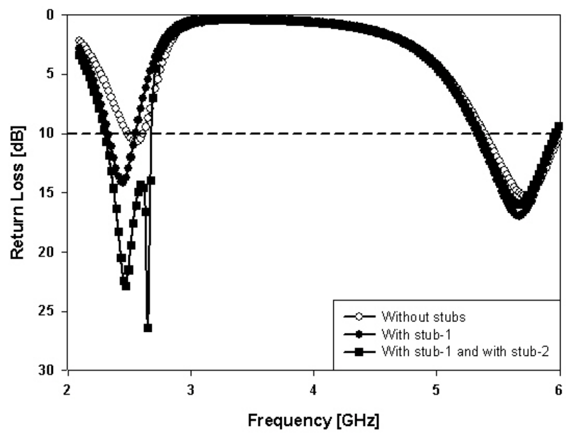


Figure 2: Comparison of simulated return loss characteristics with and without stub-1 and stub-2

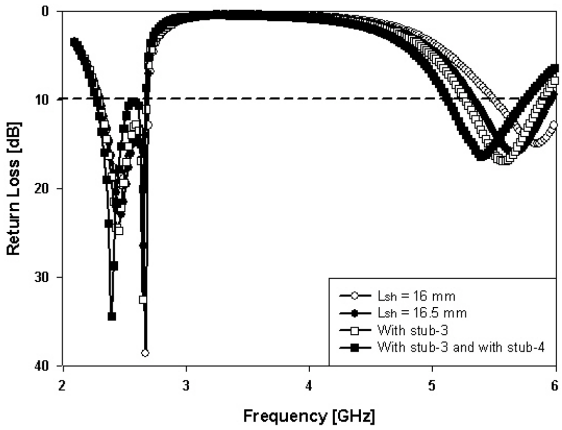


Figure 3: Simulated return loss characteristics for various L_{sh} values and with and without stub-3 and stub-4 [The inverted-F antenna with stub-1 and stub-2]

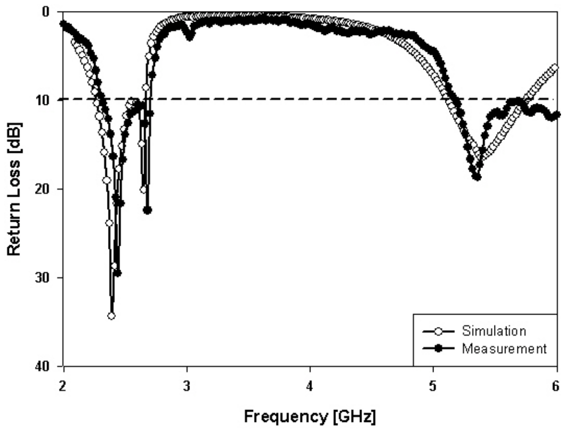
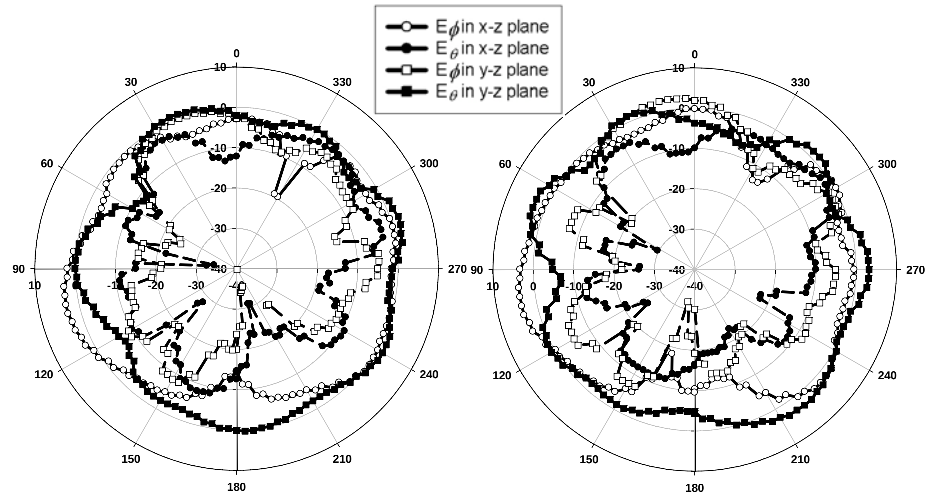
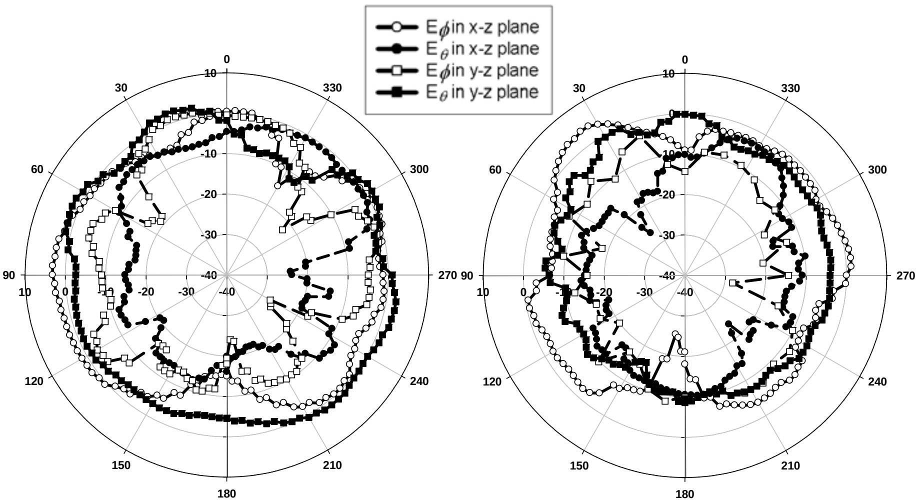


Figure 4: Comparison of simulated and measured return losses of the optimized antenna



(a) (b)



(c) (d)

Figure 5: Measured radiation patterns of the proposed antenna: (a) 2.3 GHz, (b) 2.4 GHz, (c) 2.5 GHz, (c) 5.6 GHz

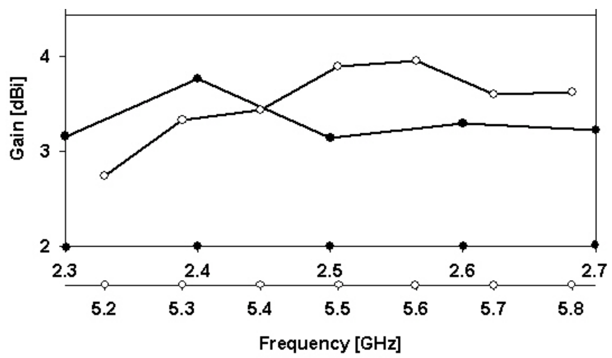


Figure 6: Measured antenna gain of the proposed antenna

Acknowledgments

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