A Ground-Slot Loaded UWB Antenna with 5 GHz Band Notch Function

#Wen-Tsan Chung [1], Chow-Yen-Desmond Sim [2], and Ching-Her Lee [1]
[1] Department of Electronics Engineering, National Changhua University of Education
Changhua 500, Taiwan, m96642020@mail.ncue.edu.tw, iecher@cc.ncue.edu.tw
[2] Department of Electrical Engineering, Feng Chia University
Taichung 40724, Taiwan, cysim@fcu.edu.tw

1. Introduction

The Ultra-wideband (UWB) technology has attracted much attention recently especially in short-range mobile communication systems. The antenna design for this technology requires an operating band of 3.1-10.6 GHz, and to avoid interferences to the existing WLAN band (5.15-5.825 GHz) for IEEE 802.11 a/b/g, one simple method is to modify the structure of the UWB antenna. For a printed monopole UWB antenna, the most commonly studied shapes to achieve UWB operation are circular and rectangular/square. To obtain a band-notched function at the 5 GHz band, the most commonly recommended methods are slot loading the radiating patch [1]. Other unusual techniques such as embedding a pair of symmetrical parasitic elements near the radiating patch [2], inserting a compact coplanar resonant cell (CCRC) on the coplanar waveguide feed line [3], and loading a pair of slits on the ground plane [4] have also been reported recently.

In this paper, a novel and compact microstrip-fed printed monopole antenna with a band-notched characteristic for UWB applications is proposed. To achieve UWB performance, a patch antenna with an octagonal shape is studied first. Then by simply embedding a pair of symmetrical thin L-shaped slots in the ground plane of this proposed antenna, a band rejection in the frequency band of 4.95 to 5.98 GHz is attained. The time-domain performance of this antenna is also studied to ensure that this proposed antenna is applicable to any short-range UWB systems.

2. Antenna Design

The geometry of the proposed UWB antenna is presented in Fig. 1. This microstrip-fed UWB antenna is printed on a 30 × 30 mm^2 FR4 substrate (with thickness 1.6 mm and relative permittivity 4.4), and the dimensions of the ground plane are 30 × 10.5 mm^2. To achieve bandwidth optimization, the gap between the octagonal patch and the ground is set at 1 mm. An octagonal patch with a side length of 7 mm and a vertical radius of 8.5 mm measured from the centre of the patch is selected for achieving the required UWB. Two L-shaped slots are embedded at both sides of the ground plane, and the width of both slits are fixed at 0.5 mm. Note that an open-ended slot (3 × 3 mm^2) is also embedded in the ground plane, located directly under the microstrip feed line for impedance matching purposes.

3. Results and Discussion

The measured and simulated results of the return loss for the optimized dimensions are shown in Fig. 2. In this figure, the measured result relates well with the simulated one. It is also apparent that the proposed antenna is able to operate between the UWB required band (3.1-10.6 GHz) for VSWR < 2 (return loss below 10 dB), while excluding the 5 GHz notched band (4.95-5.98 GHz). The measured radiation patterns of the proposed antenna in the two principal planes for frequencies at 4, 7, and 10 GHz are plotted in Fig. 3. Nearly omni-directional patterns are observed at the x-z plane for 4 and 7 GHz. A large variation in the 10 GHz pattern is also observed which could be due to the distortion or noises generated from the measurement equipment at this frequency. The peak antenna gains for the proposed band-notched UWB antenna and its counterpart without a band-notched function (without L-shaped slots) are presented in Figure 4. This measurement shows a drastic reduction in peak gain of around 8.5 dB for the proposed antenna in the notched band of around 5.2 GHz, as compared to its counterpart without the notched function.

In the design of a UWB communication system, a constant and stable group delay with respect to the frequency is vital; otherwise, temporal smearing of the signal will incur in the system. Fig. 5 presents both the group and phase variation of the proposed antenna. Except in the notched band, a group delay of less than 1 ns and a linear response in the phase delay are observed within the UWB operation. This measurement has further verified that the proposed antenna is suitable for any short-range UWB communication applications.

Acknowledgments

The authors will like to thank the members of the Institute of Antenna Engineers of Taiwan (IAET) for their support and consultation during the design of this antenna.

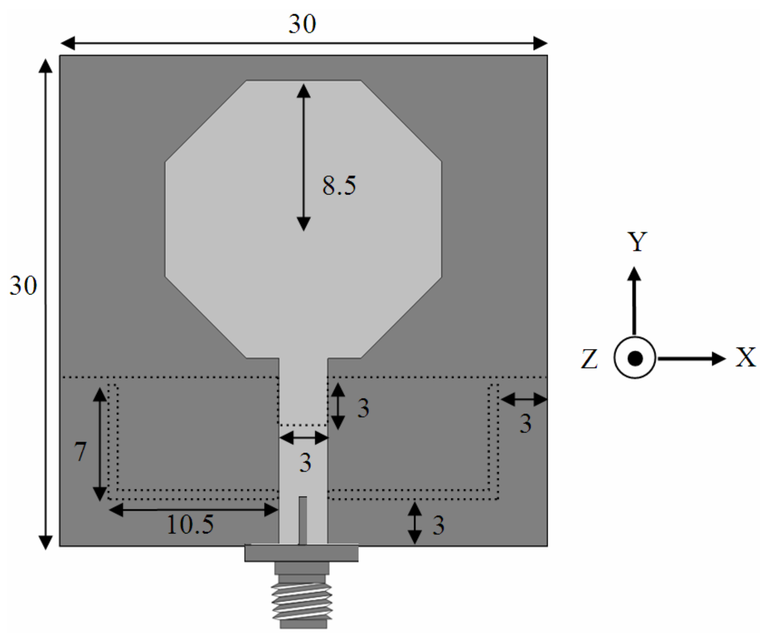

Figure 1: Geometry of the proposed band-notched monopole UWB antenna.

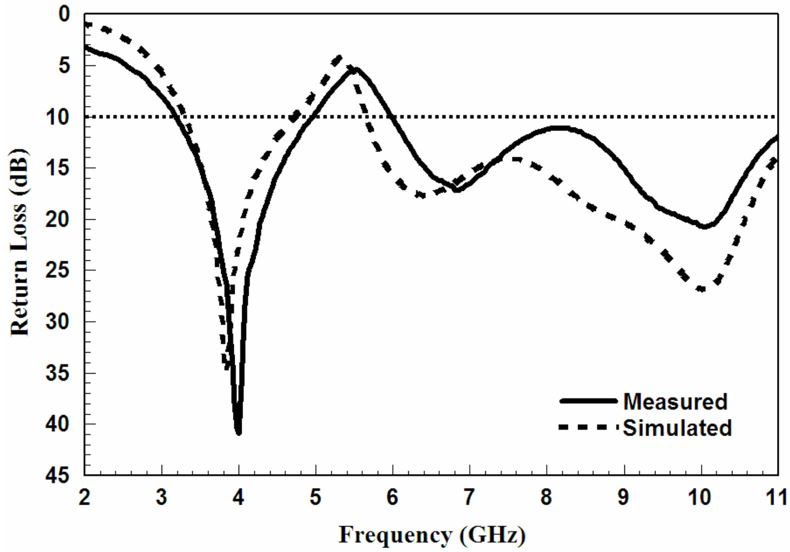

Figure 2: Comparison of measured and simulated return loss values.

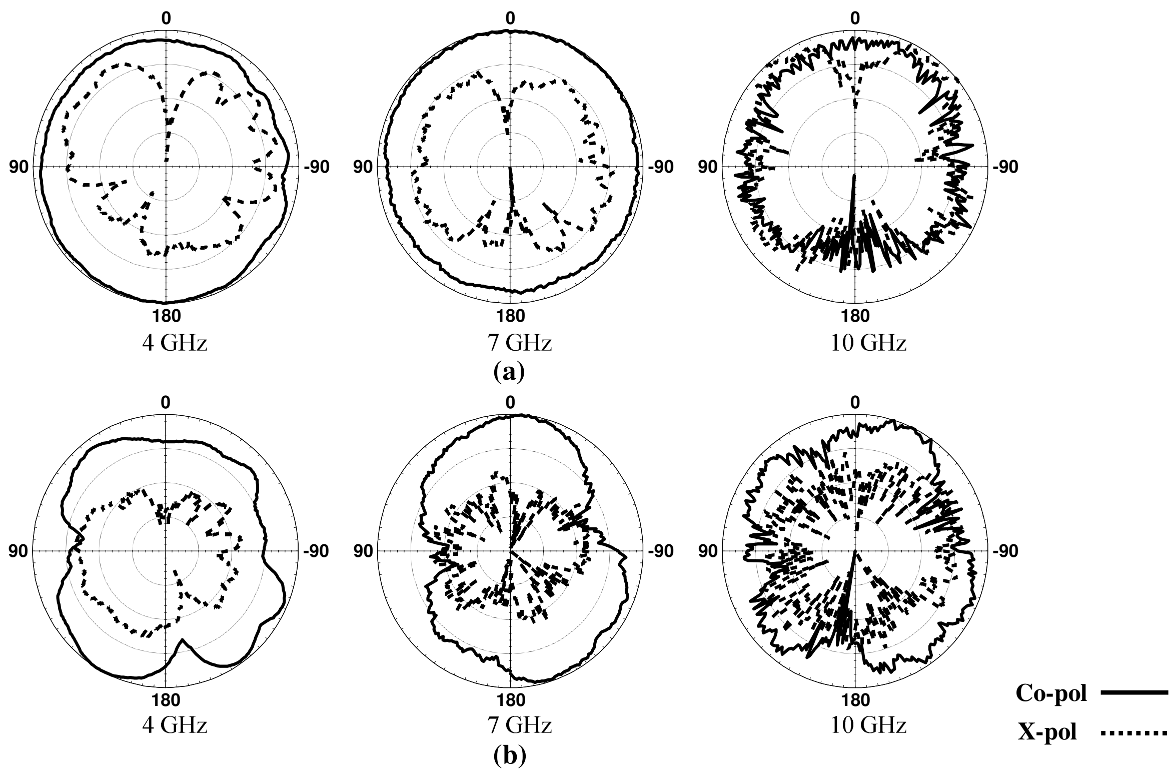

Figure 3: Measured radiation patterns at two principal planes: (a) XZ-plane patterns and (b) YZ-plane patterns.

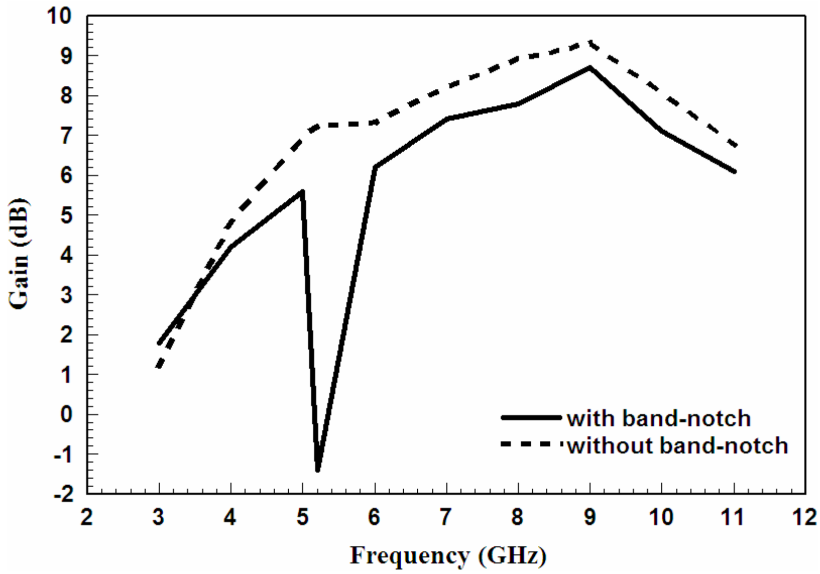

Figure 4: Measured antenna peak gain (with and without a band-notched function)

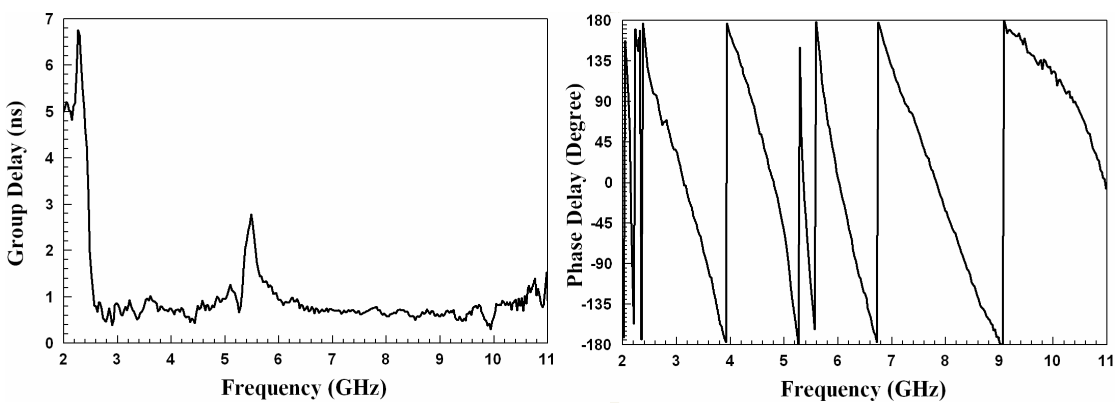

Figure 5: Group and phase delay measurement of the proposed antenna.

References

[1] J.N. Lee, J.K. Park, "Impedance Characteristics of Trapezoidal Ultra-wideband antennas with a notch function", Microwave and Optical Technology Letters, vol. 46, no. 5, pp. 503-506, Sep. 2005.

[2] K.H. Kim, Y.J. Cho, S.H. Hwang, S.O. Park "Band-notched UWB planar monopole antenna with two parasitic patches", Electronics Letters, vol. 41, no. 14, pp. 783-785,July 2005.

[3] S.W. Qu, J.L. Li, Q. Xue "A band-notched ultrawideband printed monopole antenna", IEEE Antennas and Wireless Propagation Letters, vol. 5, pp. 495-498, Dec. 2006.

[4] S.W. Su, K.L. Wong, "Printed band-notched ultrawideband Quasi-dipole antenna", Microwave and Optical Technology Letters, vol. 48, no. 3, pp. 418-420, Mar. 2006.