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Design and Implementation of UWB CPW-Fed Planar Monopole Antenna with Dual Band Rejection Characteristics

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1. Introduction

With the development of high-speed switching technology, ultra-wideband (UWB) systems in high-performance wireless technology is receiving more attention. In February 2002, the Federal Communications Commission (FCC) issued a ruling that UWB systems could use an unlicensed frequency band ranging from 3.1 GHz to 10.6 GHz for data commutations, radar, and other applications so long as their radio signals satisfy a set of spectral masks for indoor and outdoor environments (Nie & Chen, 2008; Maeng et al., 2009).

However, the design of antennas for UWB applications faces many challenges. Interference is a serious problem for UWB application systems. The rejection of interference with some existing narrowband wireless services, such as IEEE 802.11a (5.15~5.825GHz) wireless local area network (WLAN) systems and IEEE 802.16 (3.3~3.8GHz) World Interoperability for Microwave Access (WiMAX) systems are necessary for UWB application systems. One way to suppress these interfering signals is to use a spatial filter such as a frequency selective surface above the antenna. However, this approach requires too much space.

Recently, many UWB antennas have been proposed in an attempt to overcome the interference problem using frequency band rejection design. The most popular approaches for an antenna design with frequency band rejection are embedding slots (Jyoti et al., 2010; Su et al., 2010; Zhang et al., 2010). However, most of these designs have single band-notched characteristics for the rejection of the WLAN band or WiMAX band. Only a few articles addressed the dual or multi-band rejection designs (Abdollahvand et al., 2010; Hassani et al., 2011; Mei et al., 2010; Wei et al., 2011).

Obtaining highly efficient band-notch characteristics is a challenging issue. The main problem of the frequency band rejection design is the difficulty of controlling the bandwidth of the notch band in a limited space. Furthermore, strong coupling between two adjacent notch bands is obstacle to achieve efficient dual band-notched UWB antennas. Therefore, an efficient frequency bands rejection of the WLAN band and WiMAX band is difficult to implement for UWB applications.

In this chapter, we propose an ultra-wideband coplanar waveguide (CPW)-fed planar monopole antenna with dual band rejection characteristics. The proposed antenna consists of a microstrip patch with U-n slot (Yang, 1999, 2002). It can achieve a wide bandwidth of 3.0~11.0GHz for voltage standing wave ratio (VSWR) of less than 2, with dual band rejection

of 3.15~3.79GHz and 5.13~5.85GHz. Firstly, we present the basic structure for the proposed antenna in section 2. The simulation and measurement results will be presented in section 3 and the conclusion follows in section 4.

2. Proposed antenna

Fig. 1 shows the geometry of the proposed CPW-fed monopole antenna with dual band rejection characteristics, and the parameters of the proposed antenna are presented in Table 1. The antenna is fabricated on an inexpensive FR4 substrate with a dielectric constant of 4.4 and a thickness of 1.60 mm. A CPW transmission line with W_{10} = 3.00 mm and a gap distance of W_{11} = 1.00 mm between the single strip and two planar ground planes are used for feeding the antenna. Two ground planes, which have the same size of W_9 = 17.50 mm × L_{10} = 29.00 mm are symmetrically placed on each side of the CPW line. The proposed antenna has an U-n slot; a n-shaped slot for band rejection with L_5 = 1.2 mm, L_8 = 6.0 mm, W_3 = 18.0 mm, W_4 = 16.0 mm and U-shaped slot with L_6 = 1.2 mm, L_7 = 5.0 mm, W_5 = 12.0 mm, W_6 = 8.0 mm.

The proposed CPW-fed antenna structure is easy to implement with a printed circuit board. The CPW-feeding for the antenna in Fig. 1 is designed for 50 Ω input impedance. The use of U-n slot can lead to produce an additional surface current path and thus we obtain ultra-wideband operations with dual band rejection characteristics.

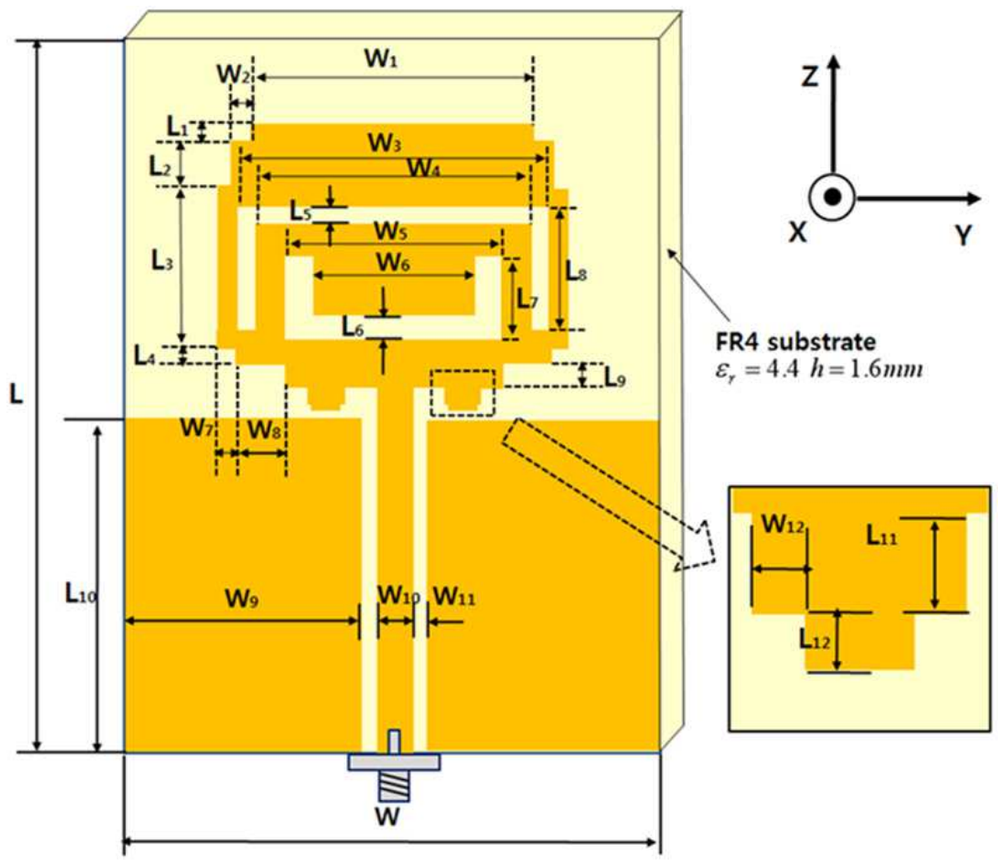


Fig. 1. Geometry of the proposed antenna.

Parameter	Length(mm)	Parameter	Length(mm)
W	40.0	L	52.0
W_1	16.0	L_1	1.0
W_2	1.0	L_2	4.0
W_3	18.0	L_3	9.9
W_4	16.0	L_4	1.0
W_5	12.0	L_5	1.2
W_6	8.0	L_6	2.0
W_7	1.0	L_7	5.0
W_8	3.0	L_8	6.0
W_9	17.5	L_9	1.8
W_{10}	3.0	L_{10}	29.0
W_{11}	1.0	L_{11}	0.8
W_{12}	0.2	L_{12}	0.2

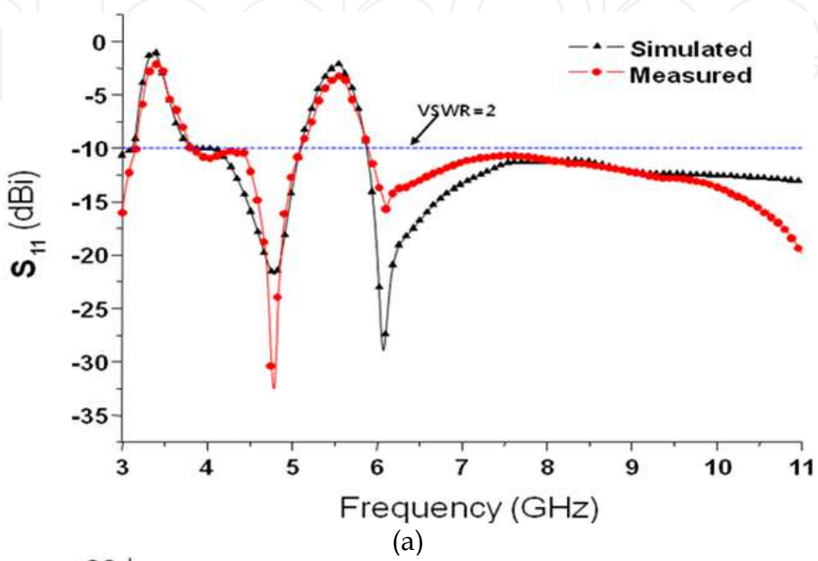
Table 1. Design parameters of the proposed antenna.

3. Simulation and measurement results

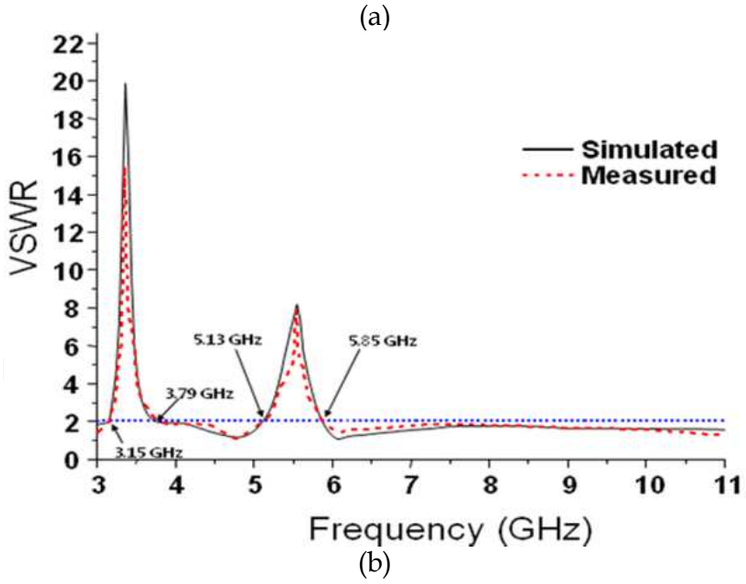
The electrical characteristics of the proposed antenna were simulated using the High Frequency Structure Simulator (HFSS) of Ansoft. The implementation of the CPW-fed monopole antenna with dual band rejection characteristics is shown in Fig. 2.

Fig. 2. Photograph of the implemented antenna.

The measurements of the electrical characteristics, such as the radiation patterns, VSWR and return loss, of the implemented antenna were conducted in an anechoic chamber equipped with an HP 8510C network analyzer and a far field measurement system. Fig. 3 shows the S_{11} and VSWR characteristics. The S_{11} of the design example is shown in Fig. 3(a), which demonstrates that the proposed antenna covers the frequency band of 3.0 ~ 11.0 GHz for VSWR<2, except for its dual rejection bands ranging 3.15~3.79GHz and 5.13~5.85GHz. Fig. 3(b) shows the VSWR of the design example.



(a)



(b)

Fig. 3. Simulated and measured electrical characteristics. (a) S_{11}, (b) VSWR.

Fig. 4 shows the measured antenna gain. The maximum measured gain of the design example is about 6.13 dBi at 10.6 GHz. The measured co-polarization and cross-polarization radiation patterns of the implemented antenna in the xy-plane and xz-plane at four different frequencies are illustrated in Fig. 5. The radiation patterns show that the antenna has omnidirectional radiation characteristics.

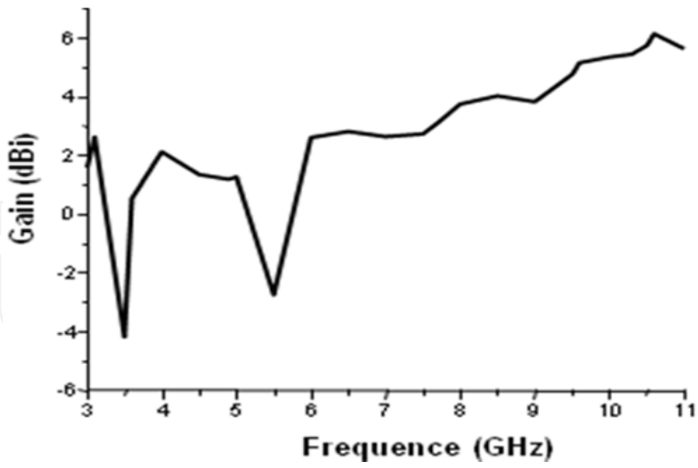
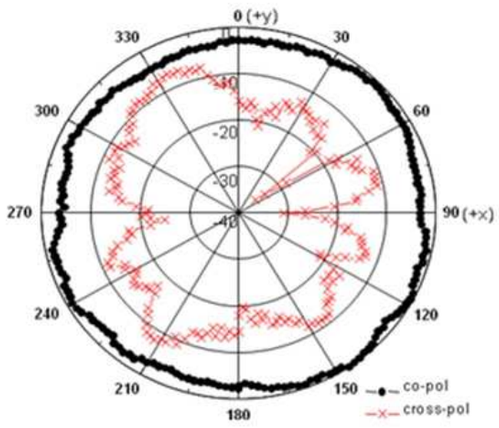
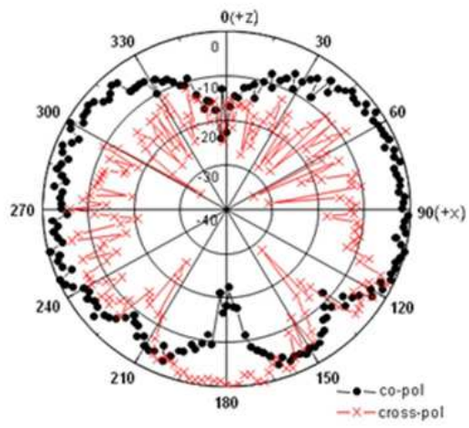


Fig. 4. Measured results for antenna gain of the design example.

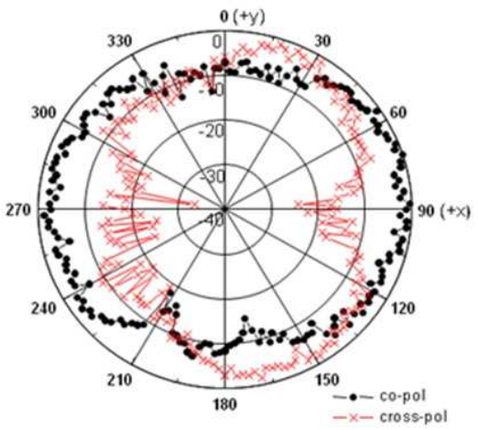


xy-plane

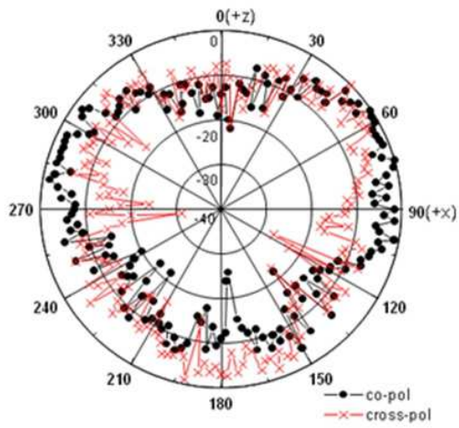


xz-plane

(a)

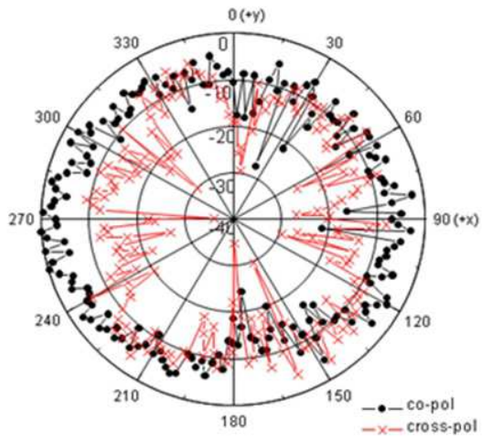


xy-plane

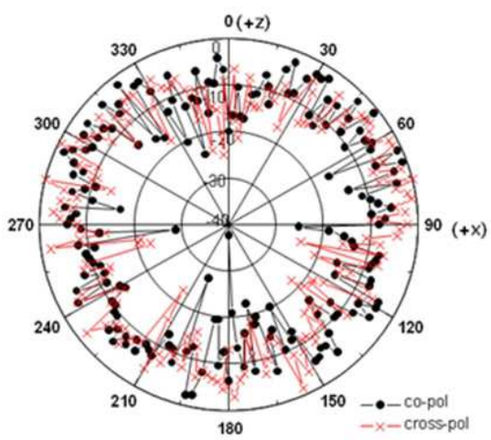


xz-plane

(b)

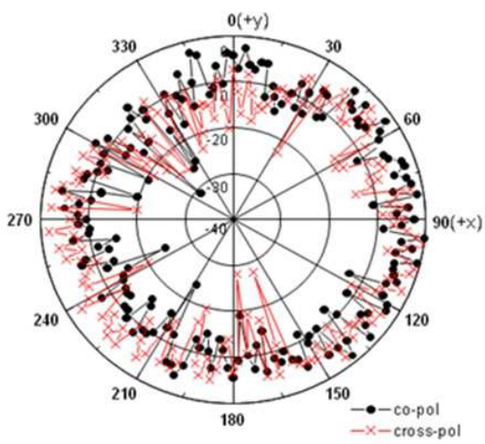


xy-plane

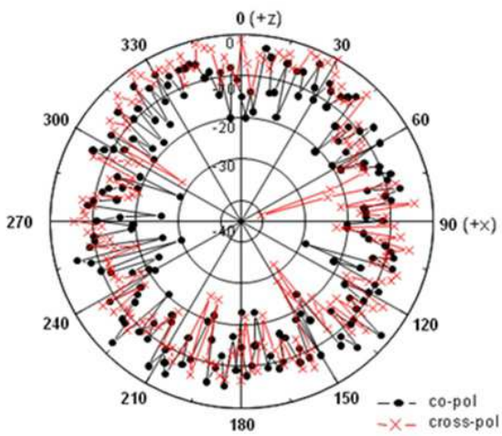


xz-plane

(c)



xy-plane



xz-plane

(d)

Fig. 5. Measured co-polarization and cross-polarization radiation patterns. (a) at 3 GHz , (b) at 6 GHz, (c) at 8 GHz, (d) at 11 GHz

4. Conclusion

We proposed an ultra-wideband CPW-fed planar monopole antenna with dual band rejection consisting of U-n slot. The CPW-fed planar monopole antenna provides extremely broadband characteristics with a planar compact structure, and the U-n slot has an effect on its band rejection characteristics. The measured results for the proposed antenna show that the frequency band of 3.0~ 11.0GHz is covered for VSWR<2, except for its dual rejection band ranging 3.15~3.79GHz and 5.13~5.85GHz, which is sufficient for UWB communication. The broadband antenna design is simplified by employing a CPW feeding structure and

good omnidirectional radiation patterns are obtained. The proposed antenna is suitable for use in UWB systems.

5. Acknowledgement

This work was supported by the University of Incheon Research Grant in 2010.

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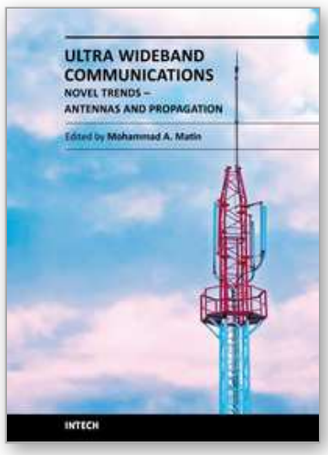

Ultra Wideband Communications: Novel Trends - Antennas and Propagation

Edited by Dr. Mohammad Matin

ISBN 978-953-307-452-8
Hard cover, 384 pages
Publisher InTech
Published online 09, August, 2011
Published in print edition August, 2011

This book explores both the state-of-the-art and the latest achievements in UWB antennas and propagation. It has taken a theoretical and experimental approach to some extent, which is more useful to the reader. The book highlights the unique design issues which put the reader in good pace to be able to understand more advanced research.

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