A Compact Band Notched UWB Antenna for Mobile Applications

Nam-I Jo, Dang-Oh Kim, and Che-Young Kim
School of Electrical Engineering and Computer Science, Kyungpook National University
Sankyuk-dong Puk-gu, Daegu 702-701, South Korea

Abstract—In this paper, a compact circular UWB (ultra-wideband) antenna with WLAN 802.11a/n band (5.15∼5.825 GHz) rejection characteristic is proposed for the mobile applications. The proposed UWB antenna was compact enough to be loaded into a mobile handset. The performance of the suggested antenna is mostly dependent on the gap between circular radiator and the ground plane. In order to have the band notched operation, the CSRR (complementary split ring resonator) is etched inside the circular patch of the UWB antenna.

MWS (Microwave Studio) of CST company was utilized in the design stage. The antenna was constructed on a substrate, Rogers 4003, with the thickness of 0.8 mm and relative permittivity of 3.38. A size of substrate is $24 \times 37.5 \text{ mm}^2$ and a radius of circular radiator is 5 mm long. The proposed antenna covers the frequency band from 3.2 to 10.6 GHz ($S_{11} \leq 10 \text{ dB}$), and the band rejection occurs about 5.7 GHz band. A simulation shows the maximum gain of 5.2 dBi, and radiation pattern is nearly omni-directional over the entire $-10 \text{ dB}$ return loss bandwidth. It also represents the group delay below 1 nsec over UWB communication band (3.2 GHz ∼ 10.6 GHz) except WLAN band. Based on the experimental results, the proposed antenna could be a good candidate for the handheld mobile handsets.

1. INTRODUCTION

Since the Federal Communications Commission (FCC) released the ultra-wideband communication band 3.1 ∼ 10.6 GHz in 2002, the various type of UWB antenna has been developed for use in the wireless communication system [1]. One popular application of the UWB communication is the field of mobile multimedia system due to its high data rate. However, the high data rate demands the wide bandwidth, inevitably loosing stringent protection from the interference such as the wireless LAN (WLAN) colocated band at 5.2 GHz/5.8 GHz [2]. Thus it is essential to have a wide bandwidth together with the specified band stop. Some published UWB antennas reveal a good behavior for a relaxed size. However, they are too cumbersome to be integrated into smaller sized mobile device. In other words, it necessitates extra space as a ground and circuit plane to be fitted into the real sized mobile handset. Hence, a key challenge in the design of mobile UWB antenna is adapting both to a wide bandwidth with rejection band and to a smaller dimension. In this paper, a compact mobile UWB antenna with band notched characteristic is proposed. Band notched characteristic is achieved by embedding complementary split ring resonator (CSRR) slots on the radiator. As compared with the published antennas in [3] and [4], the size of the proposed antenna is miniaturized by more than about 50% in the similar performance.

2. ANTENNA DESIGN

Figure 1(a) and the left antenna in Figure 1(b) show the geometry of the proposed UWB antenna. The proposed antenna has been fabricated on a substrate, Rogers 4003, with the thickness of 0.8 mm and relative permittivity of 3.38.

The width of the feed line at input of the proposed antenna is 1.8 mm long providing 50 Ω characteristic impedance. As shown in the Figure 1, the antenna consists of a circular patch, CSRR, and modified partial ground plane. By using the Microwave Studio of CST company, the optimized parameters are found to be $\text{Cir.} R = 5 \text{ mm}$, $W = 4 \text{ mm}$, $L = 1 \text{ mm}$, and $\text{Gap} = 0.58 \text{ mm}$. Figure 1(b) illustrates the size comparison between the proposed (left antenna) antenna and the traditional (right antenna) antenna published. The circular radiator of proposed antenna is about half smaller than that of the published UWB antenna. The size reduction becomes the crucial point in the implementation process of mobile handset.

The geometry of the CSRR and the equivalent circuit of the CSRR are shown in Figure 2. The equivalent circuit of the CSRR is a sort of the LC resonant circuits with the inductance and the distributed capacitance [5].
The equivalent circuit model of the Figure 2(b) is the same as the resonant circuit of the band rejection filter connected $L, C$ in parallel. Its resonance frequency can be expressed as [6]

$$\omega_o = \sqrt{\frac{2}{\pi r_o LC}}$$

Figure 1: The geometry of the proposed UWB antenna, (b) photograph of the proposed UWB antenna (left), and traditional UWB antenna (right).

Figure 2: (a) The geometry of the CSRR, (b) the equivalent circuit of the CSRR.

where $L$ is the inductance per unit length between the annular slots, $C$ is the total capacitance of the CSRR, and $r_o$ is the average radius of the two annular slots [6]. The parameters of the CSRR used in proposed antenna are $R_{1} = 3.3$ mm, $G_{1} = 1$ mm, $G_{2} = 1.5$ mm and $G_{3} = 0.5$ mm.
3. RESULT AND DISCUSSION

Figure 3 represents the simulated and measured return loss curve. The measured return loss is very close to those of simulated results. The proposed antenna has an impedance bandwidth (reference level $S_{11} < -10\, \text{dB}$) from 3.2 to 10.6 GHz rejecting the 5–6 GHz band. By adjusting the gap between the circular radiator and the ground plane, the wideband could be achieved. In particular, by adjusting $W$ and $L$ of the ground plane, the band above 9 GHz was duly obtained.

![Return Loss Curve](image1)

Figure 3: Simulated and measured return losses.

![Radiation Patterns](image2)

(a) (b)

Figure 4: Simulated radiation patterns (a) $E$-plane, (b) $H$-plane.

![Group Delay](image3)

Figure 5: The measured group delay of the proposed antenna.
Figure 4 is the radiation patterns simulated at 4, 6, and 8 GHz, respectively. It can be seen that the antenna exhibits a nearly omni-directional radiation pattern in the $H$-plane ($xz$-plane) and a dipole like radiation pattern in the $E$-plane ($yz$-plane), which possesses the suitable pattern as a mobile antenna.

The group delay measured by Anritsu 38397C vector network analyzer is plotted in Figure 5. A group delay is an important parameter carrying information on a pulse dispersion. Except for the rejection band, spreading over the range of UWB communication, the group delay variation is less than 1 ns ensuring a proper operation as the mobile UWB antenna.

4. CONCLUSION

This article described the compact band notched UWB antenna for the mobile handsets. The CSRR is used to achieve a band-notched characteristic and the gap between the circular radiator and the ground plane has been introduced to provide the wideband performance. With the noted techniques, the proposed antenna offers wideband (3.2~10.6 GHz) operation and band (5~6 GHz) notched characteristic together with size reduction essential to the mobile phones. These benefits are confirmed by the simulation and the measurement on the fabricated UWB antenna.

REFERENCES