# A Novel UWB Antenna with Dual-band Notched Characteristics

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**Abstract**— A novel omnidirectional ultra-wide band (UWB) antenna with dual band-notched characteristics are designed in this paper. To obtain extended impedance band-width, a small rectangular-shaped defected ground structure is used. The antenna has a good performance on impedance characteristics with the bandwidth from 2.0 GHz to 13.7 GHz. A U-shaped defected patch structure as well as a $\prod$-shaped defected patch structure are applied to obtain a dual band-notched characteristics at bandwidth of 5.29 GHz $\sim$ 6.608 GHz and 3.30 GHz $\sim$ 3.87 GHz, covering WIFI (5.470 GHz $\sim$ 5.725 GHz) and WIMAX (3.3 GHz–3.8 GHz) working frequency bandwidth. The problem of interference among spectrum can be solved effectively using this antenna.

## 1. INTRODUCTION

In 2002, the Federal Communications Commission approved rules for the commercial use for the ultra-wideband (UWB) with a frequency range of 3.1 GHz–10.6 GHz for commercial purposes, and then UWB technology has been widely used in various radars and it play an important role in the communication system [1, 2], because of the narrowband system of the UWB technology has incomparable advantage just like low cost, high speed and anti-multipath effect. However, the working bandwidth for UWB antenna will cause interference with existing narrowband wireless communication systems, for example WIFI (5.470 GHz–5.725 GHz) and WiMAX (3.3 GHz–3.8 GHz). Therefore, in order to prevent the interference between the spectrum and improve the utilization rate and independence of spectrum, it is particularly important to research UWB antenna with the stopband characteristics [3, 4].

UWB antenna with band-notched characteristics has many different kinds of structure. Generally, they always develop from two basic structures, one is 'strip' and the other one is 'slot'. Recently, to obtain the frequency band-notch function, modified planar monopoles with the slots on the patch of the antenna is proposed [5–7]. Modified planar monopoles with the strip structure is proposed to get double band-notched characteristics [8]. Multiple fractal-shaped slots-based UWB antenna is proposed to get triple band-notched functionality [9]. In this paper, a novel dual band-notched UWB antenna is proposed with the $\prod$-shaped and U-shaped slots in the patch. Obvious band-notched characteristics and good performance on omnidirectional radiation characteristics on the whole frequency band are realized by this simple structure. In aspect of implementing spectrum coexistence the antenna will gets better application.

## 2. ANTENNA DESIGN

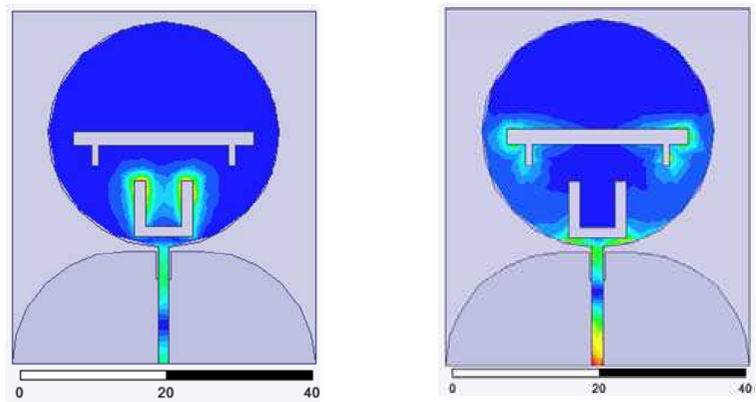
$\prod$-shaped and U-shaped are designed in the patch of the UWB antenna. According to the theory of resonance, the formula used to calculate the size of the slot is $W = \lambda_{re}/2$, $\lambda_{re} = \lambda_0/\sqrt{\varepsilon_{re}}$, $\lambda_0$ is the wavelength of the center frequency of the notch band. So the band-notched characteristics for different working bandwidths can be realized by improving the size of the slots.

When the size of slot is $W = \lambda_{re}/2$, current resonance will occur around slot, the surface current distribution of the antenna at 5.5 GHz and 3.5 GHz are shown in Figure 1. As it is shown, current resonance occurs around U-styled slot and current distributes mostly around U-styled slot at 5.5 GHz. Band-notched function is created at 5.5 GHz because of the energy radiated by the antenna is few. The same situation occurs at 3.5 GHz around $\prod$-styled slot. So two distinct band-notched functions are got by the new structure.

The geometry of the presented antenna is illustrated in Figure 2. The dimensions of the optimized antenna are depicted in Table 1. The antenna is fabricated on a substrate of 50 mm $\times$ 40 mm $\times$ 0.8 mm with dielectric constant of 4.5, the loss tangent of 0.0035. The antenna consists of a circle radiation patch connected to a 50-$\Omega$ microstrip line on the front side and a partial ground plane on the back side.

## 3. RESULTS AND DISCUSSION

The band-notched characteristics produced by different slots are illustrated, simulated VSWR of the antenna with different slots shown in Figure 3. As it is shown, because of the different sizes




5.5 GHz 3.5 GHz

Figure 1: Surface current distribution on the proposed antenna at 5.5 GHz and 3.5 GHz.

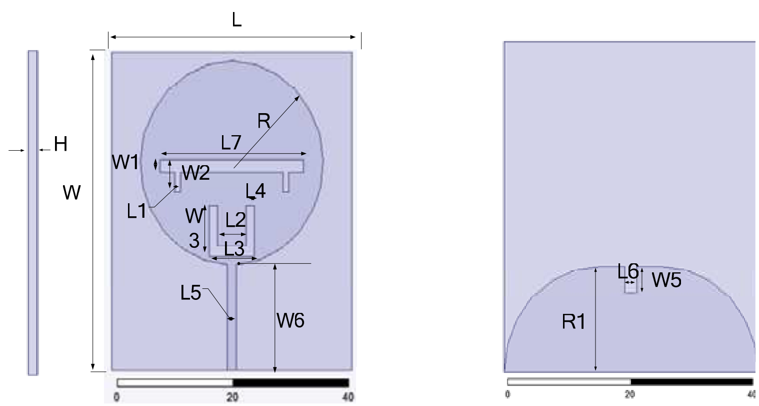


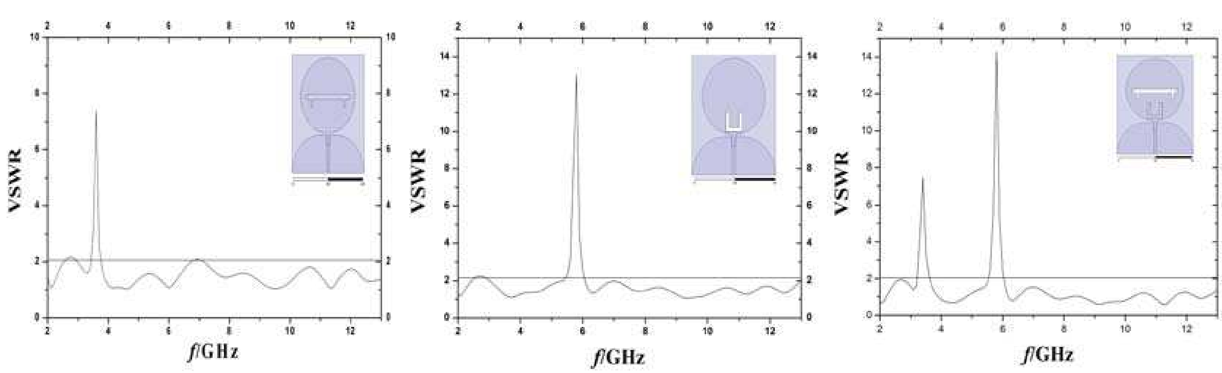

Figure 2: Geometry of the proposed antenna.

Table 1: Optimized antenna parameters (units: mm).

| $W$ | $W1$ | $W2$ | $W3$ | $W4$ | $W5$ | $W6$ | $L1$ | $L2$ | $L3$ | $L4$ | $L5$ | $L6$ | $L7$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 2 | 5 | 8 | 1.5 | 4 | 16.8 | 1 | 5 | 8 | 1.5 | 1.6 | 2.1 | 24 |

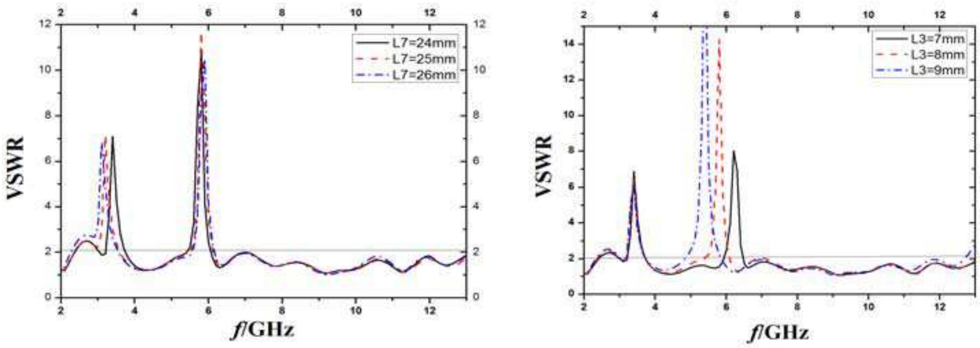
of the $\prod$-shaped and U-shaped slots, the antenna has different band-notched characteristics. Two independent stopbands from 3.30 GHz–3.87 GHz and 5.29 GHz–6.608 GHz are created distinctly. The band-notched characteristic near 3.5 GHz mainly affected by the size of $\prod$-shaped slot, while the band-notched characteristic near 5.5 GHz mainly affected by the U-shaped slot. Meanwhile, the simulated result of a reference antennas with only one slot are also depicted as comparison.

Figure 4 illustrates simulated VSWR for the proposed antenna with different $L3$ and $L7$. It




(a) (b) (c)

Figure 3: Simulated $S_{11}$ for different slots.




(a) (b)

Figure 4: Simulated $S_{11}$ for different sizes of $L7$ and $L3$.

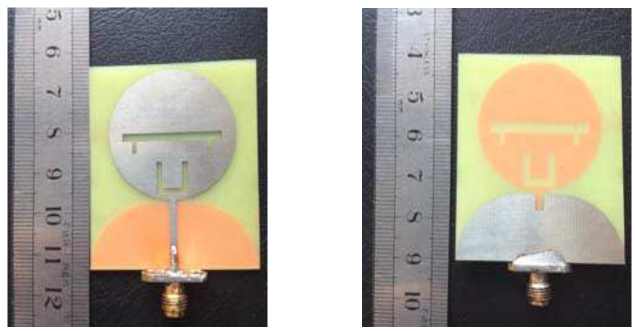


Figure 5: Photograph of the fabricated antenna.

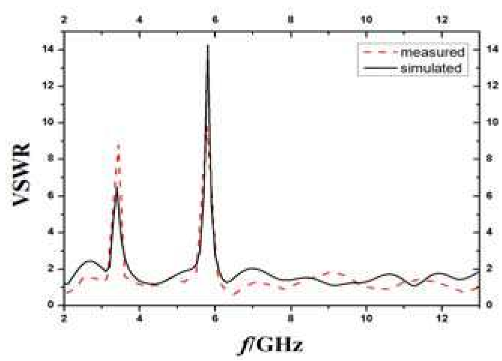
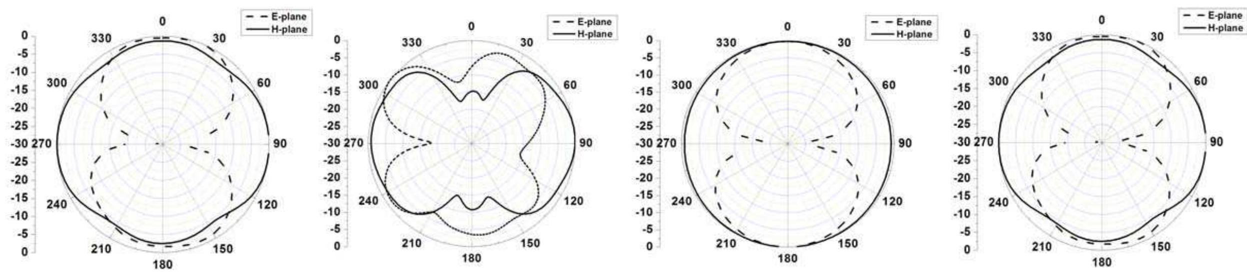



Figure 6: Simulated and measured VSWR.

exhibits the effect of the size of U-shaped and $\prod$-shaped slots, actually the center of the notch band is associated with the size of the slots. The parametric study shows that as the length of the segment $L3$ changes, the band produced by U-shaped slot is shifted significantly without affecting the other notched band. On the contrary, when the $\prod$-shaped slot size $L7$ shifts, the lower notched band shifts significantly without affecting the higher notched band. And we can see that the bigger the $L3$ and $L7$ the lower the notch frequency turns to be. The working frequency band of WIFI (5.470 GHz–5.725 GHz) and WIMAX (3.3 GHz–3.8 GHz) can be covered by shifting the size of $L3$ and $L7$.

The photograph of the antenna is shown in Figure 5. The simulated and measured VSWR of the proposed antenna are shown in Figure 6. It is shown that the simulated and measured results exhibit a good consistency.

The simulated radiation patterns at 2 GHz, 5 GHz, 7 GHz, 9 GHz are depicted in Figure 7. It can be seen that the antenna has a nearly omnidirectional radiation pattern in the $H$-plane and a radiation pattern in the $E$-plane. The presented antenna exhibits a good radiation performance.




(a) 7 GHz (b) 9 GHz (c) 2 GHz (d) 5 GHz

Figure 7: Radiation patterns of the antenna at (a) 5 GHz and (b) 7 GHz.

## 4. CONCLUSION

A novel compact UWB planar antenna with dual-notched bands has been presented and discussed. The wide impedance band-width (2.0 GHz–13.7 GHz) is realized by a rectangle-shaped defected ground structure (DGS). The presented antenna exhibits a broad bandwidth and omnidirectional radiation performance. In addition, the dual band-notched characteristics are realized by a U-shaped as well as a $\prod$-shaped slot. Simulated and measured results show that the working bandwidth of WIFI (5.470 GHz–5.725 GHz) and WIMAX (3.3 GHz–3.8 GHz) are covered by the two band notches. The problems of spectrum coexistence and interference among spectrum can be solved effectively.

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