Progress In Electromagnetics Research Letters, Vol. 16, 35–44, 2010

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

M. Zhang, Y.-Z. Yin, J. Ma, Y. Wang, and W.-C. Xiao

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

X.-J. Liu

China Airborne Missile Academy
Luoyang, Henan, China

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 $20 \times 37.5\,\mathrm{mm}^2$. 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

Received 9 June 2010, Accepted 8 July 2010, Scheduled 13 July 2010
Corresponding author: M. Zhang (zhm.xd@163.com).

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 × 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 Ω 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.

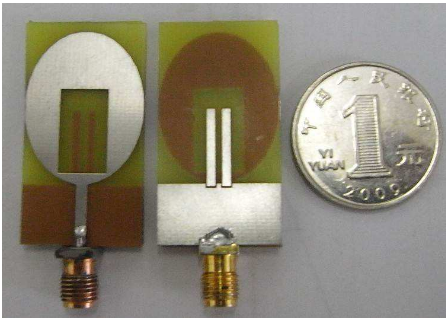

Figure 1. Photograph of the proposed antenna.

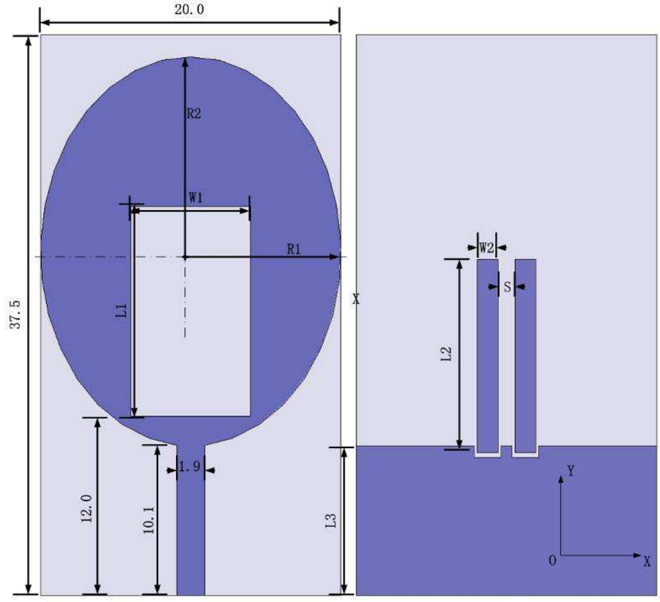

Figure 2. Configuration of the proposed antenna (Unit: mm). (a) Front view. (b) Back view.

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

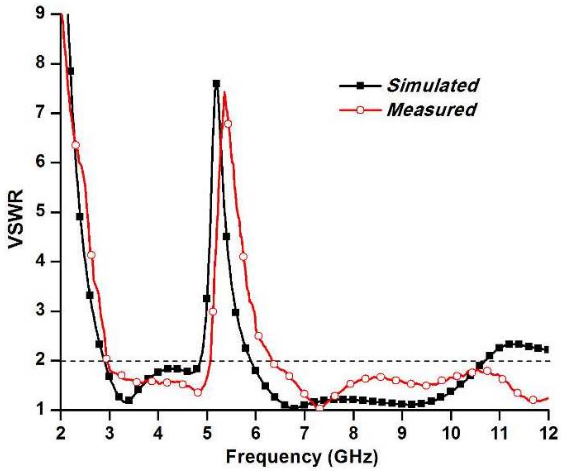

Figure 3. Simulated and measured VSWR curves of the proposed antenna.

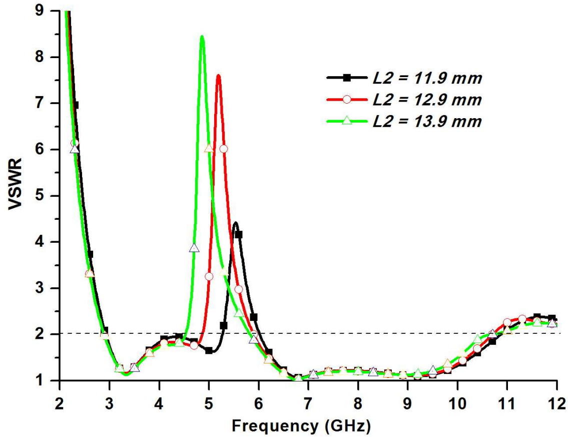

Figure 4. Simulated VSWR curves of the proposed antenna with various strip lengths L_2.

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.

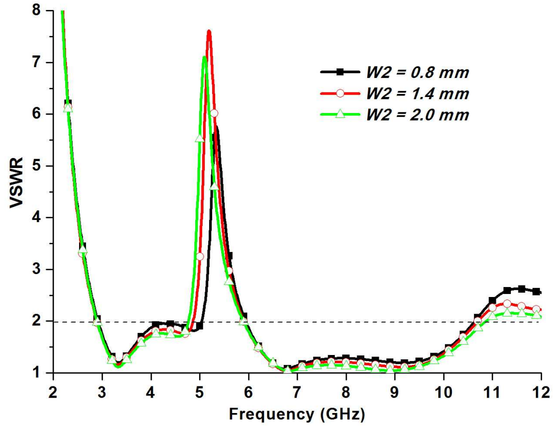

Figure 5. Simulated VSWR curves of the proposed antenna with various strip widths W_2.

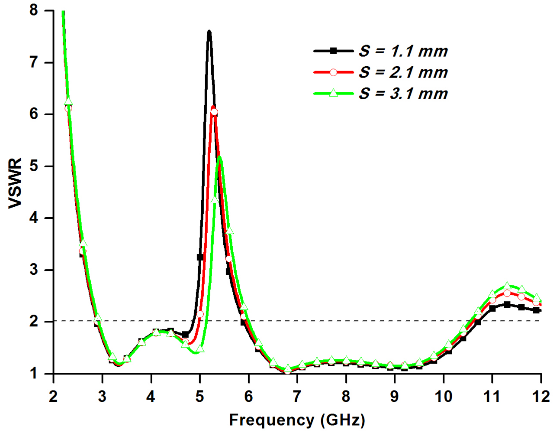

Figure 6. Simulated VSWR curves of the proposed antenna with various distances S between the coupling strips.

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

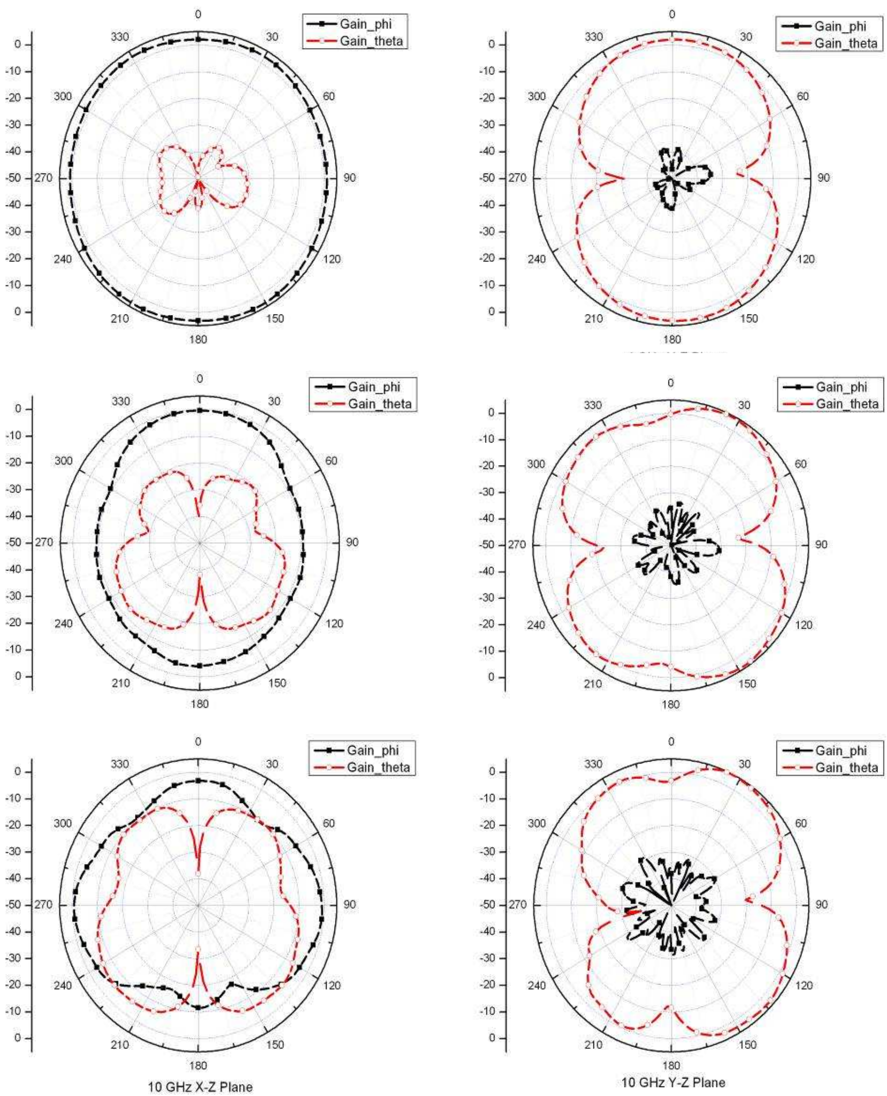

Figure 7. Radiation patterns of the proposed antenna.

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

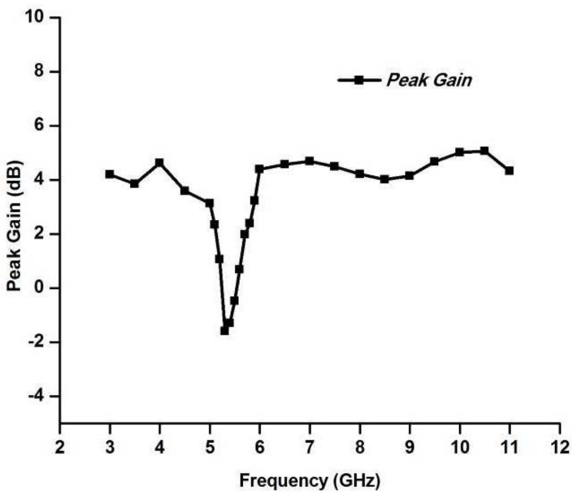

Figure 8. Peak gains of the proposed antenna.

frequency and the rejection characteristic gets weaker. The distance varying from 1.1 mm to 3.1 mm leads to the central frequency' 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.

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