

## **A RACKET-SHAPED SLOT UWB ANTENNA COUPLED WITH PARASITIC STRIPS FOR BAND-NOTCHED APPLICATION**

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**Abstract**—A racket-shaped slot ultra-wideband (UWB) antenna coupled with parasitic strips for band-notched application is proposed in this paper. By attaching a pair of parasitic rectangular strips on the bottom of the substrate, a band-notched characteristic is well realized. Adjusting the length, width of the two strips and the distance between them, a band-rejected filter characteristic at the WLAN operation in 5.15–5.825 GHz frequency band can be obtained. The fabricated antenna has a small size of  $20 \times 37.5 \text{ mm}^2$ . Good agreement is achieved between the simulated and measured results, both of which show an ultra-wide impedance bandwidth from 3.1 to 10.6 GHz for VSWR less than 2 except the bandwidths of 5.15–5.825 GHz for WLAN.

### **1. INTRODUCTION**

Recently, UWB system has drawn much attention due to its attractive features, such as simple configuration, low cost, and resistant to severe multi-path and jamming. As an essential part of the UWB system, UWB antenna has been developed widely and rapidly. Although UWB antennas using other planar structures such as dipole patch antennas [1–4] and slot structures [5–7] can be achieved well, monopole antennas are more favorable for UWB application due to their

symmetrical and omnidirectional radiation patterns, wide impedance bandwidths, low cross-polarization levels, easy fabrication processes, and so on in [8–13].

To avoid the interference between the UWB system operated in 3.1–10.6 GHz frequency band and the WLAN system operated in 5.15–5.825 GHz frequency band, UWB antennas with a notched band are more and more appealing, which will lead to the complexity of antenna design, undoubtedly. To achieve the notched band function, there are various approaches reported in [10–19], such as cutting a slot on the patch or the ground [10–16], putting parasitic elements near the printed monopole [17], and attaching stubs or strips [18, 19]. In [19], the notched band is created by adding a strip in the slot and the strip is on the same side of the substrate with the radiating patch.

In this paper, a simple UWB slot antenna coupled with parasitic strips for band-notched application is introduced. Attaching a pair of parasitic rectangular strips on one side of the substrate, a notched band function is created. After properly adjusting the length, width of and distance between the coupling strips, a desired notched frequency band is obtained well. From the simulated and measured results, good performances in impedance and radiation patterns are also achieved. Details of the proposed antenna will be discussed later.

## 2. ANTENNA DESIGN

Figures 1 and 2 illustrate the photograph and configuration of the proposed UWB antenna, which is printed on an inexpensive FR4 substrate with relative permittivity of 4.4, thickness of 1 mm, and total size of 20 mm  $\times$  37.5 mm. The radiating element of the fabricated antenna consists of an elliptic patch with short axis and long axis radius of  $R_1$  and  $R_2$ , respectively. A wide rectangular slot with the dimension of  $L_1 \times W_1$  is etched in the elliptic patch. The patch is fed by a 50  $\Omega$  microstrip line with a uniform width of 1.9 mm. The whole radiating structure looks like a racket with a slot. The semiground with a length of  $L_3$  is designed on the opposite side of the substrate. The coupling strips with the length of  $L_2$ , width of  $W_2$  and distance of  $S$ , are etched on the same side with the semiground, leading a band-notched characteristic. The simple wide slot UWB antenna shows a sufficient and desired rejection characteristic operated at 5.15–5.825 GHz frequency range and the monopole-like radiation patterns. The optimized design parameters are depicted as shown in Table 1.

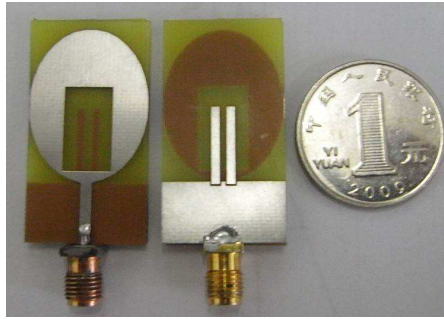


Figure 1. Photograph of the proposed antenna.

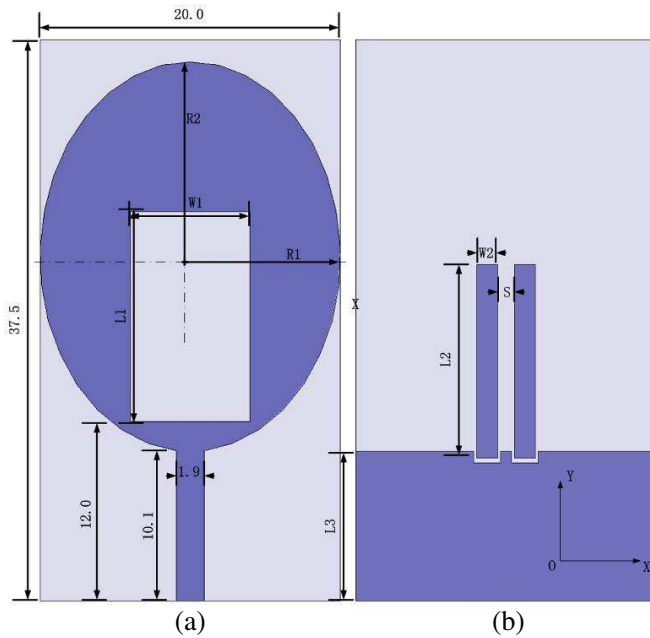


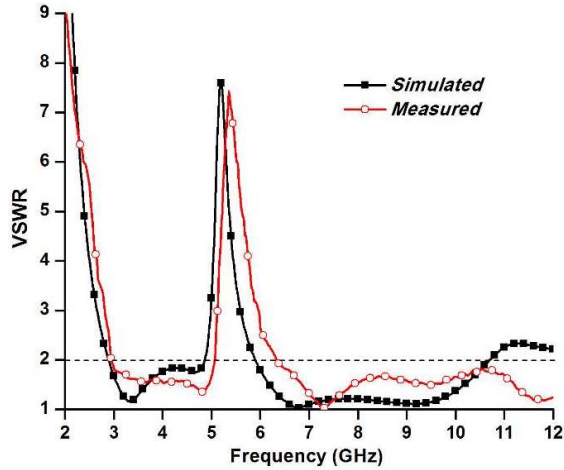
Figure 2. Configuration of the proposed antenna (Unit: mm). (a) Front view. (b) Back view.

Table 1. Optimal parameters of the proposed antenna.

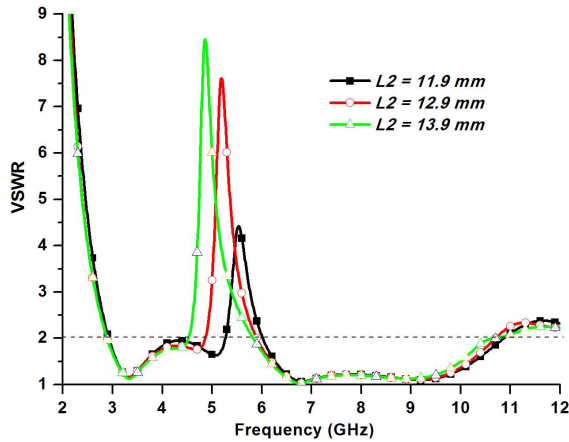
Parameters	$L_1$	$W_1$	$L_2$	$W_2$	$L_3$	$R_1$	$R_2$	$S$
Values (Unit: mm)	14	8	12.9	1.4	10	10	13	1.1

### 3. RESULTS AND DISCUSSION

In our research, the simulated and measured results are obtained with the help of the High-Frequency Structure Simulation software (HFSS) and WILTRON-37269A vector network analyzer. Figure 3 illustrates the voltage standing wave ratio (VSWR) curves of the proposed UWB

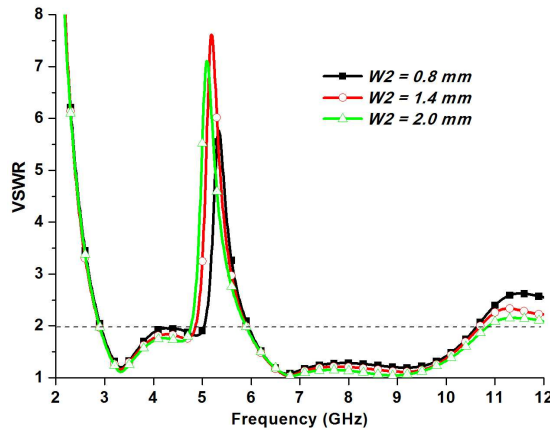


**Figure 3.** Simulated and measured VSWR curves of the proposed antenna.

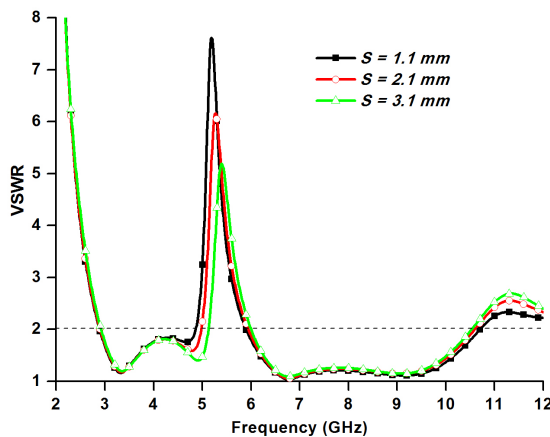


**Figure 4.** Simulated VSWR curves of the proposed antenna with various strip lengths  $L_2$ .

antenna. As shown in this figure, it is obvious that there is a minor shift between the simulated and measured results, which is mainly caused by the fabrication error and the external SMA connector. The SMA connector is not accounted for in the simulation but is used in the experiment so that a varying reactance is loaded, leading to the movement of resonant points. Thus, the tested result is in agreement with the simulated one.



**Figure 5.** Simulated VSWR curves of the proposed antenna with various strip widths  $W_2$ .



**Figure 6.** Simulated VSWR curves of the proposed antenna with various distances  $S$  between the coupling strips.

Figure 4 shows the VSWR curves of the presented antenna with various strip lengths  $L_2$ . As demonstrated in Figure 4, it is clear that the central frequency of the notched band is controlled by the length of the strips. When the length of the two strips varies from 11.9 mm to 13.9 mm simultaneously, the frequency shifts from

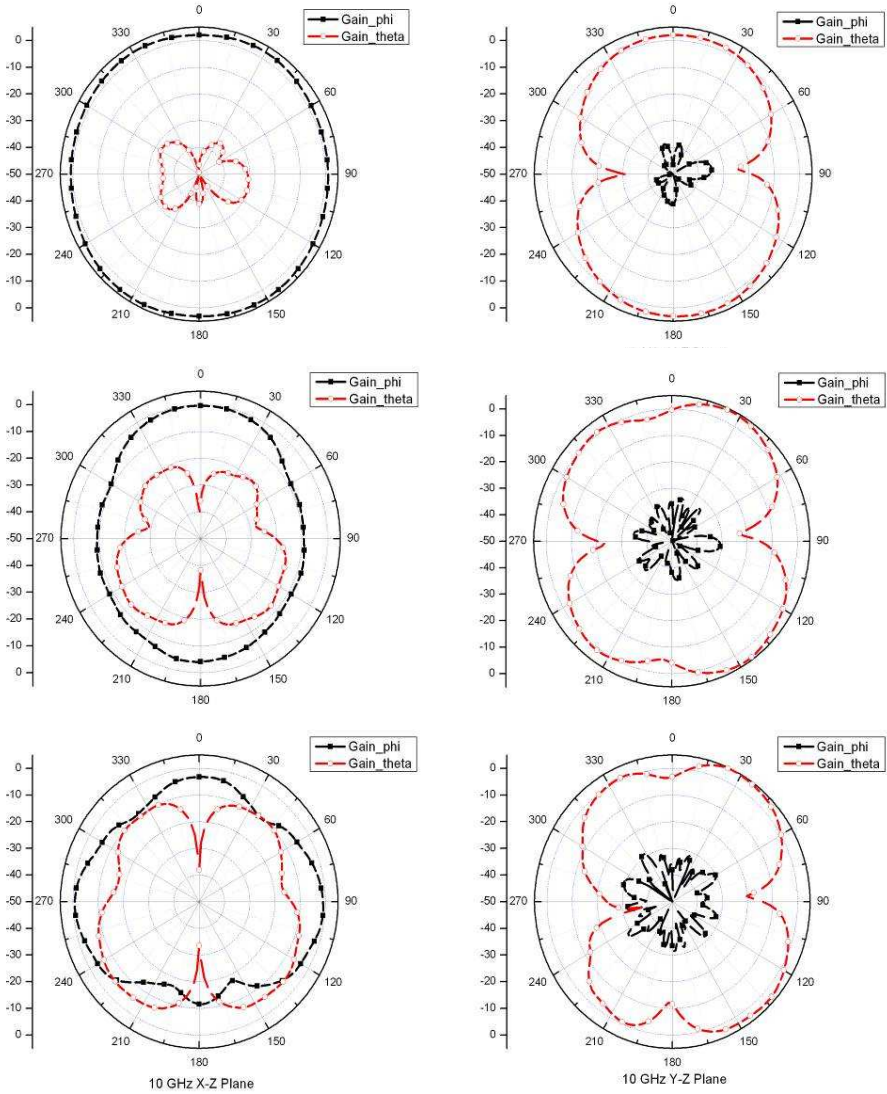


Figure 7. Radiation patterns of the proposed antenna.

around 5.52 to 4.87 GHz. With the increasing of  $L_2$ , the rejection characteristic becomes obvious and strong. In addition, just changing the length of any strip can yield the coincident conclusion, duly a little shift. Besides, the length  $L_2$  also affects the width of the notch bandwidth. With the increasing of  $L_2$  from 11.9 mm to 13.9 mm, the notch bandwidth widens from 0.76 GHz (5.27–6.03 GHz) to 1.34 GHz (4.5–5.84 GHz).

Figure 5 exhibits the effect of the various strip widths  $W_2$  on VSWR curves. It is apparent that the width of the strip  $W_2$  also has an effect on the rejected frequency. A frequency shift from 5.34 GHz to 5.1 GHz corresponds to the changement of the strip width from 0.8 mm to 2.0 mm. The phenomenon means that  $W_2$  has a less effect comparing with  $L_2$  on the rejected frequency. Moreover, the same with  $L_2$ ,  $W_2$  affects the notch bandwidth as well. When  $W_2$  varies from 0.8 mm to 2 mm, the bandwidth widens from 0.89 GHz (5.04–5.93 GHz) to 1.16 GHz (4.77–5.93 GHz). Therefore, the parameter  $L_2$  mainly determines the desired notched band and  $W_2$  can be used for fine-tuning the band. With properly designing the two parameters, the design procedure can be more flexible.

Figure 6 demonstrates the simulated VSWR versus frequency of the presented antenna for the distance  $S$  of 1.1 mm, 2.1 mm, and 3.1 mm between the two strips. It can be seen that as the distance between the two strips gets larger equivalent to the fact that the strips get closer to the slot edge, the notch-band frequency shifts to the higher

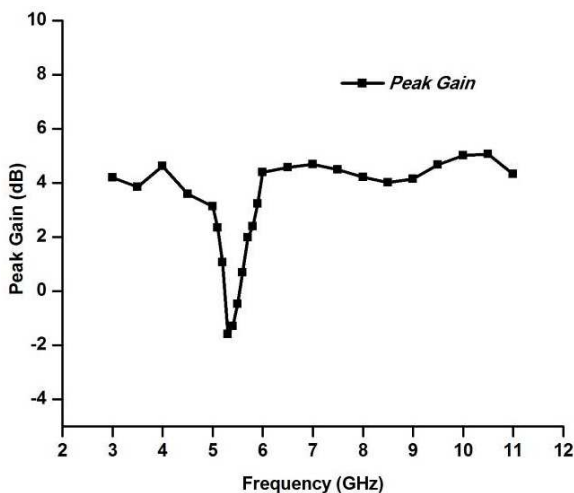


Figure 8. Peak gains of the proposed antenna.

frequency and the rejection characteristic gets weaker. The distance varying from 1.1 mm to 3.1 mm leads to the central frequency's remotion of the rejected band from 5.28 GHz to 5.39 GHz. When the strips are located out of the slot, the stop band disappears.

The radiation characteristics of the proposed antenna are also investigated. The far-field radiation patterns at 4, 8 and 10 GHz in  $x$ - $z$  and  $y$ - $z$  plane, respectively, are shown in Figure 7. The results indicate that the radiation patterns are almost omnidirectional in the  $H$ -plane and bidirectional in the  $E$ -plane. Figure 8 shows the peak gains of the proposed antenna. It can be observed that the peak gains of the proposed antenna range from 3.86 to 5.02 dB over the operating band except the 5–6 GHz WLAN band, and are about  $-1.59$  dB at the lowest point of 5.3 GHz.

#### 4. CONCLUSION

A compact UWB antenna with band-notched characteristic is presented and experimentally studied. With the employment of the coupling parasitic strips, a notch band is generated. By adjusting the length, width of the coupling strips and the distance between them, the desired rejection band is obtained. The experimental results exhibit that the fabricated antenna covers the UWB band with VSWR less than 2, while avoiding EM interference with the WLAN band operated at the 5.15–5.825 GHz.

#### REFERENCES

1. Li, W.-Y., K.-L. Wong, and S.-W. Su, "Ultra-wideband planar shorted dipole antenna with two C-shaped arms for wireless communications," *Microwave Opt. Technol. Lett.*, Vol. 49, 1132–1136, 2007.
2. Horita, A. and H. Iwasaki, "A planar dipole antenna with wideband characteristics for UWB and wireless LAN," *Electronics and Communications in Japan*, Vol. 90, Part 1, 22–30, 2007.
3. Low, X.-N., Z.-N. Chen, and T. S. P. See, "A UWB dipole antenna with enhanced impedance and gain performance," *IEEE Trans. Antennas Propag.*, Vol. 57, No. 10, 2959–2966, Oct. 2009.
4. Hu, Y.-S., M. Li, G.-P. Gao, J.-S. Zhang, and M.-K. Yang, "A double-printed trapezoidal patch dipole antenna for UWB applications with band-notched characteristic," *Progress In Electromagnetics Research*, Vol. 103, 259–269, 2010.
5. Cheng, S., P. Hallbjörner, and A. Rydberg, "Printed slot planar



- inverted cone antenna for ultrawideband applications,” *IEEE Antennas Wireless Propag. Lett.*, Vol. 7, 18–21, 2008.
6. Row, J.-S. and S.-W. Wu, “Circularly-polarized wide slot antenna loaded with a parasitic patch,” *IEEE Trans. Antennas Propag.*, Vol. 56, No. 9, 2826–2832, Sep. 2008.
  7. Liu, J., D. Zhao, and B.-Z. Wang, “A beveled and slot-loaded planar bow-tie antenna for UWB application,” *Progress In Electromagnetics Research M*, Vol. 2, 37–46, 2008.
  8. Koohestani, M. and M. Golpour, “Compact rectangular slot antenna with a novel coplanar waveguide fed diamond patch for ultra wideband applications,” *Microwave Opt. Technol. Lett.*, Vol. 52, 331–334, 2010.
  9. Yin, X.-C., C.-L. Ruan, C.-Y. Ding, and J.-H. Chu, “A planar U type monopole antenna for UWB applications,” *Progress In Electromagnetics Research Letters*, Vol. 2, 1–10, 2008.
  10. Zheng, Z.-A. and Q.-X. Chu, “Compact CPW-fed UWB antenna with dual band-notched characteristics,” *Progress In Electromagnetics Research Letters*, Vol. 11, 83–91, 2009.
  11. Tu, S., Y.-C. Jiao, Y. Song, and X.-Z. Wang, “A novel monopole dual band-notched antenna with tapered slot for UWB applications,” *Progress In Electromagnetics Research Letters*, Vol. 10, 49–57, 2009.
  12. Tu, S., Y.-C. Jiao, Y. Song, and Z. Zhang, “A novel miniature strip-line fed antenna with band-notched function for UWB applications,” *Progress In Electromagnetics Research Letters*, Vol. 10, 29–38, 2009.
  13. Li, L.-X., S.-S. Zhong, and M.-H. Chen, “Compact band-notched ultra-wideband antenna using defected ground structure,” *Microwave Opt. Technol. Lett.*, Vol. 52, 286–289, 2010.
  14. Wang, X.-M., Z.-B. Weng, X. Zhang, and Y.-C. Jiao, “Planar multiateral monopole antenna with band-notch characterization for UWB applications,” *Microwave Opt. Technol. Lett.*, Vol. 51, 2186–2189, 2009.
  15. Zhang, X., T.-L. Zhang, Y.-Y. Xia, Z.-H. Yan, and X.-M. Wang, “Planar monopole antenna with band-notch characterization for UWB applications,” *Progress In Electromagnetics Research*, Vol. 6, 149–156, 2009.
  16. 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*, Vol. 78, 209–218, 2008.
  17. Zaker, R., C. Ghobadi, and J. Nourinia, “Novel modified UWB

- planar monopole antenna with variable frequency band-notch function,” *IEEE Antennas Propog. Lett.*, Vol. 7, 112–114, 2008.
18. Shin, J., S. Hong, and J. Choi, “Design of a band-stop UWB antenna with two L-shaped stubs,” *Microwave Opt. Technol. Lett.*, Vol. 51, 2656–2660, 2009.
  19. Ryu, K. S. and A. A. Kishk, “UWB antenna with single or dual band-notches for lower WLAN band and upper WLAN band,” *IEEE Trans. Antennas Propag.*, Vol. 57, No. 12, 3942–3950, Dec. 2009.