Miniaturized High-band UWB Monopole Antenna

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***Abstract* – Recently, position sensing systems using radio frequency has attracted much attention. Especially, High-band ultra-wideband (UWB) system (7.5 - 10.25GHz) which has high range resolution about several cm is expected to many applications of over the variety of fields, such as medical, human and food trace not only wireless communication. The purpose of this study is to obtain the high-band UWB antenna which is composed of a single metal layer and to miniaturize the UWB antenna for high-band UWB application.**

***Index Terms* — UWB, high-band, coplanar waveguide, single layer, monopole antenna.**

I. Introduction

After the Federal Communications Commission (FCC) in the United States released unlicensed frequency band (3.1 - 10.6GHZ) for commercial communication application [1], many UWB antennas was reported and applied to the system. In Japan, frequency band of the UWB system is divided into low-band (3.4 – 4.8GHz) and high-band (7.25 – 10.25GHz) because interference from the 5GHz-band wireless LAN (IEEE 802.11a) systems become a serious problem. In particular high-band UWB is suitable for position sensing because this frequency can be used with license free and high resolution. There are a lot of researches about the full-band UWB antennas [2], however those of the high-band UWB antennas are almost no reports.

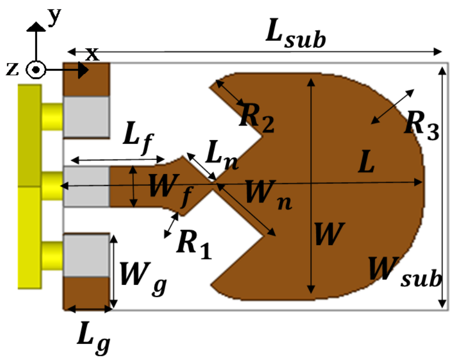
Moreover 3D integration or stacking of the multilayer of the printed circuit board has been focused. Therefore, the antenna which is composed of a single metal layer is required for cost effective and thin devices. Also UWB antenna generally used for position sensing is required to be a flat gain and omnidirectional radiation pattern.

In this paper, we designed miniaturized high-band UWB antenna for position sensing application. In order to realize the single metal layer, coplanar waveguide (CPW) is applied as a feed line. We designed and simulated the frequency response of our proposed antenna by using the commercial electro-magnetic field simulator (Ansoft; HFSS, ver.13). We also fabricated the high-band UWB antenna by using FR4 printed circuit board and measured reflection coefficient and radiation patterns.

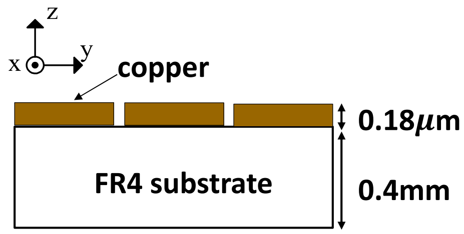
II. Antenna Design

Fig. 1 shows the layout and cross section of the proposed miniaturized monopole antenna for high-band UWB. The substrate of the antenna is 0.4mm thick FR4 ($\varepsilon_r = 4.4, \tan\delta = 0.02$) with 18μm thick top layer of the metal (Cu). As shown in Fig. 1 (b), this antenna is composed of a single layer of the metal by using CPW feed line. This antenna is designed with the size of 8.5mm × 6mm which is about 25% size reduction compared to previous research [3].

In order to improve the reflection coefficient of the pass band especially in the high-band, current path lengths are optimized by inserting the notches and by changing the notch width (W_n) (see Fig. 1 (a)). Fig. 2 shows the simulated surface current density without notches at 9.5GHz. The location of the notches are determined by the position of the maximum current density. Fig. 3 shows the W_n dependence of the reflection coefficient of proposed antenna. In Fig. 3, wide band impedance matching is realized at $W_n = 1.6$mm.



(a) Top view



(b) Side view

Figure 1. Design of the single antenna.

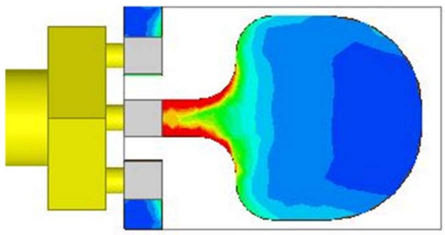


Figure 2. Simulation result of the current distribution without notches at 9.5GHz.

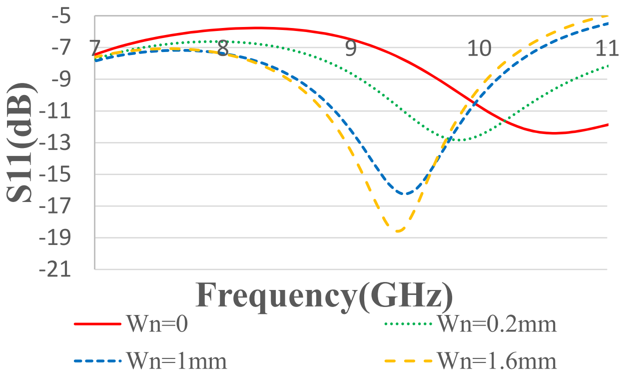


Figure 3. Variation of the return loss by changing W_n

III. Antenna Fabrication and Measurement Results

Fig. 4 shows the photograph of the proposed high-band UWB monopole antenna. Antenna size is 8.5mm × 6mm and the dimensions of the antenna is determined as L_{sub} = 8.5mm, L = 8 mm L_f = 2 mm, L_g = 2 mm, L_n = 0.9 mm, W_{sub} = 8.5 mm, W = 5.5 mm, W_f = 1 mm, W_g = 1.85 mm, W_n = 1.6mm. Fig. 5 shows the return loss of the measured and simulated results of the proposed antenna. Because of the non-uniformity of the dielectric constant of the substrate, center frequency of the measured results is shifted to lower side. However, the pass band of the measured results almost satisfies the high-band UWB system. Simulated return loss of the proposed antenna is equal to or smaller than -7dB in all of the high-band. Measured return loss of the proposed antenna is equal to or smaller than -7dB in 8.1 to 9.75GHz.

Fig. 6 shows the measured and simulated radiation patterns in y-z plane co-polarization at 9GHz. Measured result of radiation pattern is similar to that of the simulation result. Our proposed antenna has an omnidirectional radiation patterns.

Figure 4. Photograph of the proposed antenna.

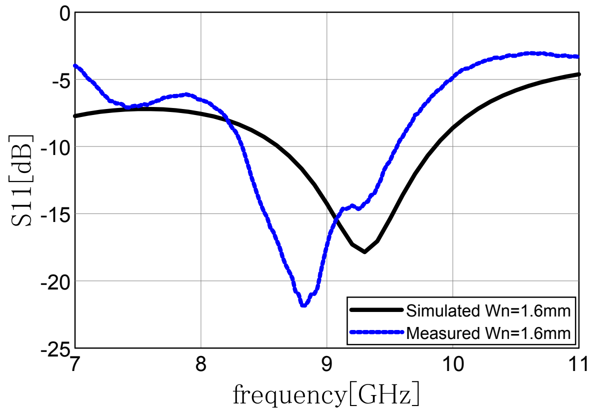


Figure 5. Measured and simulated return loss of the proposed antenna.

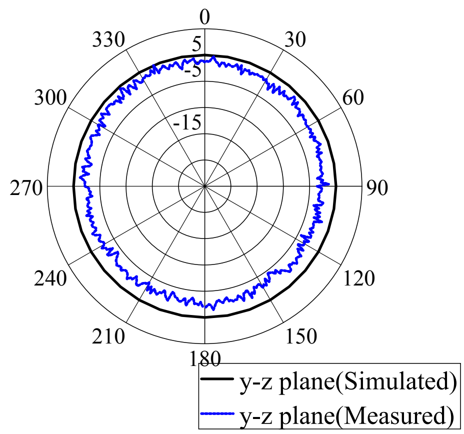


Figure 6. Measured and simulated radiation pattern of the proposed antenna.

IV. Conclusion

In this paper we designed the miniaturized high-band UWB antenna which size is 8.5mm × 6mm. Proposed antenna is composed of a single metal layer and CPW feed line is applied. By attaching the notches and optimize the size and position, wide band impedance matching is realized. Measured result of the return loss is equal to or smaller than -7dB in 8.1 to 9.75GHz with omnidirectional radiation.

References

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