A Simple Monopole Slot Antenna with High Band-notch Characteristics for Ultra-wideband Communication Applications

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Abstract— In this paper, a simple ultra-wideband antenna with tunable and high rejection band-notch characteristics is proposed on the basis of a polygon slot structure. The designated notch bands are realized by the use of an inverted V-shaped stub inserted into inside of the polygon slot and a stub integrated into the radiating patch. The flexible tunable band-notch characteristics are achieved by adjusting the dimensions of the stubs. The simulation results show that the proposed antenna can provide a wide bandwidth, a flexible tunable and high rejection band-notch characteristics, and good omnidirectional radiation patterns, making it suitable for various band-notched ultra-wideband communication applications.

1. INTRODUCTION

The demand of high data rate and wide bandwidth has promoted ultra-wideband (UWB) to become an attractive technology in recent decade years. UWB antenna is one of the important components to build an indoor UWB system, which face much more challenges owing to its small size and wide bandwidth. To meet the rapidly developed UWB technologies, many printed UWB antennas with compact sizes have been proposed and investigated. However, there exist some narrowband systems, including IEEE802.11y wireless local area networks (WLAN) (3.6575–3.69 GHz), world-wide interoperability for microwave access (3.3–3.69 GHz), IEEE 802.11j WLAN band operating at 4.9–5.0 GHz and 5.03–5.091 GHz and IEEE 802.11a WLAN band operating at 5.15–5.35 GHz and 5.47–5.725 GHz, which have higher operating power than UWB systems and,hence, may interfere with UWB systems [1–13].

In order to mitigate the potential interferences from the above mentioned narrowband systems, a great number of band-notched UWB antennas have been proposed and well designed in the previous articles. Although these band-notched UWB antennas can provide desired notch band characteristics, most of them are realized by inserting various slots in the radiating patch or in the ground plane, which may leak electromagnetic waves and, hence, result in extra interferences [1–6]. Consequently, parasitic elements [7], resonators [8–12] and stub [13] have been employed to develop band-notched UWB antennas. However, some of them are complex in structure, which is difficult to tune and design in practical engineering, others are large in size or low rejection band characteristics.

For these reasons, we propose a simple ultra-wideband antenna with flexible tunable and high rejection band-notch characteristics on the basis of a polygon slot structure. The proposed band-notched characteristics are realized by using an inverted V-shaped stub inserted into inside of the pentagon slot in the coplanar waveguide (CPW) and a stub integrated into the pentagon radiating patch. The center frequencies of these band notches are tunable by adjusting the dimensions of the proposed stubs. In addition, the proposed antenna can obtain high rejection band in comparison with previously developed band-notched UWB antennas. The simulated results show that the proposed UWB antenna has a wide bandwidth, tunable band notches, high rejection notch characteristics with VSWR greater than 50, and omnidirectional radiation patterns, which makes it suitable for indoor UWB communication applications.

2. STRUCTURE OF THE PROPOSED ANTENNA

Figure 1 illustrates the geometry structure of the proposed high rejection notch band UWB antenna. The proposed antenna consists of a pentagon slot which is etched on the CPW-ground plane, a pentagon radiating patch with a polygon slot, a stub settled in the middle of the polygon slot, an inverted V-shaped stub inserted into inside of the pentagon slot and a CPW-fed structure which includes the CPW fed signal strip line and the CPW-ground plane. The UWB antenna is etched on a substrate whose relative permittivity is 2.65, and the loss tangent and the thickness of the substrate are 0.002 and 1.6 mm, respectively. The two notch bands and high rejection function are implemented by using the inverted V-shaped stub and the stub inserted in the polygon slot. The CPW-fed signal strip (CFSS) has a width of 3.6 mm and the gap between the CFSS and the CPW ground plane is 0.2 mm. The center frequencies of the proposed antenna are tunable to cover a wide rejection band, which are used to filter out the unwanted signal from 3.5 GHz WiMAX band and 5.5 GHz WLAN band.

The proposed antenna is designed step by step and the design procedure is shown in Fig. 1. Firstly, a UWB antenna is designed and is given in Fig. 1(a), which is antenna-1. Next, a UWB antenna with a 3.5 GHz band notched is presented, which is antenna-2. Finally, another notch band is generated by using an inverted V-shaped stub inserted into inside of the pentagon slot, which is denoted as antenna-3. The antenna-3 is our proposed antenna with high rejection band notch characteristics and it has been optimized by using the HFSS. The optimized antenna geometry parameters are $L = 32$, $W = 24$, $L1 = 1.1$, $L2 = 13.6$, $L3 = 9.3$, $L4 = 3.5$, $L5 = 14.7$, $L6 = 3$, $L7 = 8.5$, $W1 = 0.5$, $W2 = 3$, $W3 = 0.4$ (unit: mm).

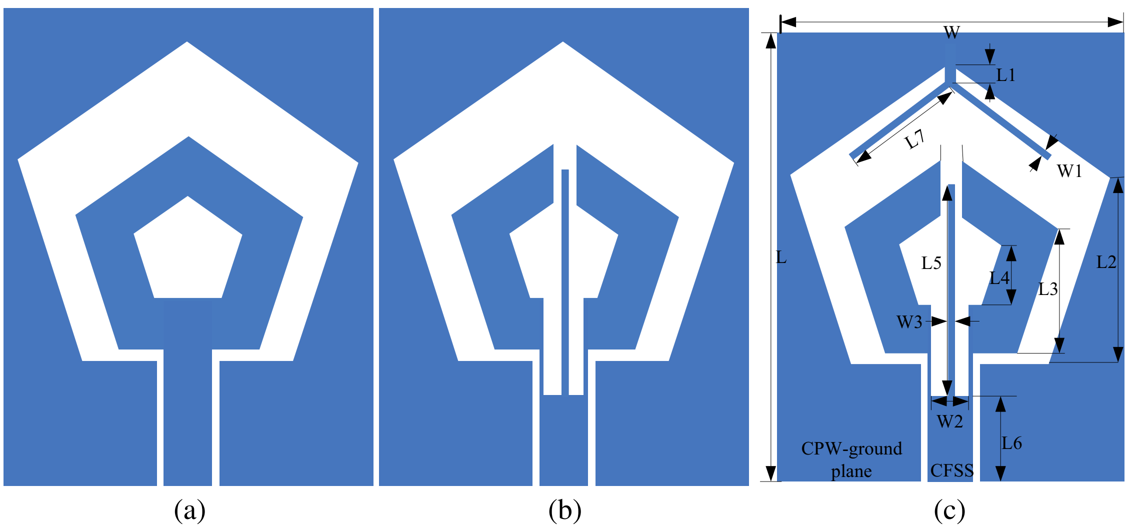

Figure 1: Geometry structure of the proposed antenna. (a) Antenna-1. (b) Antenna-2. (c) Antenna-3.

3. PERFORMANCE OF THE PROPOSED ANTENNA

In this section, parameter effects of $L5$ and $L7$, band-notch characteristic, radiation patterns are investigated to exploit the performance of the proposed antenna. Fig. 2(a) shows the effects of $L5$ on the impedance bandwidth. It can be seen that the center frequency of the lower notch band moves to low frequency with an increment of $L5$ ranging from 13 mm to 15 mm, which is attributed to the increased $L5$ that prolongs the resonance length of the stub. $L7$ has important effects on the center frequency of the upper notch band. Fig. 2(b) gives the effects of $L7$ on the impedance bandwidth of the proposed antenna. It is found that the center frequency of the upper notch band shifts from 6.2 GHz to 4.8 GHz when $L7$ increases from 7 mm to 10 mm, while the center frequency of the lower notch keeps constant. However, the band-notched depth at the lower notch band is reduced, while the band-notched depth at the upper notch band is increased. Figure 2(c) illustrates the band-notched characteristics of the proposed antenna. It is observed that the proposed antenna without these two stubs (antenna-1) is a UWB antenna, which can cover the whole UWB band released by FCC in 2002. When the proposed antenna has only the lower stub, denoting as antenna-2, it has a notch band to filter out the unwanted narrowband interferences from 3.5 GHz WiMAX band. When the proposed antenna integrate both stubs, which is named as antenna-3, it has two notch bands operating at 3.5 GHz band and 5.5 GHz WLAN band to prevent narrowband interferences. Thus, we can say that the lower notch band is generate by using the stub which is integrated with the radiating patch together, while the upper notch band at the 5.5 GHz WLAN band is produced by the use of the inverted V-shaped stub which is inserted into inside of the pentagon slot.

The radiation patterns of the proposed antenna are investigated and are shown in Fig. 3. We can see that the proposed antenna has an omnidirectional radiation pattern in the H-plane, and a quasi-omnidirectional radiation pattern in the E-plane. However, the E-plane radiation patterns

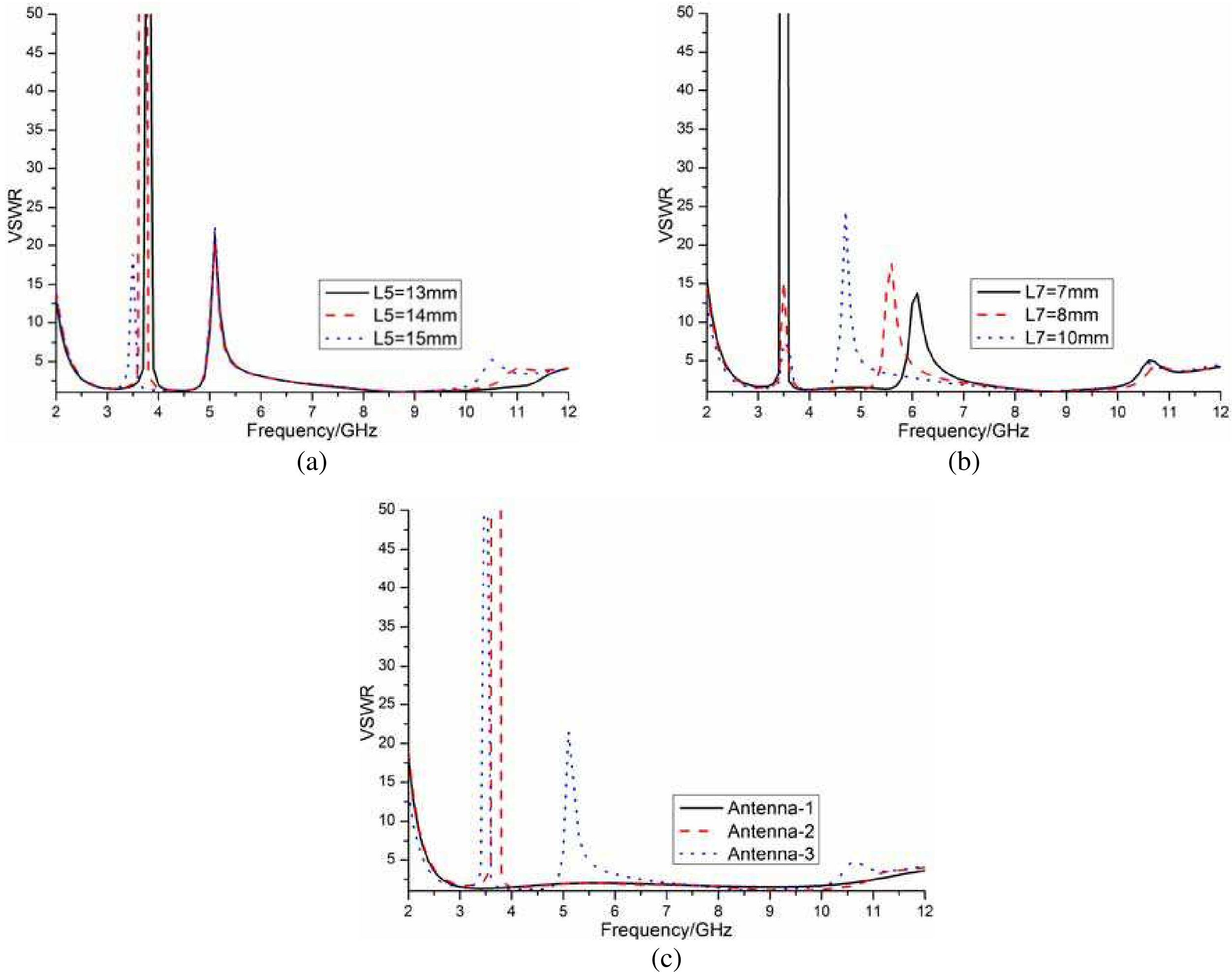

Figure 2: Performance of the proposed antenna. (a) $L5$. (b) $L7$. (c) Band-notched characteristic.

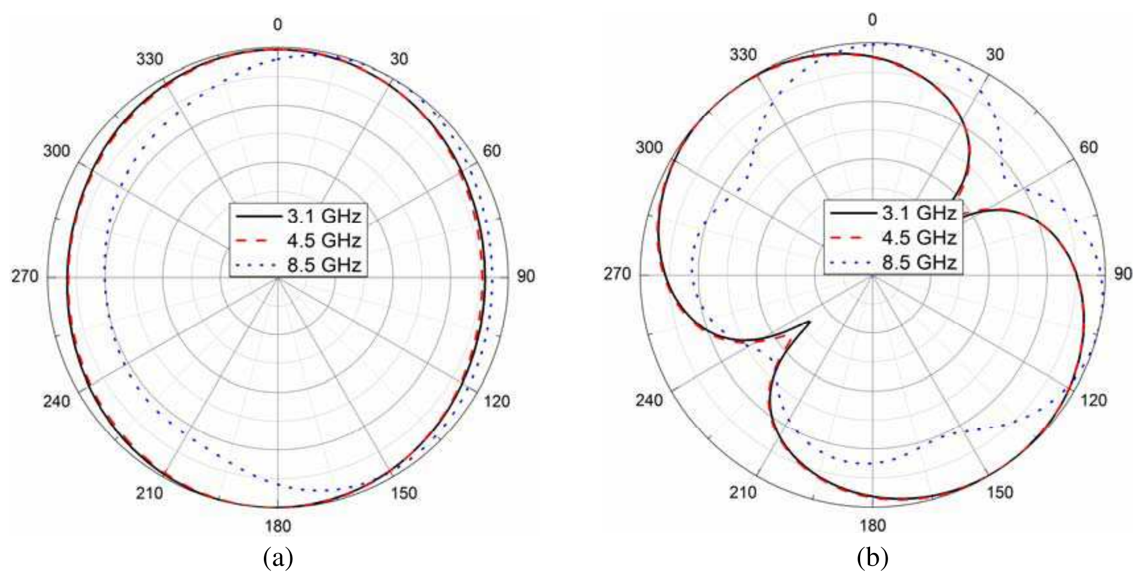

Figure 3: Radiation patterns of the proposed antenna. (a) H-plane. (b) E-plane.

are slant because of the slots which may leak extra electromagnetic waves. Table 1 compares the proposed antenna with early reported band-notched UWB antennas with respect to the size and peak VSWR which can depict the rejection depth. We note that only a few previously presented

Table 1: Comparisons of several existing band-notched UWB antennas.

References	Dimensions (mm^2)	Rejection band	Peak VSWR
[1]	28×21	4.5–6 GHz	> 10
[2]	40×31	4.13 GHz & 5.2 GHz	15
[3]	28×21	5–6 GHz & 8 GHz	6.3
[4]	30×26	3.4 GHz&5.5 GHz	9
[5]	22×18	3–3.8 GHz & 5–6 GHz	10
[6]	28×21	5–6 GHz	> 10
[7]	40×30	3–4 GHz & 5–6 GHz	> 8
[8]	34×34	5 GHz WLAN	9
[9]	40×31	5.15 GHz	15
[10]	34×27	3.23–5.93 GHz	14
[11]	33×25	3.5 GHz & 5.5 GHz	6
[12]	32×24	5–6 GHz	> 10
[13]	28×24	Tunable 3.55–6.8 GHz	26
Proposed	32×24	Tunable 3.1–7 GHz	> 50

antennas can provide peak VSWRs with their values greater than 15. Although the Reference [13] has a peak gain of 26, it can only provide a notch at each fixed dimensions. With the increment of frequency, the peak VSWR reduces quickly. At 5.5 GHz in Fig. 5 in [13], the peak VSWR is less than 10. In our design, the antenna can not only provide two tunable notch bands, but also can provide a high peak VSWR which is greater than 50 at 3.5 GHz WiMAX band and is better than 15 at the 5.5 GHz WLAN band.

4. CONCLUSION

A pentagon-slot UWB antenna with tunable and high rejection band-notched characteristics has been proposed and its performance has been evaluated in this paper. The results show that the proposed antenna has two tunable notch bands, which can filter unwanted signals from a large range. The lower notch band also has a high rejection characteristic with VSWR > 50, while the rejection depth at upper notch band reach up to 15. The results show that the antenna has two tunable notches and high rejection band, making it suitable for band-notched UWB systems.

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