Design of Double-Notch Ultra-Wideband Antenna

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***Abstract*— A dual-notch ultra-wide band antenna is designed which consists of a U-shaped radiator bed by 50 ohms micro-strip. The defected ground structures have been adopted. A series resonant circuit is engraved in the feeder to achieve a notch in the 5.15GHz-5.85GHz band, parasitic strip structures are added on both sides of the feeder to implement another notch in the 3.3GHz-3.8GHz band. Simulation result shows that the U-shaped dual-notch antenna works stably at 2.4GHz-12.5GHz. It can effectively avoid the interference of both wireless local area network (5.15GHz–5.85 GHz) and the worldwide interoperability for microwave access (3.3–3.8GHz) frequency bands. Experiment result verified the design available.**

Keywords—U-shaped; dual-notch; ultra-wideband; defected ground structure

I. Introduction

Recent years, wireless communication technology has developed rapidly. The demand of personal communication has also increased dramatically at the same time. The previous spectrum has become extremely crowded, and ultra-wideband technology can effectively solve this problem. Since February 2002, the U.S. Federal Communications Commission has classified the ultra-wideband band of 3.1GHz-10.6GHz as a civilian band, UWB technology has been widely used [1]. However, there are other wireless narrowband communication systems in the UWB band, such as 3.3GHz-3.8GHz WiMAX and 5.15GHz-5.825GHz WLAN and other narrowband wireless systems [2]. They interfere with ultra-wideband systems. In order to reject these interferences, a notch structure may be introduced on the basis of an ultra-wideband antenna so that the antenna becomes a trapped antenna with a band-stop effect [3]. The "notch function" of an antenna is to use some methods to make the antenna show a larger reflection coefficient in a specific frequency band to filter out unwanted frequency bands [4]. Different structures can be loaded to achieve the notch characteristics of UWB antennas [5]. For example, adding a parasitic element to the antenna structure, using a fractal structure, adding a tuning node, slotting [6].

A method of combining parasitic elements with slotting is discussed. Parasitic elements are added on both sides of the feeder, and the resonant circuit is loaded on the feeder. The U-shaped ultra-wideband antenna has achieved double-notch, avoiding the interference of WLAN and WiMAX narrowband wireless communication systems in the pass band.

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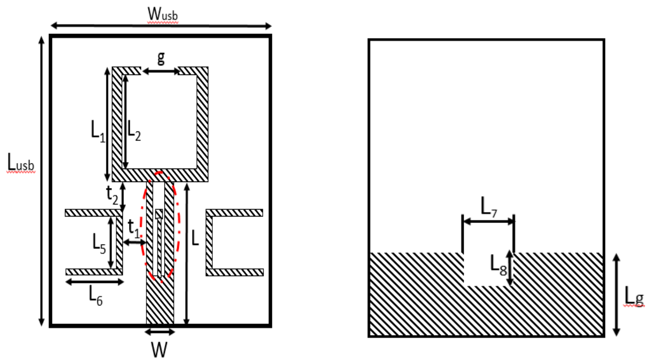
II. Antenna Structure Design

Fig.1 depicts a dual notch U-shaped ultra-wideband antenna. Its front face is formed by a U-shaped radiation patch and a 50Ω rectangular micro strip transmission line. U-shaped parasitic strips are added symmetrically on both sides of the feeder, and a series resonant circuit is engraved in the feeder. The back of the antenna is a defected ground structures.

The way to achieve notch is to embed a resonant circuit in the micro strip feeder [8]. The detailed structure of the resonant tank is shown in Fig.3. In the structure of Fig.2, a rectangle with a side length of L_4 is connected to a square with side length a. It can be seen as a series resonant circuit. When the series resonant circuit corresponds to the working frequency, the entire circuit exhibits pure resistance.

$$L_4 = \frac{c}{4 f_{0} \sqrt{\varepsilon_r}} \tag{1}$$



(a) antenna front view (b) antenna back view

Fig. 1. Double notch U-shaped UWB antenna Fig caption.

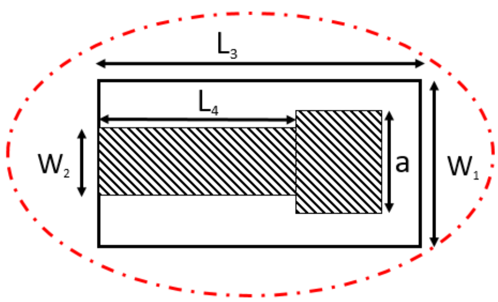


Fig. 2. Series resonant structure(zoom in).

In (1), C is the speed of light, f_0 is the center frequency, and ε_r is the relative permittivity of the dielectric plate.

III. Results and Discussion

The initial parameters of the antenna are given in Table Ⅰ. Set the parasitic stripe width to 0.5 mm. For the dielectric substrate, a polytetrafluoroethylene material having a dielectric constant of ε_r=4.4 and thickness H=1.5mm was selected. The substrate size is *Lusb*=35mm and *Wusb*=30mm.

The length L_4 in the resonant structure is scanned and the distance t_1 between the parasitic stripe structure and the feed line is scanned. The simulation results are shown in Fig.3 and Fig.4. Fig.3 clearly shows that as the distance t_1 between the parasitic strip structure and the feed line gradually increases, the S_{11} of the antenna gradually decreases.

As can be clearly seen from Fig.4. As the length of the resonant structure L_4 increases, the center frequency of the corresponding stop band moves to the left and becomes small.

TABLE I. ANTENNA INITIAL PARAMETERS (UNIT:MM)

Parameter	L	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
Size	14	14.3	8.7	6	5.6	6.3	9.7	2.7	4.2
Parameter	W	W_1	W_2	g	L_g	t_1	t_2	a	
Size	3.4	2.3	0.5	1.5	12.9	0.6	1	1.7	

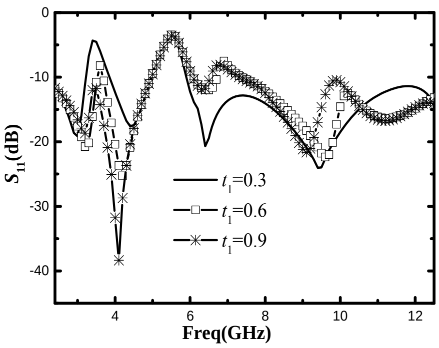


Fig. 3. Relations between the return loss and the dimensions variation of parameter t_1 (unit:mm).

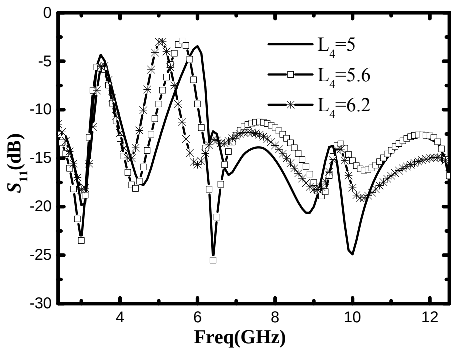


Fig. 4. Relations between the return loss and the dimensions variation of parameter L_4 (unit: mm).

This is the same principle as formula (1). We optimized the antenna parameters based on the parametric sweep. Parameters of the optimized antenna are given in Table Ⅱ.

Fig.5 and Fig.6 show the radiation patterns of the dual notch U-shaped ultra-wideband antennas at 2.5 GHz and 7.5 GHz. At 2.5 GHz the double-notch U-shaped ultra-wideband radiation pattern clearly shows that the *E-plane* radiation pattern of the antenna exhibits similar dipole characteristics at low frequencies, and the *H-plane* radiation pattern is approximately equal in the frequency range. Omnidirectional and symmetric. However, at the high frequency of 7.5GHz, the *E-plane* radiation pattern has a certain degree of distortion. The *H-plane* radiation pattern can be approximated as omnidirectional and symmetrical.

TABLE II. OPTIMIZED ANTENNA PARAMETERS (UNIT:MM)

Parameter	L	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
Size	14	14.3	8.7	6	5.6	7.3	9.7	2.7	4.2
Parameter	W	W_1	W_2	g	L_g	t_1	t_2	a	
Size	3.4	2.3	0.5	1.5	12.9	0.3	1	1.7	

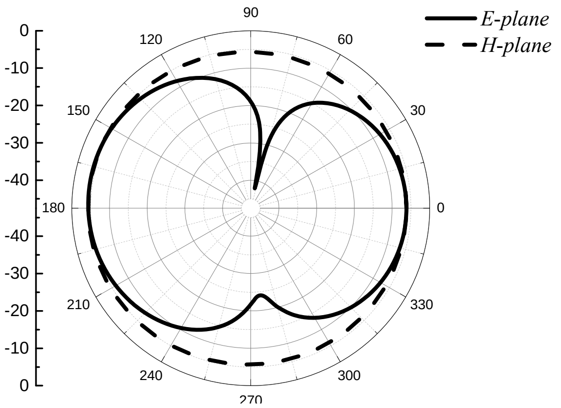


Fig. 5. 2.5GHz radiation pattern (E-plane: *YoZ Plane*, H-plane: *XoY Plane*).

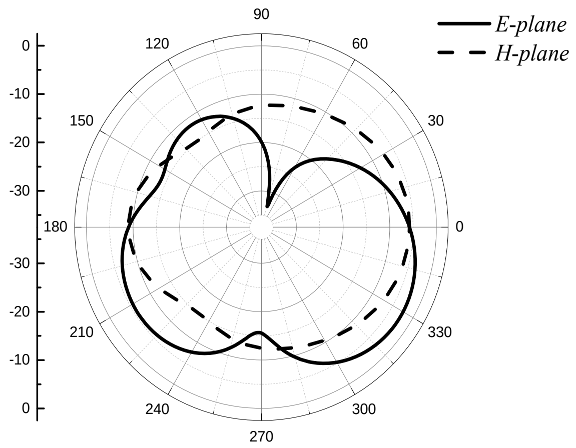
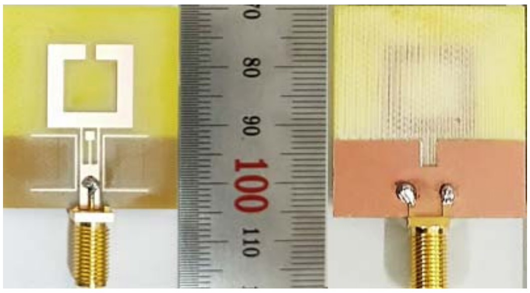


Fig. 6. 7.5GHz radiation pattern (*E-plane*: YoZ Plane, *H-plane*: XoY Plane).

Physical processing and fabrication of the antenna are performed as above in Fig.7. Measured with a vector network analyzer of the antenna return loss (S_{11}), in our laboratory compare the measurement results, simulation results shown in Fig.8.

It can be seen from the Figure that although the antenna has a dual notch feature, there is a large offset in the 3.5 GHz notch band. The return loss of the center frequency at the 5.5 GHz notch has decreased by a certain margin. The high frequencies after 6 GHz also have large frequency offsets from the simulation results. The reason for the analysis is as follows. First: The distance t_1 between the parasitic strip and the micro strip line is too small, only 0.3mm, and there is a loss of precision after machining. Second: the performance of the dielectric substrate will change as the frequency changes.



(a) top view (b)back view

Fig. 7. The fabricated antenna prototype.

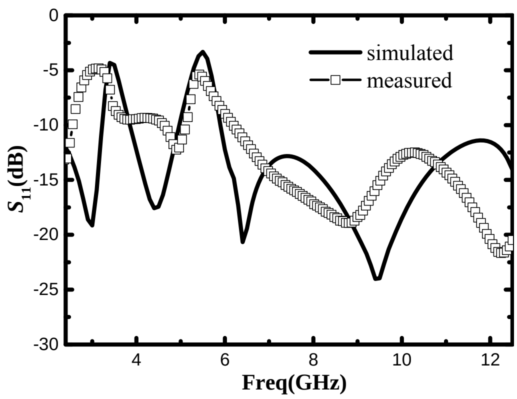


Fig. 8. Comparison of actual measurement and simulation return loss.

IV. Conclusion

In this paper, a new type of dual notch ultra-wideband antenna is proposed. The antenna size is 35mm×30 mm×1.6mm. By loading the resonant circuit on the feeder and adding parasitic stripe structure. Filter out the 3.3GHz-3.8GHz and 5.15GHz-5.85GHz frequency bands. The performance of the stop-band width is greatly improved compared to the conventional dual-trapped ultra-wideband antenna. Effectively eliminates interference from WLAN and WiMAX narrowband wireless systems. The bandwidth of the UWB antenna designed in this paper is 2.4GHz-12.5GHz. Compared with the traditional ultra-wideband antenna bandwidth 3.1GHz-10.6GHz has been greatly improved, the application of double-notch U-shaped ultra-wideband antenna is wider.

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