

## A NOVEL MINIATURE STRIP-LINE FED ANTENNA WITH BAND-NOTCHED FUNCTION FOR UWB APPLICATIONS

S. Tu, Y. C. Jiao, Y. Song, and Z. Zhang

National Laboratory of Antennas and Microwave Technology  
Xidian University  
Xi'an, Shaanxi 710071, P. R. China

**Abstract**—A novel compact strip-line fed UWB antenna with band-notched characteristic is proposed. By employing a balanced antipodal structure and strip-line feed, the size of this antenna has been reduced to only  $23\text{ mm} \times 27.5\text{ mm}$  with the dielectric substrate of relative permittivity 2.65. Meanwhile, a slot is added onto the radiating patch of the mid metalisation layer to realize the band-notched function, by tuning the length of which suitable rejected frequency band can be obtained. According to the measured results, the proposed antenna has a large bandwidth totally satisfying the requirement of UWB applications ( $3.1 \sim 10.6\text{ GHz}$ ) with good stable omnidirectional radiation patterns and gains except in the rejected frequency band ( $4.9 \sim 6.2\text{ GHz}$ ). Details of this antenna are described, and the experimental results of the constructed prototype are given, too.

### 1. INTRODUCTION

The ultra wideband (UWB) antennas provide high data transmission rate, low power consumption, and simple hardware configuration in communication applications such as RFID device, sensor net work, radar, and location tracking systems. Nevertheless, these systems are commonly required for the UWB antenna with compact size, low cost, and omnidirectional radiation [1]. In addition, to prevent the potential interference between the existing operating bands, such as WLAN ( $5.15 \sim 5.825\text{ GHz}$ ), band-notched function is appreciable and necessary for a good candidate UWB antenna.

---

Corresponding author: S. Tu (allenishere01@yahoo.com.cn).

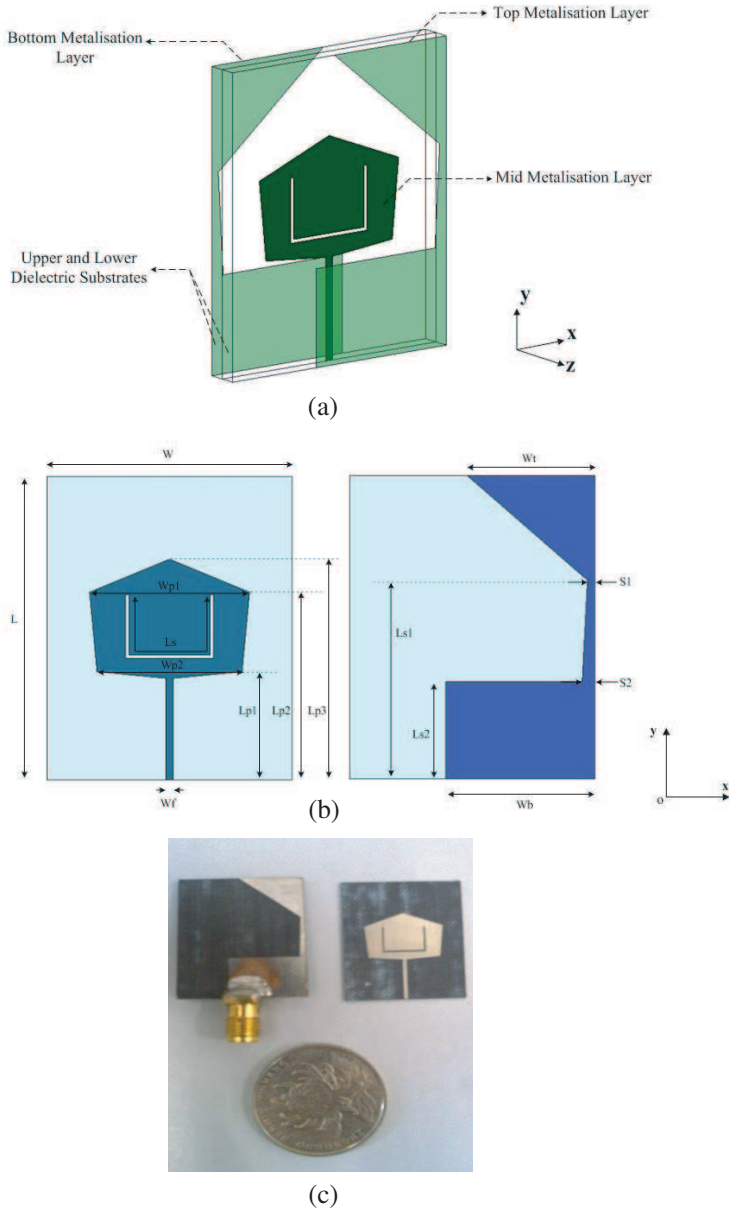
In this article, a novel band-notched UWB strip-line fed antenna with compact size is presented. By using the balanced antipodal structure and strip-line feed, compact size of this antenna ( $23 \text{ mm} \times 27.5 \text{ mm}$ ) is obtained. It has been reduced significantly, compared with the other reported UWB antennas, the sizes of which are commonly larger than  $30 \text{ mm} \times 30 \text{ mm}$  [2–6]. Moreover, to prevent the potential interference between the existing operating bands applied to WLAN ( $5.15 \sim 5.825 \text{ GHz}$ ), band-notched characteristic is realized by inserting a slot onto the mid-layer patch. The length of the slot controls the rejected band center frequency, by adjusting which suitable notched band can be achieved. According to the measured results, the operation bandwidth of the proposed antenna is from  $3.05 \text{ GHz}$  to  $12 \text{ GHz}$ , which is about  $4 : 1$ , and totally covers the UWB band ( $3.1 \sim 10.6 \text{ GHz}$ ). Stable omnidirectional radiation patterns and good gain except in the rejected band have also been obtained. Details of the antenna design are described and a theoretical and experimental investigation of the antenna is given as well.

## 2. ANTENNA DESIGN

Figure 1 shows the geometry of the proposed antenna. This antenna is fabricated on two dielectric substrates (upper and lower), both with the same size of  $27.5 \text{ mm} \times 23 \text{ mm}$ , the thickness  $h = 0.5 \text{ mm}$ , the relative permittivity  $\epsilon_r = 2.65$ , and  $\tan \delta = 0.002$ . As seen in Figure 1(a), the bottom and top metalisation layers are a pair of tapered antipodal wide slots, and it is a hexagonal patch with the strip-line on the mid metalisation layer. The slot on the hexagonal patch is added to realize the band-notched function, and by tuning the length of which the suitable rejected frequency band can be obtained. The design concept

**Table 1.** Dimensions of the proposed antenna.

THE RELATIVE PERMITTIVITY $\epsilon_r = 2.65$ , AND $\tan \delta = 0.002$			
$h$	0.5 mm	$Wf$	0.7 mm
$W$	23 mm	$Ls$	19.8 mm
$L$	27.5 mm	$Wt$	12 mm
$Wp_1$	15 mm	$Wb$	14 mm
$Wp_2$	13.6 mm	$Ls_1$	18 mm
$Lp_1$	9.2 mm	$Ls_2$	8.8 mm
$Lp_2$	17 mm	$S_1$	0.7 mm
$Lp_3$	20 mm	$S_2$	1.2 mm



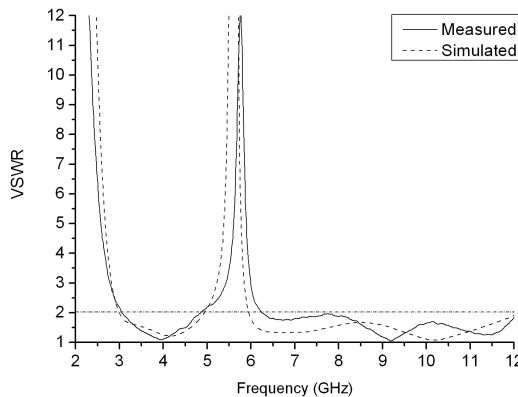
**Figure 1.** Geometry of the proposed antenna: (a) Schematic diagram; (b) Configuration; (c) Fabrication antenna.

of the notch function is to adjust the length of the embedded slots to be about half-wavelength at the desired notched frequency making the input impedance singular [7]. The variables of the designed antennas are marked in Figure 1(b). Since the top and bottom metalisation layers are of the same configuration, dimensions of only one of them are presented. The fabrication antenna is shown in the Figure 1(c). Further, the optimized values of all variables are given in Table 1 exactly.

### 3. SIMULATION AND EXPERIMENTAL RESULTS

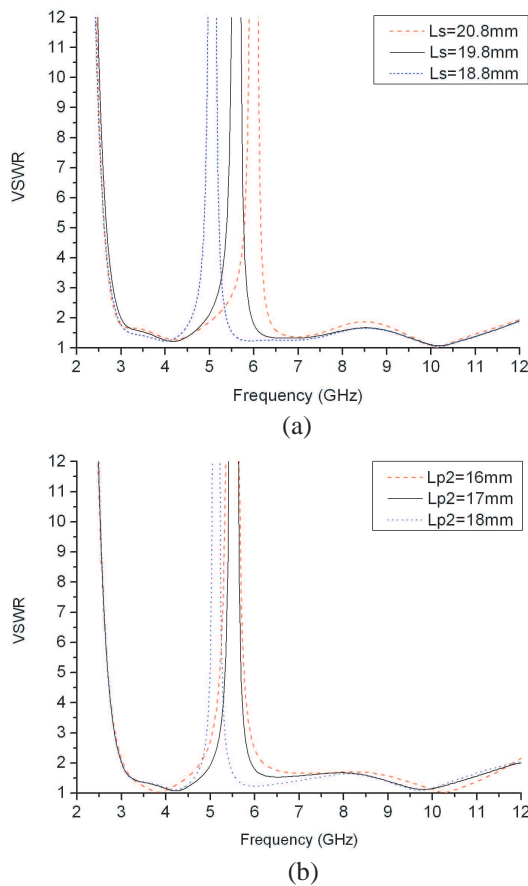
To understand the behavior of the proposed antenna modal and obtain the optimum parameters, the simulation was performed with Ansoft HFSS v11 except that the simulated radiation efficiency result was obtained by CST Microwave Studio 2006, and the measurement was carried out with a WILTRON37269A vector network analyzer after fabricated. Figure 2 depicts the simulated and measured VSWR performance of this antenna. It can be seen from the measured result that all frequency bands of UWB fulfill the requirement of  $VSWR \leq 2$  other than 4.9–6.2 GHz which covers the WLAN band (5.15 ~ 5.825 GHz). There is an agreement between the measured and simulated results.

Figure 3(a) indicates the simulated VSWR results for the proposed antenna in terms of diverse values  $L_s$ . The length of the slot added on

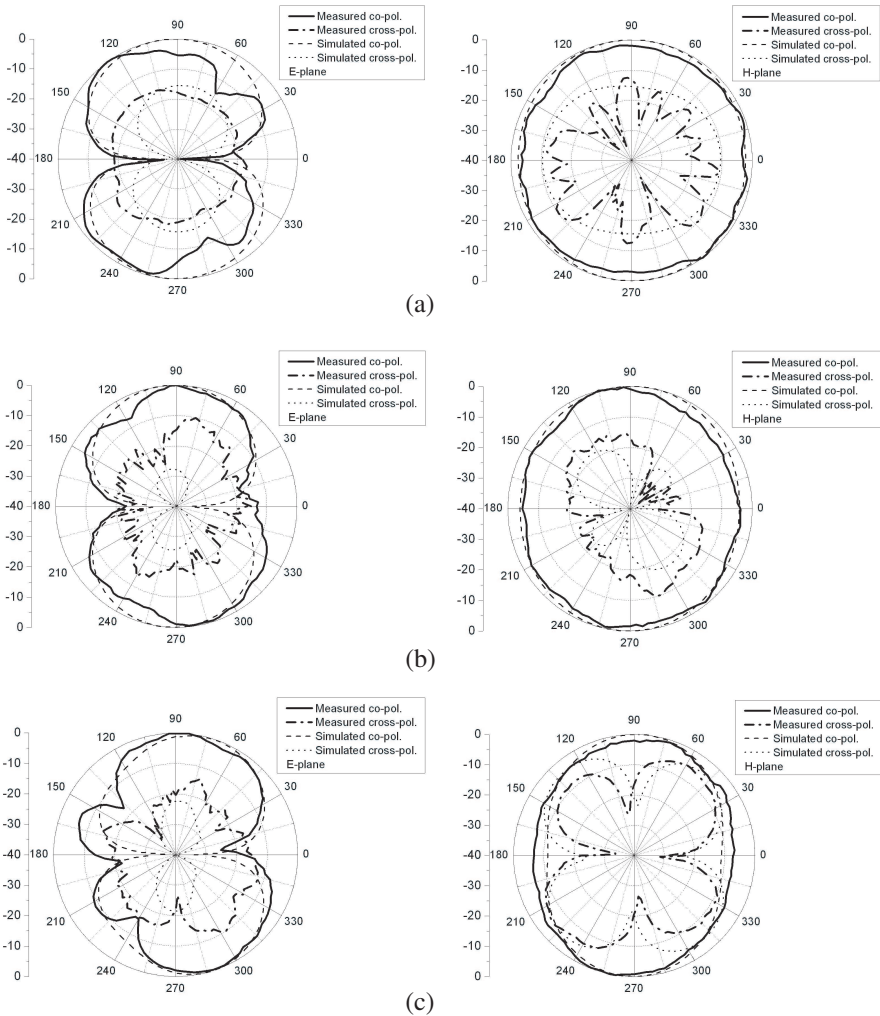


**Figure 2.** The comparison of the measured and simulated VSWR results.

the hexagonal patch of the mid metalisation layer controls the center frequency of the notched band. It can be concluded from the results that the rejected band can be easily adjusted by tuning the values of  $L_s$  with little influence on VSWR performance. Given the radiation pattern of this antenna, the symmetrical slot has been used to realize the band-notched function, therefore the location of the slot is mainly determined by the parameter  $L_{p2}$ . Figure 3(b) displays the simulated VSWR result in terms of different values  $L_{p2}$ , and  $L_{p2} = 17$  mm is finally chosen in this design. The measured radiation patterns at 3.5 GHz, 6.5 GHz and 9 GHz are presented in Figure 4, which indicates the radiation patterns of the proposed antenna at frequencies out of



**Figure 3.** Simulated VSWR results for the proposed antenna respectively in terms of (a)  $L_s$  and (b)  $L_{p2}$ ; other parameters keep the same as given in Table 1.



**Figure 4.** Measured and simulated  $E$  plane and  $H$  plane radiation patterns of the proposed antenna (10 dB/div) at (a) 3.5 GHz, (b) 6.5 GHz, (c) 9 GHz.

the rejected band are stable and omnidirectional in the  $E$ -plane ( $xy$  plane) and similar in the  $H$ -plane ( $yz$  plane) with its compact size.

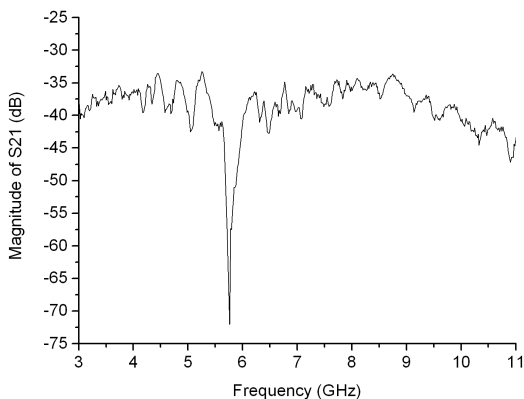
The antenna system is considered as a two-port network, and the transmission scattering parameter  $S_{21}$  which indicates the transfer function, is measured and shown in Figure 5. Pairs of proposed antennas are used as the transmitting and receiving antennas. The

transmitter and receiver are positioned face to face with a distance of 30 cm, longer than 15 cm mentioned in [12], which indicates that the proposed antenna can work in a larger area. It also should be noted that the measurement was performed in a real environment with reflecting objects in the surrounding area.

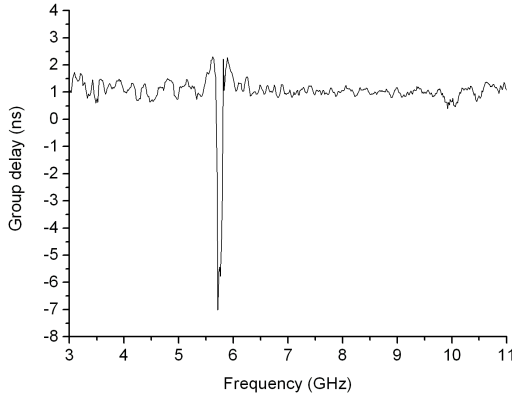
Figure 6 displays the measured group delay of the proposed antenna system. The variation of the group delay is within 1.0 ns across the whole UWB band except the notched band, in which the maximum group delay is more than 4 ns. The group delay corresponds well to the magnitude of  $S_{21}$ , which proves that the antenna has a good time-domain characteristic as well as a small pulse distortion. Additionally, the antenna peak gain in part of the operating band is shown in Figure 7, where a sharp gain decreases around 5.7 GHz, reflecting the effect of the dual band-notched characteristic. The radiation efficiency of this antenna is simulated by CST Microwave Studio 2006 and presented in Table 2.

**Table 2.** Simulated radiation efficiency of the proposed antenna versus frequency.

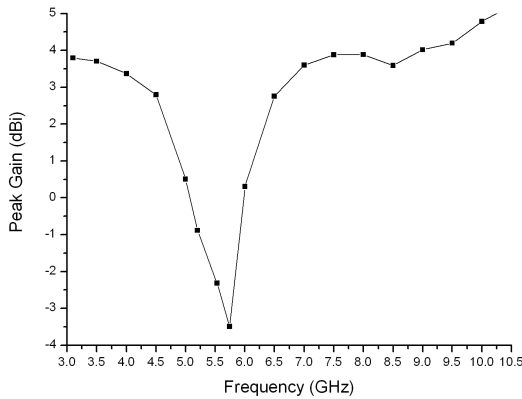
Frequency (GHz)	3.1	4	5	5.5	6	7	8	9	10	10.5
Radiation efficiency (%)	97.31	99.96	99.57	87.13	99.94	98.77	99.82	99.91	98.83	99.59



**Figure 5.** Measured magnitude of  $S_{21}$ .



**Figure 6.** Measured group delay of the transfer system.



**Figure 7.** Measured peak gain of the proposed UWB antenna.

#### 4. CONCLUSION

A novel miniature strip-line fed antenna with band-notched function has been demonstrated to exhibit UWB characteristics. A balanced antipodal structure and strip-line feed are utilized in this design to reduce the antenna size with sufficient matching band. Compared with most of the conventional UWB antennas, the size of the proposed antenna has been reduced significantly. Via inserting the slots on the hexagonal patch of the mid metalisation layer, suitable band-



rejected characteristic can be realized. The measured results indicate that the proposed UWB antenna not only owns stable good radiation patterns and good gains, but also prevents interference from other communication systems.

## REFERENCES

1. Zhang, L. N., S. S. Zhong, C. Z. Du, and J. H. Chen, "Compact UWB planar monopole antenna with band-notch function," *Microwave Opt. Technol. Lett.*, Vol. 51, 1908–1911, 2009.
2. Zhang, F., F. S. Zhang, G. Zhao, C. Lin, and Y. C. Jiao, "A novel compact band-notched planar monopole antenna from 3 to 40 GHz," *Microwave Opt. Technol. Lett.*, Vol. 51, 1401–1403, 2009.
3. Zhang, G.-M., J.-S. Hong, and B.-Z. Wang, "Two novel band-notched UWB slot antennas fed by microstrip line," *Progress In Electromagnetics Research*, PIER 78, 209–218, 2008.
4. Lin, C.-C. and H.-R. Chuang, "A 3–12 GHz UWB planar triangular monopole antenna with ridged ground-plane," *Progress In Electromagnetics Research*, PIER 83, 307–321, 2008.
5. Gopikrishna, M., D. Das Krishna, C. K. Aanandan, P. Mohanan, and K. Vasudevan, "Design of a microstrip fed step slot antenna for UWB communication," *Microwave Opt. Technol. Lett.*, Vol. 51, 1126–1129, 2009.
6. Zhou, H.-J, Y.-Z. Yin, J.-Y. Deng, Q.-Z. Liu, and Y.-C. Kan, "CPW-FED ultra-wideband antenna with dual band-notched characteristics," *Microwave Opt. Technol. Lett.*, Vol. 51, 330–332, 2009.
7. Chu, Q.-X. and Y.-Y. Yang, "3.5/5.5 GHz dual band-notch ultra-wideband antenna," *Electron. Lett.*, Vol. 44, 172–174, 2008.
8. Lui, W. J., C. H. Cheng, and H. B. Zhu, "Compact balanced antipodal slot antenna for ultra-wideband applications," *Microwave Opt. Technol. Lett.*, Vol. 48, 1943–1945, 2006.
9. Ren, W., Z. G. Shi, and K. S. Chen, "Novel planar monopole UWB antenna with 5-GHz band notched characteristic," *Journal of Electromagnetic Waves and Applications*, Vol. 21, No. 12, 1645–1652, 2007.
10. Chung, K., J. Kim, and J. Choi, "Wideband microstrip-fed monopole antenna having frequency band-notched function," *IEEE Microwave and Wireless Components Letters*, Vol. 15, No. 11, 766–768, Nov. 2005.

11. Chu, Q.-X. and Y.-Y. Yang, "3.5/5.5 GHz dual band-notch ultra-wideband antenna," *Electron. Lett.*, Vol. 44, 172–174, 2008.
12. Cho, Y. J., K. H. Kim, D. H. Choi, S. S. Lee, and S.-O. Park, "A miniature UWB planar monopole antenna with 5-GHz band-rejection filter and the time-domain characteristics," *IEEE Transactions on Antennas and Propagation*, Vol. 54, No. 5, 1453–1460, May 2006.