A Simple CPW-Fed UWB Antenna Design

Sang-Yong Park · Seon-Jeong Oh · Jong-Kweon Park

Abstract

In this paper, we have described a simple CPW-fed UWB antenna for wireless UWB communication. The proposed antenna consists of two symmetrical strips having two steps and CPW feeding. Two techniques(symmetrical structure, two steps) are used to produce good low-dispersion and impedance matching. The proposed UWB antenna has an omni directional radiation pattern, compact size, low dispersion, and low cost.

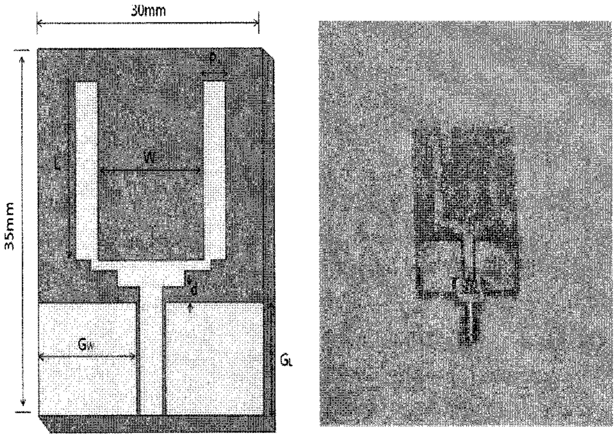
Key words : UWB Antenna, Symmetrical Strip, Omni Directional, Group Delay, Dispersion.

Ⅰ. Introduction

Ultra-wideband(UWB) technology has attracted much attention for potential use in short-range high-speed wireless communication applications. In February 2002, the FCC allocated 7.5 GHz of spectrum(3.1~10.6 GHz) for unlicensed use of communication applications. There are two main approaches: multiband orthogonal frequency division multiplexing(MB-OFDM) and direct-sequence code division multiple access(DS-UWB). The DS-UWB approach uses three spectral modes of operation: low-band(3.1~5.15 GHz), high-band(5.825~10.6 GHz), and multiband(low-band plus high-band). The MB-OFDM approach divides its full band(3.1~10.6 GHz) into 14 sub-bands, each with a bandwidth of 528 MHz. The MB-OFDM approach uses the lower three bands(3.1~4.8 GHz) as a mandatory mode[1]. The antenna for this UWB system requires an omni directional radiation pattern, compact size, low dispersion, and low cost.

Antenna designers have focused on the design of the antennas having compact, low-profile, and much wider bandwidth. The simple monopole is well-known for its radiation bandwidth but limited by the impedance bandwidth. Many techniques like U-type, notched ground, circular fractal, F-shaped etc., are proposed to increase impedance bandwidth. Recently, many kinds of UWB antennas, such as rectangular[2], trapezoidal[3], planar monopole[4]~[8], planar dipole[9], and Sierpinski sieve fractal[10], have been proposed and studied. In [11], the microstrip UWB antenna is proposed and analyzed in the time domain.

In this paper, we will focus on the simple CPW-fed UWB antenna design in the MB-OFDM system over 3.1~4.8 GHz(lower three bands). We have proposed a simple CPW-fed UWB antenna with two symmetrical strips for wireless UWB communications. The proposed antenna consists of two symmetrical strips having two steps and CPW feeding(see Fig. 1). Two techniques(symmetrical structure and steps) are used to produce low dispersion and good impedance matching. The Ansoft high-frequency structure simulator(HFSS)[12] is used to simulate the proposed antenna. The measured results of the fabricated prototype will be given and compared with the simulated results. The measured results show that the proposed antenna can cover the lower three MB-OFDM bands(3.1~4.8 GHz). The designed UWB antenna has an omni directional pattern. The variation of the group delay is less than 0.5 ns, and the path loss is almost constant across the operating frequency band.



(a) (b)

Fig. 1. (a) Geometry of the proposed UWB antenna, (b) photograph of the fabricated antenna.

Ⅱ. Antenna Design and Simulated/Measured Results

Fig. 1(a) shows the geometry of the proposed ante-

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nna. The starting point of this design is the rectangular UWB patch antenna reported in [2]. The proposed antenna consists of two symmetrical strips having two steps and a 50 Ω-CPW feeding printed on the substrate of a 1.6-mm FR4 epoxy(dielectric constant, 4.4, and loss tangent, 0.025). To design the proposed antenna, we have used two techniques: symmetrical structure and two steps. The symmetrical structure is utilized to lessen the group delay variation and dispersion. If the two strips are not symmetrical with respect to the center, the group delay variation is large and results in considerable dispersion over the operating frequency band. Two steps are used for good impedance matching. The optimum design parameters are as follows: W=14 mm, L=17 mm, d=1.5 mm, G_w=13.1 mm, P_w=3 mm, and G_L=11 mm. The dimensions of the first step are W_1=9 mm and L_1 =1.5 mm. The dimensions of the second step are W_2=16 mm and L_2=1 mm. Fig. 1(b) shows the photograph of the fabricated UWB antenna.

The prototype of the proposed antenna was constructed and measured. The antenna was measured using an Anritsu Vector Network Analyzer(37397C) in an anechoic chamber. Fig. 2 shows the measured and simulated return losses(S_{11}) versus frequency for the proposed antenna. The measured results agree highly with the simulated results. As shown in Fig. 2, the proposed UWB antenna has between 2.8 and 6.0 GHz of bandwidth below −10 dB(VSWR is 2:1). To evaluate the dispersion performance of the UWB antenna, the path loss($|S_{21}|$) and the group delay are simulated and measured.

Fig. 3(a) and 3(b) show the measured path loss and group delay of the UWB antenna. As shown in the

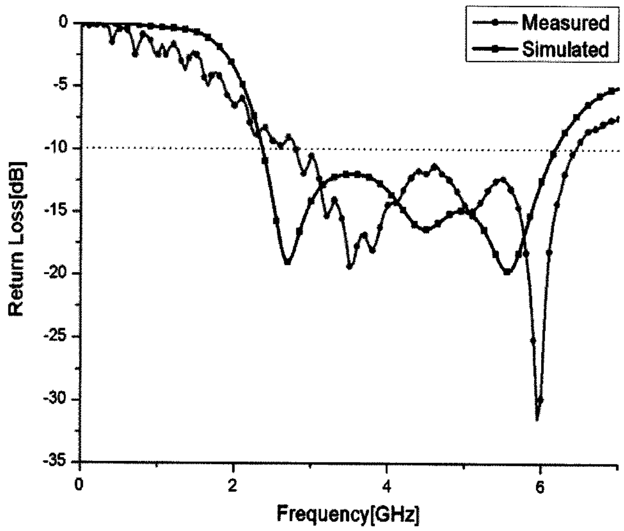
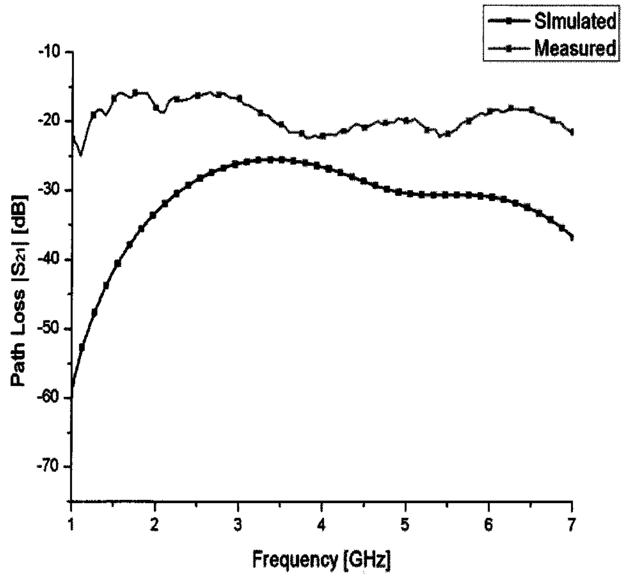
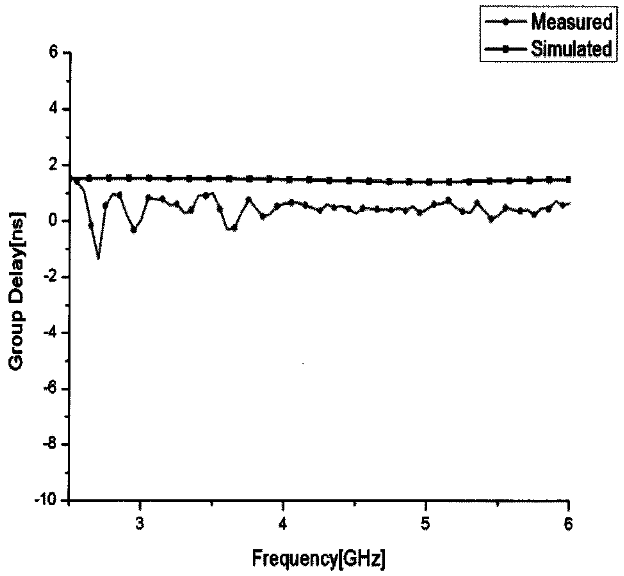


Fig. 2. Measured and simulated return losses for the proposed antenna.



(a) Path loss(|S21|)



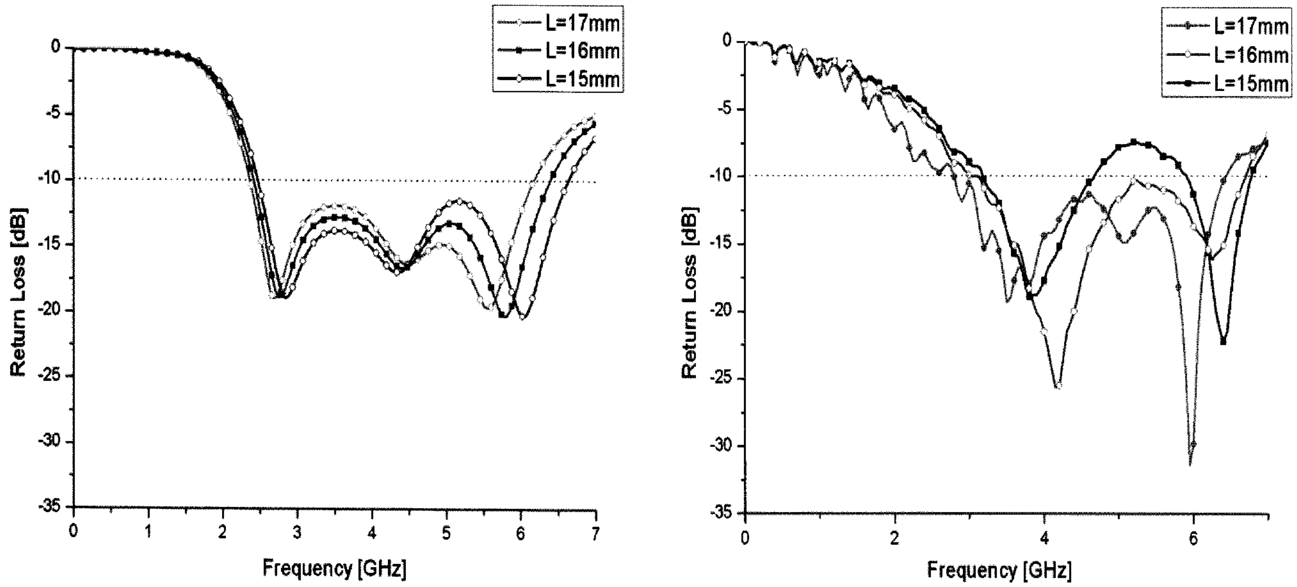
(b) Group delay

Fig. 3. Measured and simulated results of the antenna.

figure, the variation of the measured group delay is less than 0.5 ns, and the path loss is almost constant across the operating frequency band. This means that the UWB antenna has very low dispersion and, thus, is suitable for UWB communication applications.

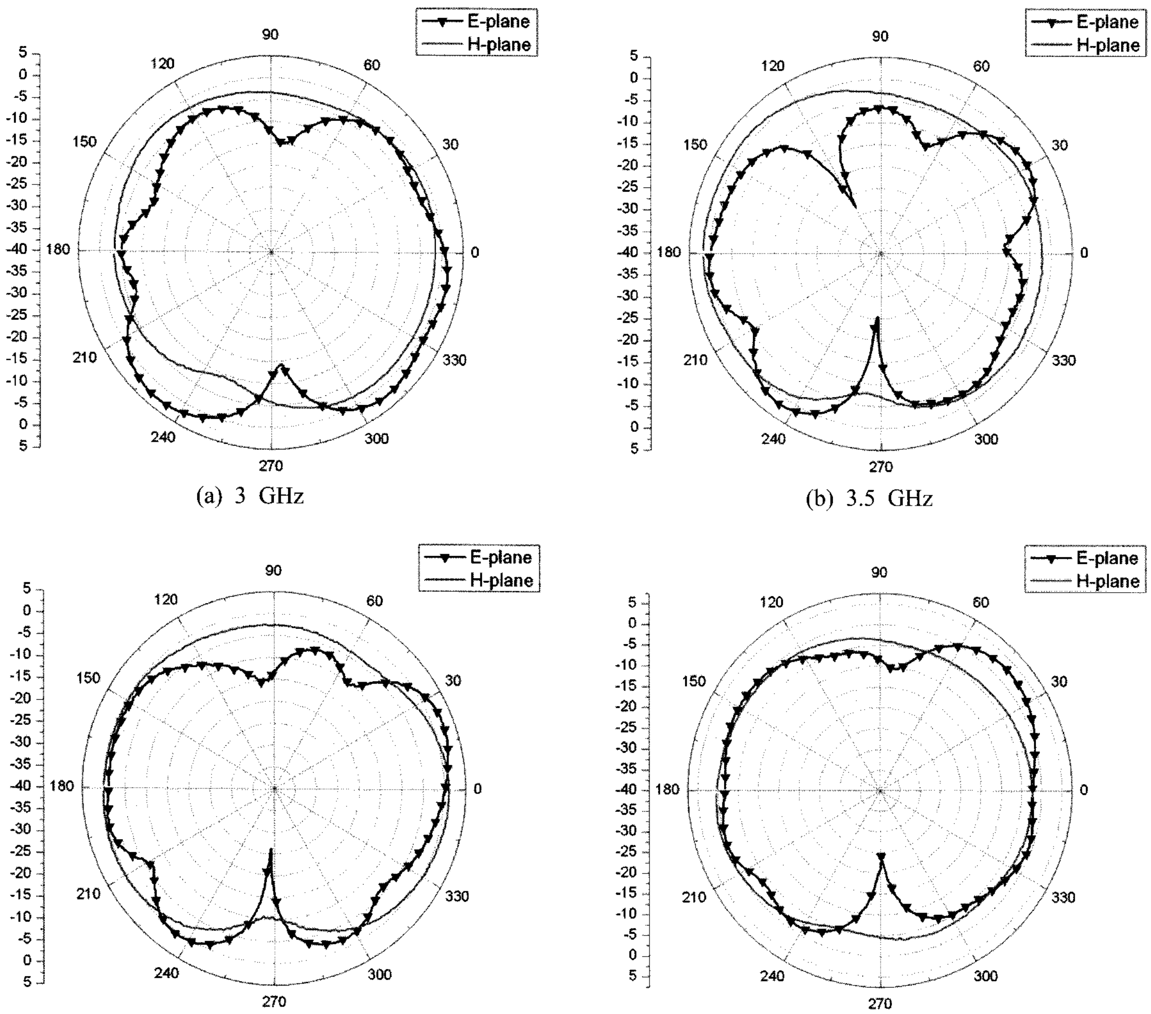
For the measurement(Fig. 3), the distance between the two antennas is 30 cm and the antenna orientation is face-to-face. A satisfactory agreement is observed between the measured and simulated results.

We have studied the effects of the strips on the return loss. Fig. 4 shows the variation of the return loss versus frequency as a function of the strip length L. From this figure, we can show that as L is increased, the −10 dB impedance bandwidth is slightly increased. Fig. 5 shows



(a) Simulated results (b) Measured results

Fig. 4. Return losses versus frequency for the different size of *L*.



(a) 3 GHz (b) 3.5 GHz (c) 4 GHz (d) 4.7 GHz

Fig. 5. Measured radiation patterns.

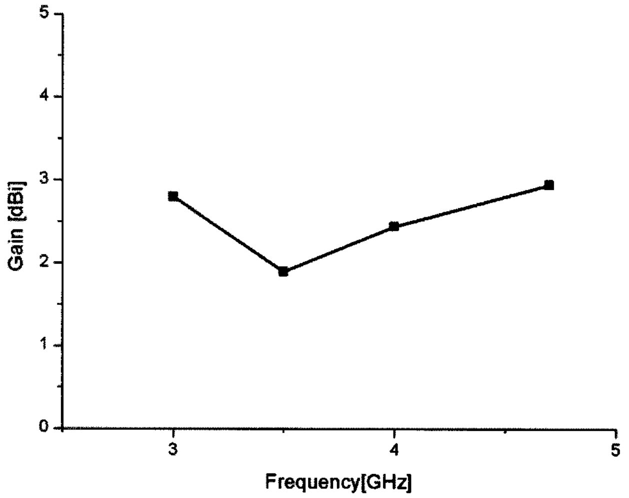


Fig. 6. Measured antenna gain of the proposed UWB antenna.

the measured radiation patterns at 3, 3.5, 4.0, and 4.7 GHz. The radiation patterns are somewhat similar to the dipole radiation patterns. Fig. 6 shows the measured antenna gain of the proposed antenna versus frequency.

As can be seen from the figure, the gain of the antenna varies from 1.8 dBi to 3 dBi over the operating frequency range, and the antenna gain variation is 1.2 dBi.

Ⅲ. Conclusion

A simple low-dispersion UWB antenna using two symmetrical strips has been proposed and studied. The proposed antenna covers the MB-OFDM lower three bands (3.1~4.8 GHz). The proposed antenna has an omni directional pattern, constant gain and group delay over the frequency band, simple structure, and compact size. Thus, the proposed antenna is suitable for UWB applications.

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[12] HFSS, High-Frequency Structure Simulator ver. 10, Finite-element package, Ansoft Corporation.

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