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Compact CPW-fed ultra-wide band antenna with dual band notched characteristics

Y. S. Li[1a)], **X. D. Yang**[1], **C. Y. Liu, and T. Jiang**[1,2]

[1] *College of Information and Communications Engineering, Harbin Engineering University, Harbin 150001, P.R. China*

[2] *Research Centre of Telecommunication, Harbin Institute of Technology, Harbin, Heilongjiang, 150080, P.R. China*

a) *liyingsong@hrbeu.edu.cn*

Abstract: A CPW-fed ultra-wideband antenna with dual band-notch characteristics is realized experimentally and numerically. Two notched frequency bands are obtained by utilizing a tuning stub between the fork-like radiation element and a rectangle slot in the CPW ground plane. The two notched bands can be controlled by adjusting the length of the tuning stub and the length of the rectangle slot. Experimental and numerical antenna shows that the proposed antenna, with compact size of $21 \times 28\,\text{mm}^2$, has an impedance bandwidth ranging from 3.1 GHz to 10.6 GHz for voltage standing-wave ratio less than 2, expect two notch band frequency 5 GHz-6 GHz for WLAN and 7.7 GHz-8.5 GHz for X-band for satellite and military applications.

Keywords: fork-like antenna, ultra-wideband (UWB), band notched antenna

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

Recently, ultra-wideband system design and applications have become the focus of wireless communications. However, over the entire operation bandwidth, there exist some narrow systems for other communication systems, such as 5.15 GHz-5.825 GHz for the wireless local area network (WLAN), 7.7 GHz-8.5 GHz at X-band for satellite and military communication applications, which may cause potential interference with the UWB systems. An effective method is to use several band-stop filters connected to the UWB antenna. Unfortunately, the system is getting large and complex. Another method is to employ an UWB antenna with notched band function. Therefore, it is necessary to design a UWB antenna with band notch characteristic to reduce the potential interference with the existent narrow systems. Some UWB antennas with band notch characteristics were investigated by using C-shaped slots [1], inverted U-shaped slots and H-shaped slot [2], split ring resonator [3], multi-U-shaped slots [4], rectangular slots and 4-shaped slots [5], and U-shaped slots and E-shaped slot [6]. However, most of the proposed antennas have complex notch band structures with large size which can't meet the demand of integrated with planar printed circuits nowadays.

In this letter, a CPW-fed UWB antenna with dual band notch characteristic is investigated numerically and experimentally. By cutting a rectangle slot in the CPW ground and inserting a tuning stub between the fork-like radiation patch, two band-notched frequencies will appear, which reduce the potential interference between UWB systems and the narrow systems. The designed antenna can meet all the requirements over the UWB band except the two notched band. The proposed antenna is simulated by using HFSS, manufactured and tested successfully. Details of the antenna design are presented and measured results of VSWRs, radiations pattern and the gains of the antenna are also given.

2 Antenna design

Fig. 1 illustrates the geometry and the configuration of the proposed dual band notch antenna. The antenna is printed on a substrate with relative permittivity 2.65, a loss tangent of 0.002 and a thickness of 1.6 mm. The size of the antenna is $21 \times 28\,\text{mm}^2$. And a $50\,\Omega$ CPW feeding structure is employed to feed the proposed antenna. The proposed antenna consists of rectangle slot with width 0.8 mm in the CPW ground and a tuning stub between the fork-like radiation patch, which excites a wide slot with length L1 and width W1. The rectangle slot determines the notch band 5-6 GHz, and tuning stub control another notch band 7.7-8.5 GHz. Generally speaking, the designed central frequency of the notch band function is to adjust the length of the rectangle slot which cut to about half wave-length at the required

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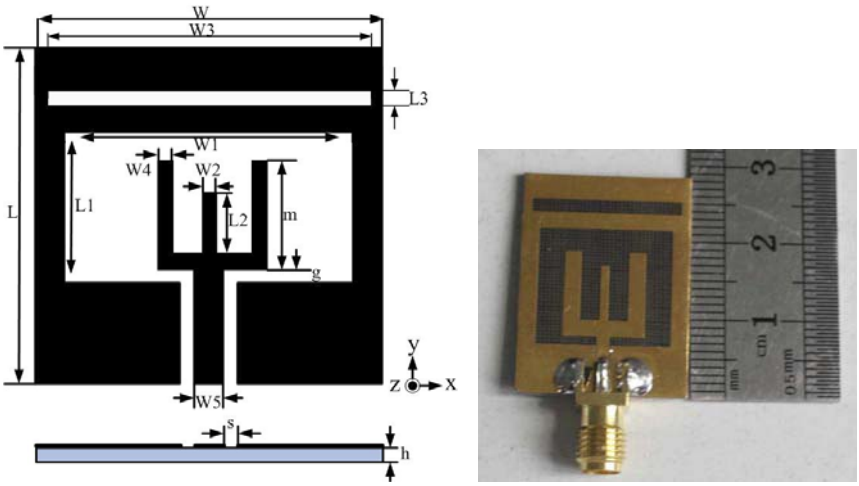

Fig. 1. Geometry of the proposed antenna. (a) The geometry; (b) Phototype of the antenna

notch band and the tuning stub between the fork-like radiation patch which is about quarter wavelength at the center frequency. The notch frequency, given the dimensions of notch band function, can be postulated as:

$$\lambda_{notch} = \frac{c}{f_{notch}\sqrt{\varepsilon_{re}}} \tag{1}$$

Where λ_{notch} is the wavelength of center frequency of the notch band, f_{notch} is the center frequency of the notch band, ε_{re} is the effective dielectric constant, and c is the speed of light. We take (1) into consideration in achieving the dimensions of the length of the rectangle slot and the length of the tuning stub at the beginning of the design and then adjust the geometry for the final design. All the parameters of the proposed antenna are optimized by using the Ansoft high frequency structure simulator (HFSS) based on FEM method. The optimized parameters are as follow: L=28 mm, W=21 mm, L1=15 mm, W1=16.8 mm, L2=7 mm, W2=1 mm, L3=19 mm, W3=0.8 mm, W4=1.4 mm, m=10.8 mm, g=1.4 mm, W5=1.4 mm, s=0.3 mm, h=1.6 mm.

3 Experimental results and discussion

According to the design rules described above, a UWB antenna with dual rejection band at WLAN/X-band was presented numerically and experimentally. The optimized antenna is also fabricated and tested. The VSWR is obtained by Anristu 37347D vector network analyzer. The simulated and measured VSWRs of the proposed antenna and the UWB antenna without rectangle slot and the tuning stub are shown comparatively in Fig. 2. It can be seen from Fig. 2, the proposed antenna can cover the whole UWB band without all the slots. It also appears that the antenna can satisfy the UWB (3.1 GHz-10.6 GHz) applications for VSWR<2, while rejects the 5-6 GHz for WLAN and 7.7 GHz-8.5 GHz for X-band applications. The differences between the simulated and measured values may be due to the errors of the manufactured antenna and the SMA connector to CPW-fed transition, which

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is included in the measurements but not taken into account in the calculated results. The measured radiation patterns at 3.5 GHz, 6.5 GHz, 9.5 GHz are shown in Fig. 3. It shows that the antenna can give a nearly omni-directional characteristic in the H-plane and quasi omni-directional pattern in the E-

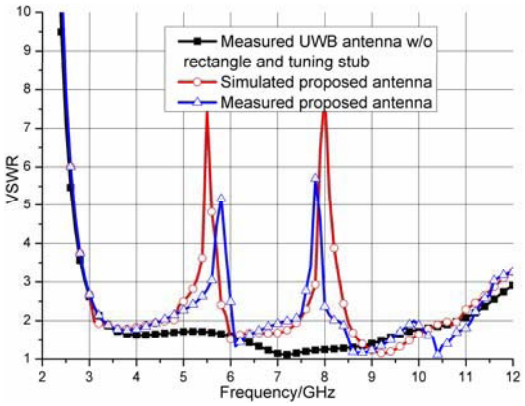

Fig. 2. VSWR of the proposed antenna and the UWB antenna without rectangle slot and the tuning stub

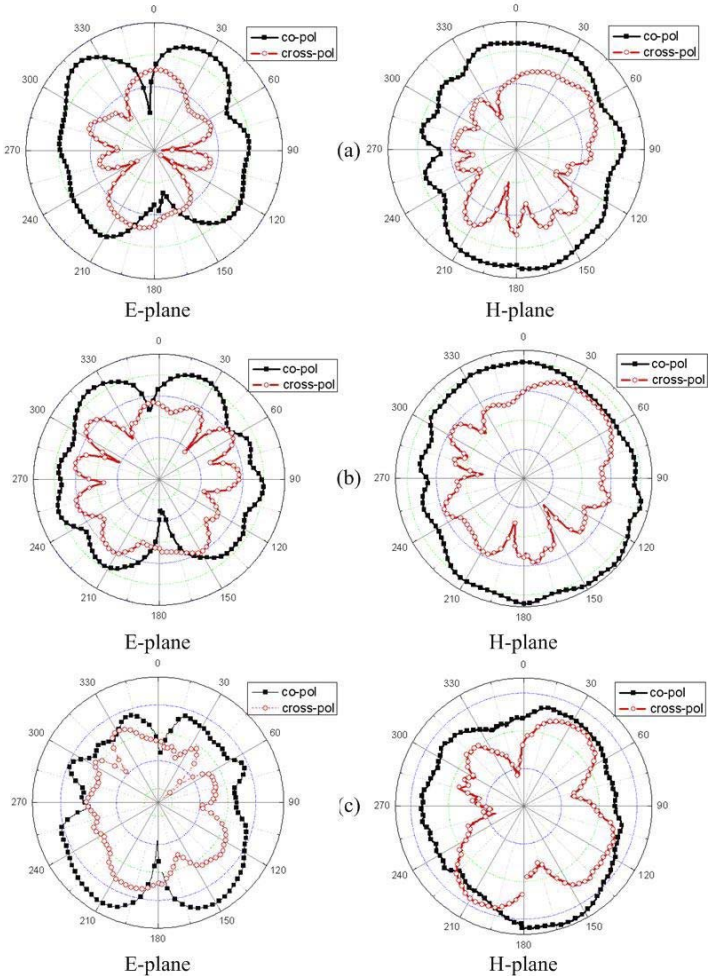

Fig. 3. Measured radiation patterns of the proposed antenna (a) 3.5 GHz; (b) 6.5 GHz; (c) 9.5 GHz

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plane. The gains of the proposed antennas with and without rectangle slot and the tuning stub are shown in Fig. 4. As desired, two sharp gains decreased in the vicinity of 5.5 GHz and 8.0 GHz. The gain drops to −4.6 dBi and −3.7 dBi at the notch band, respectively.

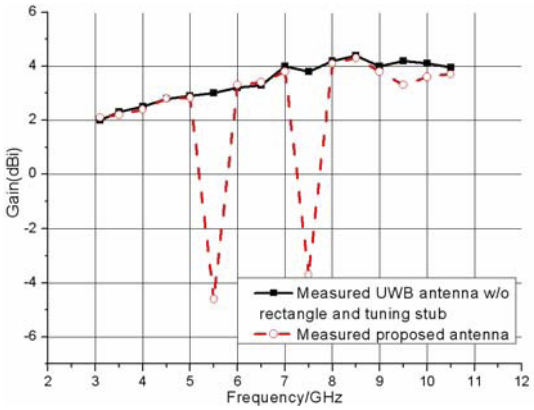

Fig. 4. Measured gain of the proposed UWB antenna with and without rectangle slot and the tuning stub 4. Conclusion

4 Conclusion

A CPW-fed ultra-wideband antenna with dual band-notch characteristics is proposed for UWB applications. Dual stop band is achieved by cutting a rectangle slot in the CPW ground and inserting a tuning stub between the fork-like patch. The antenna is successfully optimized, fabricated, tested. The results show that the antenna not only has dual band notch characteristics but also has good radiation pattern.

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