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Compact Slot Antenna For UWB Application and Band-Notch Designs

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***Abstract*—A simple and compact coplanar waveguide (CPW)-fed ultra wide band antenna is presented. The UWB antenna consists of a rectangular patch, which is etched onto an FR4 printed circuit board(PCB) with an overall size of 30mmX35mmX0.76mm. The simulation show that the UWB antenna achieves good impedance matching, consistent gain, and consistent group delay over an operating bandwidth. The correlation between the mode-based field distribution is discussed. Extended from the UWB antenna, four notch (5-6GHz) designs are also presented as a desirable feature for UWB application.**

Index Terms–CPW-fed UWB antennas, band-notched characteristics,group delay.

I. INTRODUCTION

ULTRAWIDEBAND (UWB) radio, one of the core technologies in wireless personal area networks (WPANs).has experienced a blooming growth in recent years [1]. for the moment. UWB chipsets with transmission rates up to 480 Mbps have been developed and demonstrated. Due to the inherently ultra-wide operating bandwidth from 3.1 to 10.6GHz, the circuit components in an UWB radio face quite different challenges. For example, an ultrawideband antenna involves considerable extra design constraints. In such a system the antenna behaves more like a bandpass filter in both spatial and frequency domains. Any nonideal variation of the antenna response will inevitably introduce signal distortion and hence seriously deteriorate the overall performance. Various researchers have been devoted themselves to investigating the descriptions, analyses, and optimizations of ultrawideband antennas in either time domain or frequency domain [2,3,4]. and novel antenna designs have been successfully demonstrated in the literatures as well[5,7,8]. Among those newly proposed Ultrawideband antennas, the planar monopole antennas should be the most fascinating candidate for future application due to their remarkably compact size and stable radiation characteristics. Over the designated bandwidth of UWB systems, there are existing bands used by wireless local-area network (WLAN)(IEEE802.11a and HIPER LAN/2) operating in the 5.15-5.825GHz band. It is desirable to design the UWB antenna with a notched band at 5-6GHz to minimize the potential interference. In this paper, a coplanar waveguide

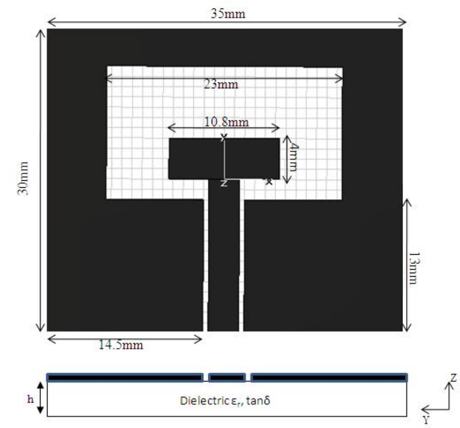

Figure 1. Geometry and configuration of the UWB Antenna

(CPW)-fed rectangular slot antenna with T-shaped stub is presented. The UWB antenna is successfully designed and verified. The antenna performs promising characteristics on the impedance matching, gain and group delay over the entire UWB band. In this paper, the UWB antenna is further extended to the band-notched function. The design concept described and four different band-notched designs provided for illustration. It shows that successful band-rejection capability for all four band-notched designs.

II. UWB ANTENNA DESIGN

A. UWB Antenna structure and Results

Figure.1 shows the geometry and configuration of a UWB antenna. The antenna was fabricated on an h=0.76mm FR4 epoxy substrate with dielectric constant ε_r =4.4 and loss tangent $tan\delta$=0.02. As shown in the figure, a rectangular radiator is fed by a 50Ω coplanar waveguide (CPW) transmission line. Since both the antenna and the feeding are implemented on the same plane, only one layer of substrate with single-side metallization is used. And the manufacturing of the antenna is very easy and extremely

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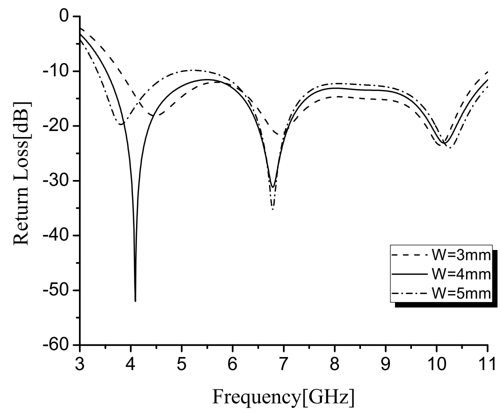
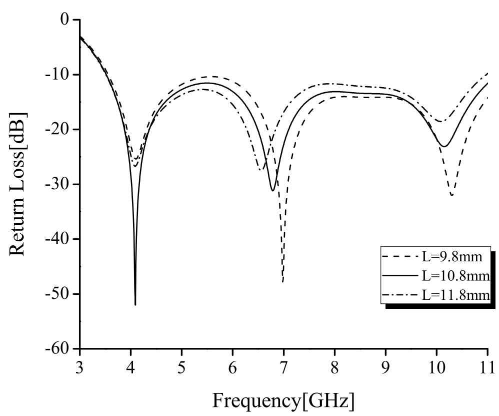


(a)



(b)

Figure 2. Effect of geometrical parameters of the proposed UWB antenna on the impedance matching

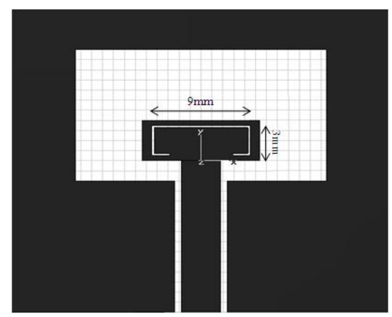
low cost. The electromagnetic software CST is employed to perform the design and optimization process.

B. Parametric Study

The parametric study is carried out to provide antenna engineers with more details of the antenna and a guideline for antenna optimization. The impedance bandwidth of -10dB return loss is investigated. It has been found that the operating band of the antenna is mainly determined by the width and length of the radiating element. The remaining parameters do not show significant effect on the impedance bandwidth but can be optimized to improve the impedance matching. To well understand the influence of these parameters on the impedance bandwidth, only one parameter is investigated at a time whereas the others are kept invariant unless especially indicated. Figure.2(a) Shows the effect of varying slot width (W), on the impedance bandwidth of the antenna. It is observed that the operating band of the antenna is much dependent on the width of the slot, the operating band shifts down. Figure.2(b) exhibits the effect of the length patch, on the impedance matching. The best performance is obtained with optimized L (10.8mm). These results suggest that the proposed antenna features typical wide-slot antenna characteristics, namely the width of the patch is the key factor to determine the operating bandwidth of the antenna. The length of the patch shows slight effect on the bandwidth whereas it can be optimized to achieve specified impedance matching.

III. BAND-NOTCH ANTENNA DESIGN

A. Band-Notch structure and Results



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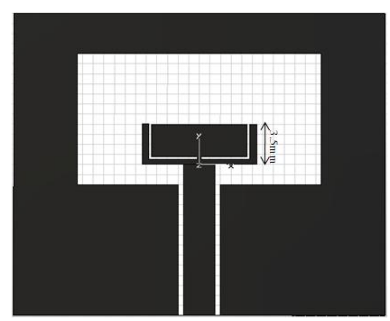
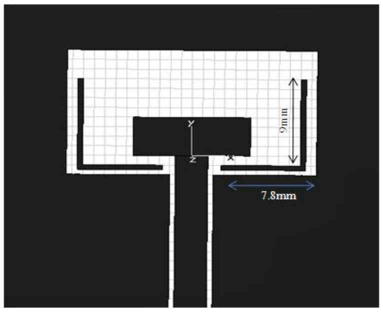


(b)

Figure 3. Geometry of the two band-notched designs using (a) the isolated slit(b) the open-end slits

The band-notch function is desirable in the UWB system to reduce the interferences with the IEEE802.11a and HIPERLAN/2 WLAN systems operating in the 5-6GHz band. In this paper, four kinds of band-notch designs are presented. The Figure.3 shows the geometry and dimensions of these designs. The first design embeds an isolated slit of total length equal to half a wavelength for the frequency at 5.5GHz inside the T-stub as shown in Figure.3(a) . The second design employs two open-end slits at the top edge of the T-stub, as shown in Figure.3(b). Where the



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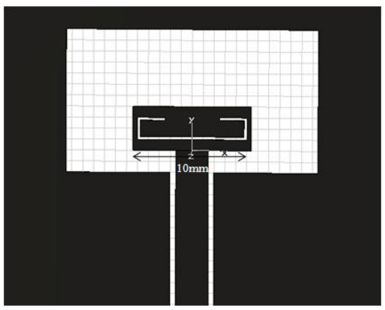
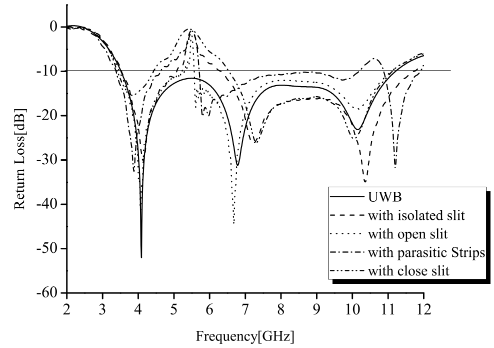
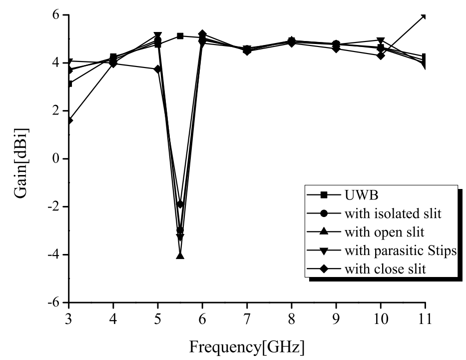


(b)

Figure 4. Geometry of the two band-notched designs using (a) the parasitic strips(b) the close-end slits



(a)



(b)

Figure 5. Return Loss and Gain of the four band-notched designs,compared to the original design(a)-(b)

effective length of each slit is around quarter wavelength for the 5.5GHz resonance. The third design utilizes two parasitic strips of half a wavelength at 5.5GHz, as shown in Figure.4(a). Fourth design embeds an close slits of total length equal to half a wavelength at 5.5GHz, as show in Figure.4(b). Note that when the band-notched design applied to antenna1. There is no retuning work required for the previously determined dimensions. Generally , the design concept of the notch function is to adjust the total length of the slits to be approximately half-wavelength at the desired notched frequency, which makes the input impedance singular at the sub-resonant frequency. To implement it, a narrow-band resonant structure is added to the original wide-band antenna area. Based on this concept, the above four designs using the isolated slit, the open-end slits, the parasitic strips, and the close-end slits as illustrated in Figure.(3)-(4). Figure.7(a)-(b) shows the simulated current distribution in notch frequency by using CST Microwave Studio. The notch frequency given [6] the dimensions of the band notched design can be postulated as

$$F_{notch} = \frac{c}{2L\sqrt{\varepsilon_{eff}}} \qquad (1)$$

Where L is the total length of the slits ε_{eff} is the effective dielectric constant and c is the speed of the light. We can take (eq 1) into account in obtaining the total length of the slits at the very beginning of the design and the adjust the geometry for the final design. Performance of the simulated Return Loss four kind of band notch antennas are shown in Figure.5(a). Compared to UWB antenna , the single band notched UWB antenna successfully blocks out the 5-6GHz band and still performs good impedance-matching at other frequencies in the UWB band. The antenna gain in the entire UWB band is presented in Figure.5(b). Which shows a sharp gain decrease in the 5-6GHz band and good performance at other frequencies in the UWB band.In Figure.6(a)- (b) at frequency 5.5GHz, the current distribution mainly flows around the slits, while around the transmission line the current is small. In this case, destructive interference for the excited surface currents in the antenna will occur, which causes the antenna to be nonresponsive at that frequency. The impedance nearby the feed-point changes acutely making large reflection at the desired notched frequency.

(a)

(b)

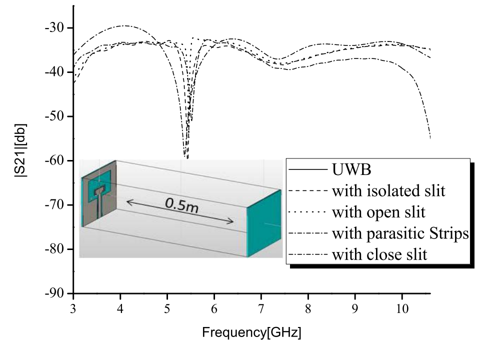
Figure 6. The field distribution of four band-notch at 5.5GHz frquency designs using (a)the isolated slit,the open-end slits.(b)the parasitic strips,the close-end slit.

IV. SYSTEM TRANSFER FUNCTION AND GROUP DELAY

In UWB application, to minimize the potential interferences between the UWB system and the narrowband systems, the variations of the transfer function magnitude and the group delay should be as acute as possible in the notch-bands and need to be constant in the un-notched bands. A transmitting/receiving antenna system satisfying these requirements will suppress the interferences coming from the narrowband systems and lead little distortion on useful signals. In this communication, the system transfer function, which is the transfer parameter S21 of a two-port network, was simulated with face-to-face orientation antenna pairs. The distance between the identical UWB antenna pair was 50cm. Figure.7(a) show simulated magnitude of the transfer parameter S21 for the proposed antennas. For band-notched UWB antennas, it can be observed that the magnitudes of the S21 quite sharp in the 5.5GHz WLAN band. In the UWB system, the phase of the radiated field should vary linearly with the frequency, that is, a stable group delay response is desirable. Figure.7(b) describes the simulated group delay for the proposed antenna. In the vicinity, the group delay variations happened in notch-band., which can deteriorate phase linearity. These variations inevitably can suppress the potential interference between the UWB system and the narrowband systems.

V. CONCLUSION

In this paper, a CPW-fed patch antenna and its extended band-notched design have been proposed for UWB application. The characteristics of the proposed antennas have been investigated through simulation. The proposed antenna has achieved good impedance matching, consistent gain, stable radiation patterns and consistent group delay over operating frequency band. Furthermore, an extended four band-notched design has been proposed with the desired performance over low/high UWB bands and notched band of 5-6GHz. The band notched characteristics can be controlled by adjusting length and width of the slit, whereas no returning of the original design is required. The parametric study has addressed the most sensitive parameters in the proposed antenna designs.



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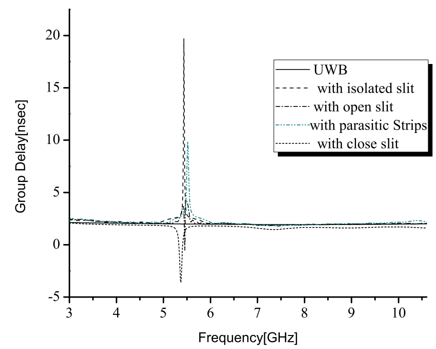

(b)

Figure 7. (a) Magnitudes of the transfer parameter(S21) (b) Group delay for the Proposed Antennas

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