A Novel Compact UWB Antenna with Triple Band-notched Characteristics

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Abstract— In this article, a novel compact ultra-wideband (UWB) planar monopole antenna with tri-notched bands is presented. The proposed antenna is fed by a microstrip line and a partial ground plane. The antenna achieves an operating bandwidth ranging from 2.9 to more than 11 GHz and triple band-notched properties of 3.22–3.91, 5.15–5.44, 5.70–5.91 GHz. Throughout this article, the simulated and experimental results of impedance characteristic, gain, and radiation patterns are presented and discussed. The proposed antenna has an overall dimension of $20 \times 21.1\,\mathrm{mm}^2$.

1. INTRODUCTION

Since the US Federal Communications Commission approved the unlicensed use of UWB from 3.1 to 10.6 GHz for commercial communications, the ultrawideband technology has drawn more and more attention for its merits such as low cost, low complexity, wide impedance bandwidth and omnidirectional radiation pattern [1]. However there still co-exists other communication protocols such as the world interoperability for microwave access (WiMAX) service (3.3–3.6 GHz) and the Wireless Local Area Network (WLAN) service (5.15–5.35 GHz, 5.725–5.825 GHz). It is necessary to avert the overlapping frequency bands.

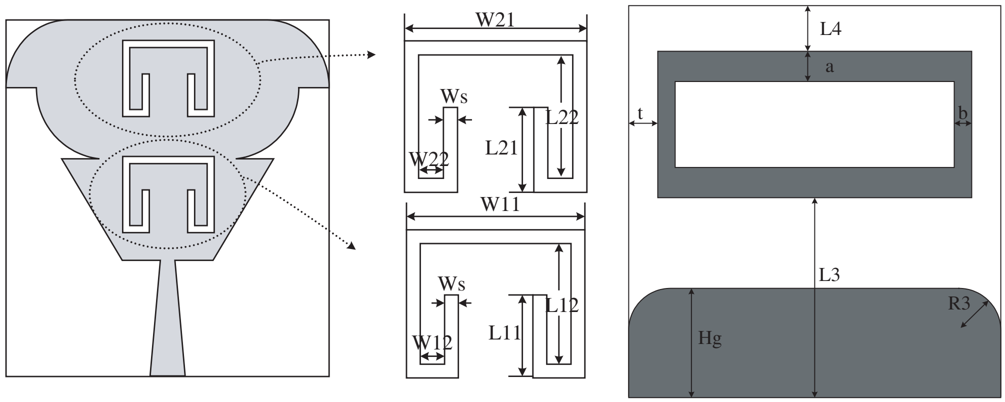
Recently, many new antennas with band-notched function have been put forward for the UWB systems which can prevent the interference problem. There are lots of ways in which band-notched characteristics can be achieved. The common and popular method is to insert different shaped slots on the patch or the ground plane, including U-shaped, -shaped, L-shaped, C-shaped and etc. [2–4]. Apart from this, there are many other methods to create the band-notched property such as using parasitic structures, adding split ring resonator (SRR) coupled to the feed-line or adopting the complimentary split ring resonator (CSRR) structure. All of the methods metioned above obey the same rule that is to introduce a pertubation into the antennas.

In this study, a novel compact UWB antenna with triple notched band at 3.22–3.91, 5.15–5.44, 5.70–5.91 GHz is proposed. A tapered radiating patch is designed to cover UWB working frequency band. The radiation patch and ground plane of the original antenna are all cut by arc which is for impedance matching over the whole UWB. Resonating element etched out above the ground plane generates the rejection at WiMAX band. To achieve the lower and higher WLAN band-notched characteristics, two independent curved slots is embeded into the radiation patch. Moreover, the proposed antenna here is significantly smaller and exhibits omni-directional radiation patterns which makes it a suitable candidate for the UWB system.

2. ANTENNA DESIGN

The configuration of the proposed antenna and its dimensions are exhibited in Figure 1. The microstrip-fed antenna has a compact size of $20 \times 21.1\,\mathrm{mm}^2$ and is printed on 1.0 mm thick F4B-2 dielectric substrate with dielectric constant 2.65 and loss tangent 0.001. Because the tapered geometry of the patch and the microstrip line, the proposed antenna will have good performances at a very wide band.

As illustrated in the Figure 1, the resonant element symmetrically etched above the ground plane generates the rejection at WiMAX band and two meandering slots embedded within the patch is designed to create the notched bands at lower and upper WLAN band. The upper band-notched slot is longer in length than the lower one corresponding to the lower and higher WLAN band conversely. Furthermore, the total length of the inserted meandering quarter wavelength slot



(a) (b)

Figure 1: Configuration of the proposed antenna with triple notched-bands: (a) top view of the antenn, (b) bottom view of the antenna. (Dimensions: $W_{11} = 5.8\,\text{mm}$; $W_{12} = 1.0\,\text{mm}$; $W_s = 0.3\,\text{mm}$; $L_{11} = 2.6\,\text{mm}$; $L_{12} = 3.7\,\text{mm}$; $W_{21} = 6\,\text{mm}$; $W_{22} = 0.9\,\text{mm}$; $L_{21} = 2.8\,\text{mm}$; $L_{22} = 4\,\text{mm}$; $t = 1.4\,\text{mm}$; $a = 1.1\,\text{mm}$; $b = 0.6\,\text{mm}$; $L_3 = 9\,\text{mm}$; $L_4 = 2\,\text{mm}$; Unit: mm).

resonator L_i $(i = 1, 2)$ can be calculated from the following formulas:

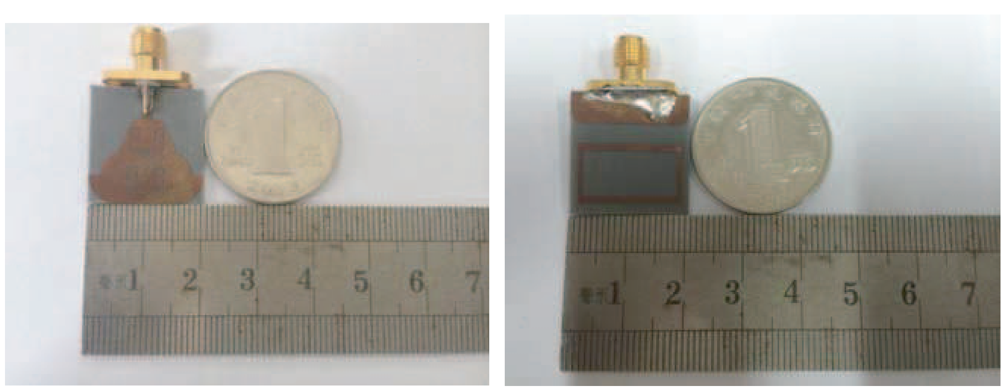
$$L_i \approx \frac{c}{4f_i\sqrt{\varepsilon_{eff}}} \tag{1}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \tag{2}$$

where c is the speed of light in free space, ε_r is the dielectric constant of the substrate, f_i $(i = 1, 2)$ is the center frequency of notched bands and ε_{eff} is effective dielectric constant.

3. MEASUREMENT RESULTS

The proposed antenna structure is simulated and optimized using Ansoft High Frequency Structure Simulator. Besides, the photo of the fabricated antenna is shown in Figure 2. From the Figure 3, one can see the simulated and measured results match well which validates our design concept and theory.



(a) (b)

Figure 2: Photograph of the fabricated UWB antenna: (a) top view, (b) bottom view.

Figure 4 shows the far-field radiation patterns at 4, 7 and 10 GHz, the copolarization and cross-polarization in the x-z (E-plane) and y-z (H-plane) planes are given. It can be observed that the proposed antenna has an approximately omni-directional radiation patterns at these frequencies.

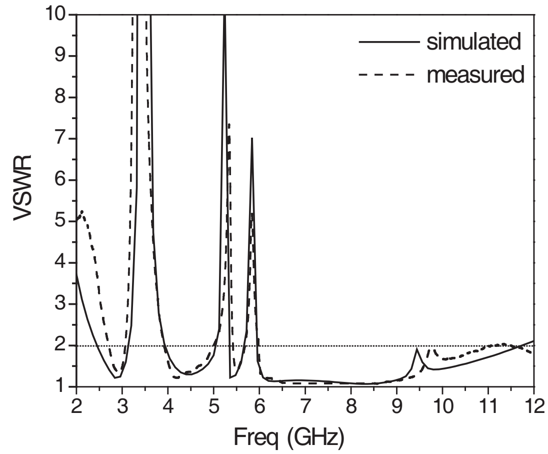


Figure 3: Simulated and measured VSWR of the proposed antenna.

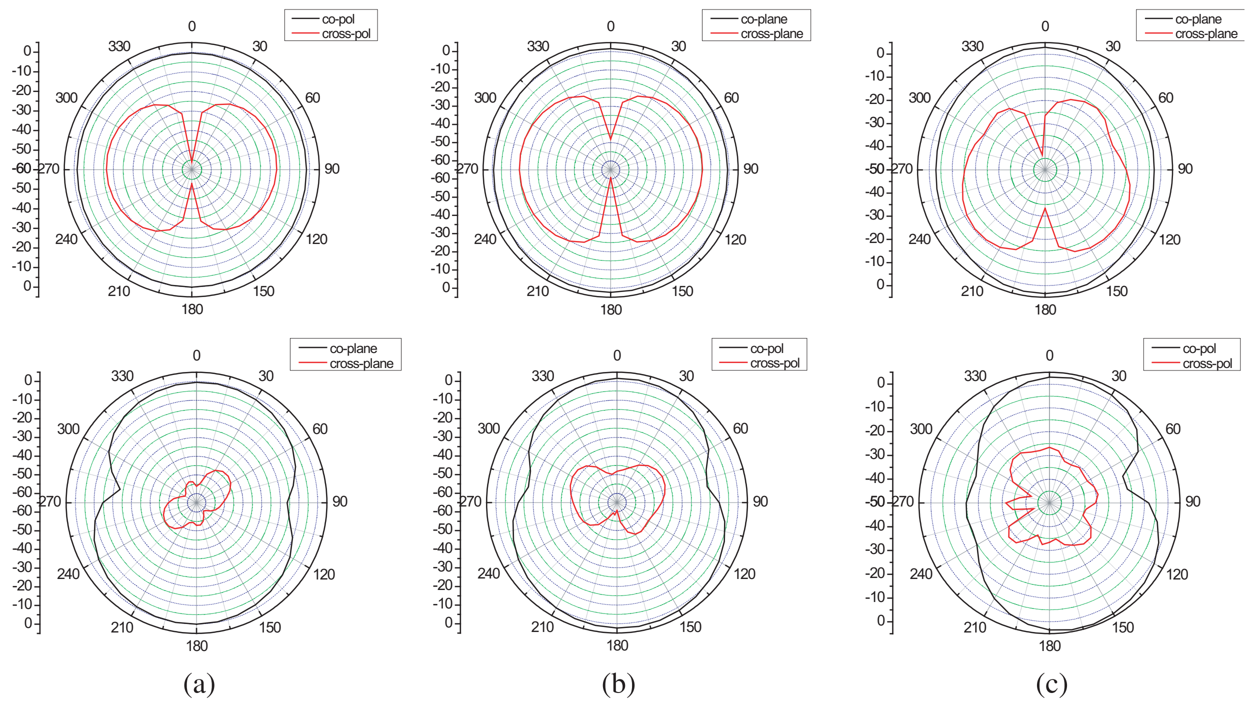


Figure 4: Radiation patterns of the antenna at (a) 4 GHz, (b) 7 GHz and (c) 10 GHz.

4. CONCLUSION

A novel compact UWB planar antenna with tri-notched bands to eliminate interfering signals from WLAN and WiMAX systems has been presented and discussed. The band notches are realized by rectangular ring above the ground plane to omit the WiMAX frequency band. To realize the WLAN notch band, two curved slots is placed into the radiation patch. It is observed from the measurement that the proposed antenna achieved good UWB performance. Therefore, the proposed antenna is suitable for UWB applications.

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