International Journal of Natural and Engineering Sciences 5 (3): 45-48, 2011
ISSN: 1307-1149, E-ISSN: 2146-0086, www.nobel.gen.tr

Design of A Planar UWB Antenna based on Inverted E-shaped Patch With Dual Band-Notched Characteristics

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Received: July 21, 2011
Accepted: July 29, 2011

Abstract

A printed monopole antenna, consisting of an inverted E-shaped form on the patch and a ground plane truncated with two mirror rectangular notches for ultra wideband (UWB) applications with dual band-notched characteristics is proposed. Two notched frequency bands are achieved by adjusting the inverted E-shape form lengths in the radiation patch. The proposed antenna operates over the frequency band between 2.8 and 13.9 GHz for a voltage standing-wave ratio (VSWR) less than 2, except two frequency notched bands of 3.2-4.2GHz and 5.1-5.9 GHz, and has small overall dimensions of $18 \times 15 \times 1mm^3$. Experimental and simulated antenna results show that the proposed antenna has a desirable VSWR level and radiation pattern characteristics for ultra wideband frequency band range.

Key Words: Dual notched bands, planar antennas, ultra wideband (UWB).

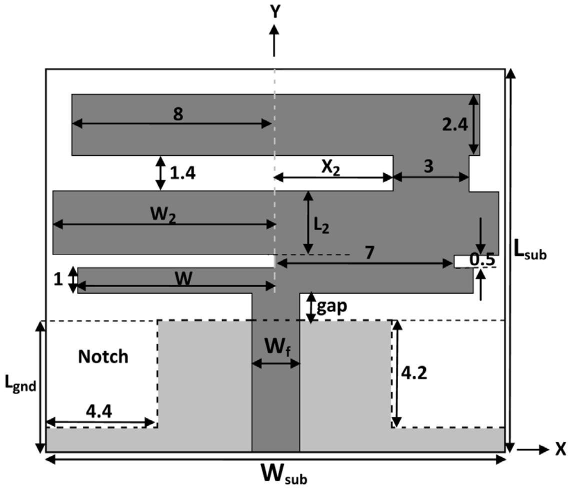
INTRODUCTION

Quick development of wireless communication in the field of UWB technology and its applications has increased demand in commerce and industry [1]. Designing the UWB antenna in these communication systems with proper dimensions, optimization and high performance is one of the microwave engineers major challenges. The main parameters of designing the UWB for rectangular monopole antennas are: simple structure and small size, which have good return loss and desirable radiation pattern and hold close to omni-directional characteristics [2-4]. To access to the proper bandwidth, there are various procedures, some of the considerable methods are for instance: slotting on a rectangular patch or using the notch on the ground plane [5-7]. In the design of an ultra wideband antenna, the shape of the antenna patch, the ground plane, and the slot on them are very important. Some of the examples of the various designed ones are: rectangular, triangular, circular and elliptical [8]. The impedance bandwidth in the constructed antenna should be accepted by FCC (Federal Communication Commission). On the other hand, there are several existing bands operating in the same ultra wideband frequency band such as the IEEE802.11a WLAN system operating in 5.15-5.825 GHz, the IEEE802.16 WiMAX system operating in 3.3-3.6 GHz and C-band satellite communications system in 3.7-4.2 GHz. Recently, several antennas with band-stop characteristics have been reported [9-14].

In this letter, a printed monopole antenna with dual band-notched characteristics is presented. In most reported antennas, up to now, the slots on the radiation patch or ground plane have been used for achieving band-notched characteristics. In this antenna, two notched frequency bands are obtained by using inverted E-shaped form in the radiation patch. By choosing the dimensions of the inverted E-shape properly, dual band-notched can be achieved. A pair of mirror rectangular notches in the corners of the ground plane is proposed for improve the high frequency performance. Details of the antenna design are presented, and comparison between simulated and measured results of VSWR, radiation pattern, and antenna gain are given.

MATERIALS AND METHODS

The designed (UWB) antenna configuration with $W_{sub} \times L_{sub}$ dimensions in indicated in Fig. 1. In this design, the antenna is constructed with a substrate made of FR4, with the thickness 1 mm and the relative dielectric constant 4.4. The feed-line microstrip width is 1.875mm for 50-Ω impedance. The constructed antenna consists of a semi-rectangular patch and rectangular ground plane. An inverted E-shaped form on the semi-rectangular patch is connected to the feedline. By adjusting the length and width of the inverted E-shape form the band-notched characteristics for WiMAX, the C-band satellite communication systems, and WLAN can be obtained. In addition, for the proper matching of the bandwidth, the distance between the semi-rectangular patch and the ground plane that is printed on the back of the substrate is indicated with gap, which provides suitable control between the lower edge patch and the ground plane. On the ground plane, a pair of mirror rectangular notches is located in the corners of the ground plane and is truncated for indicating the sensitivity of the impedance bandwidth in the upper frequency of the band and optimizing VSWR. The size of the notch in the corners of the ground plane has been optimized. A truncated ground plane plays a major role in broad band characteristics of this antenna, which helps to proper matching the patch and the ground plane.



(a)

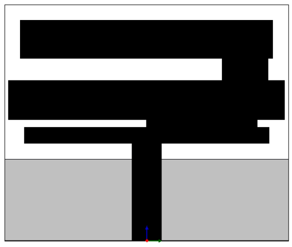
(b)

Fig.1. Configuration of the proposed antenna with small mirror rectangular notch. (a) Dimensions and parameters of the proposed antenna (units:mm). (b) Photograph of the printed monopole antenna (front).

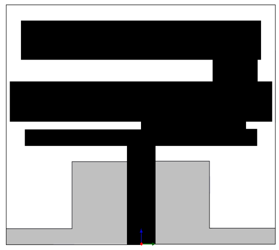
The optimal parameters of the constructed antenna are as follows: W_{sub} = 18 mm, L_{sub} = 15 mm, L_{gnd} =5.2 mm, gap = 1mm, W_f = 1.875 mm, W=7.75mm, W_2 = 8.75 mm, L_2 = 2.5 mm, X_2= 4.8mm.

RESULTS AND DISCUSSION

In this section, after introducing the proposed antenna, we investigate the various values of W, W_2, L_2, and X_2 parameters. In this parametric study, the best value for each parameter has been chosen, and by fixing it, we optimize the remainder of the parameters. The simulated results are obtained using the Ansoft simulation software high frequency structure simulator (HFSS 10) [15]. Fig. 2 shows the difference between the antenna structure and the ground planes. From the simulation results in Fig. 3, it is found that the two notches truncated in the corners of the ground plane increase the sensitivity of the upper frequency than the lower frequency. Fig. 4 shows the current distribution at the first and second notch frequency. As shown in Fig. 4(a) and (b), in these structures at the notch frequency, the current flows are more dominant around the filter structures. So, the current offset can lead to the dual band- notched at 3.2-4.2 GHz and 5.1-5.9 GHz. The first notched band corresponds to the length of the X_2. Simulated VSWR curves with different values for X_2 parameter are shown at Fig. 5. Out of the results of this simulation, we can learn that by increasing X_2 from 0 to 6 mm, the notched band moves to a lower frequency. Also, it can be observed that by changing the length of the X_2, suitable band-notch for WiMAX(3.3-3.6) and C-band (3.7-4.2) can be



(a)



(b)

Fig. 2. (a) Antenna without notch with ground plane. (b) Antenna with two rectangular notches in the ground plane.

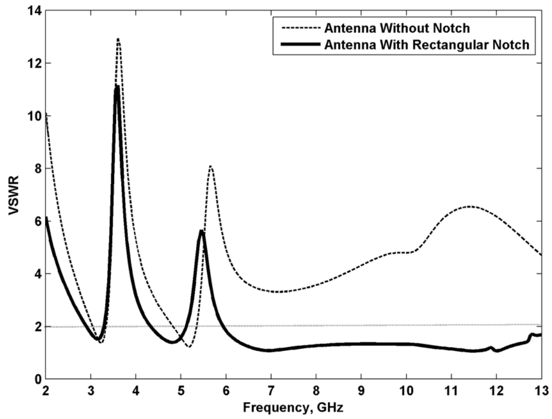
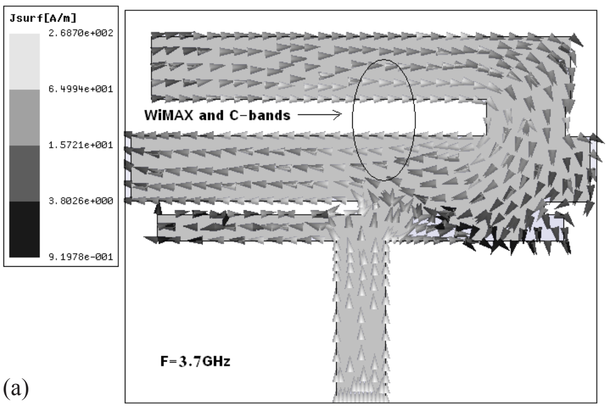
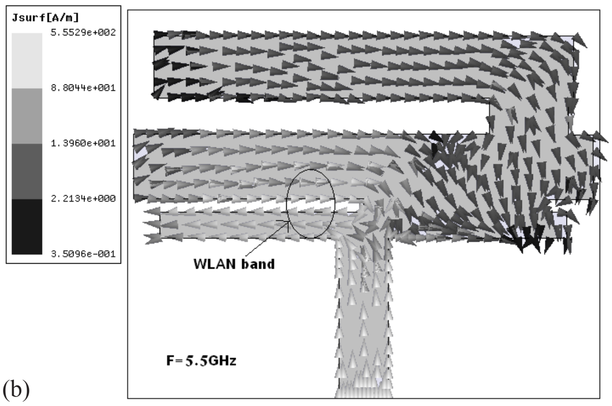


Fig. 3. Simulated VSWR for antenna shown in Fig. 2.



(a)



(b)

Fig. 4. Simulated current distributions on the patch, at (a) first notch frequency and (b) second notch frequency.

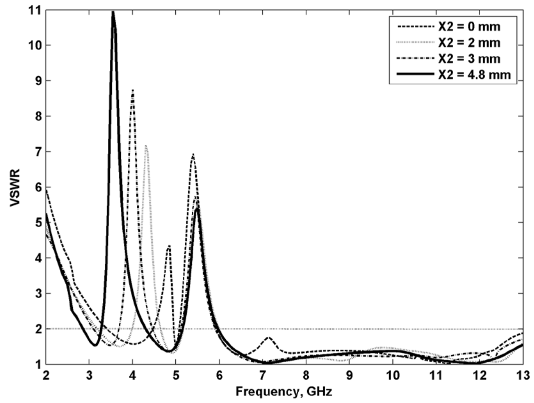


Fig. 5. Simulated band-rejection characteristics of the proposed antenna with notched bands for various values X2.

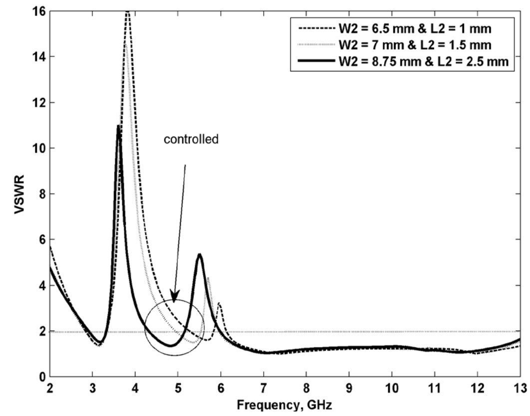


Fig. 6. Simulated band-rejection characteristics of the proposed antenna with notched bands for various values W2, L2.

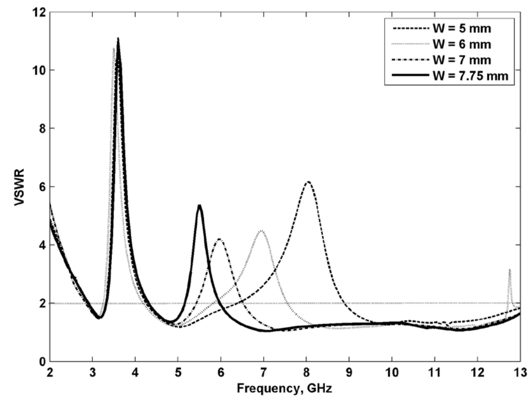


Fig. 7. Simulated band-rejection characteristics of the proposed antenna with notched bands for various values W.

achieved. In this structure, the parameters W_2 and L_2 mainly determine the first and second notched bands. Fig. 6 shows the simulated VSWR curves with different values for W_2 and L_2. It can be observed that by increasing the width of the W_2 and length of the L_2, suitable dual band-notched characteristics can be controlled. Therefore, doing several experiments, W_2 in 8.75 mm and L_2 in 2.5 mm are fixed. Fig. 7 shows the simulated VSWR curves with various values for W. As shown in Fig. 7, the central frequency of band notch at 5.5GHz decreased by

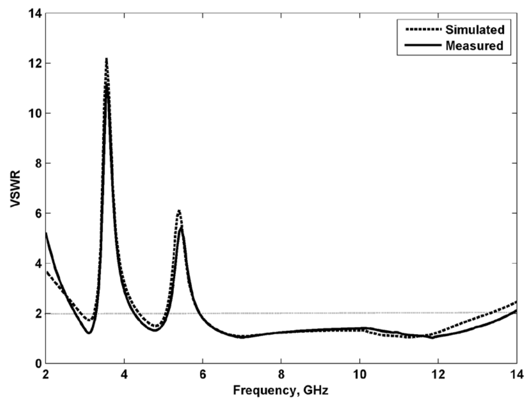


Fig. 8. Measured and Simulated VSWR of the proposed antenna.

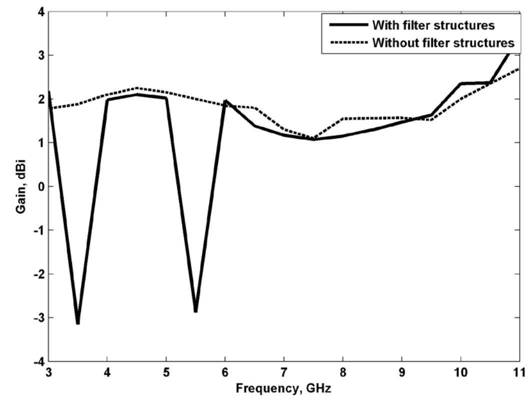


Fig. 9. Measured antenna gain of the proposed antenna.

increasing the value of W. All of the results certify that the antenna is a promising candidate for ultra wideband system to avoid interference with WiMAX (3.3-3.6), C-band (3.7-4.2), and WLAN (5.15-5.825) bands. The simulated and measured VSWR characteristic of the proposed antenna is illustrated in Fig. 8. The figure clearly shows that the constructed antenna exhibits two notched bands of 3.2-4.2 and 5.1-5.9 GHz, while maintaining wideband performance from 2.8 to 13.9 GHz for VSWR<2, covering the entire UWB frequency band. Also, the little different between the two curves results from SMA port in the laboratory. Fig. 9 shows the measured maximum antenna gain from 3 to 11 GHz for the proposed antenna with and without filter structures. The figure indicates that the realized dual band-notched antenna has good gain flatness except in the two notched bands. As shown in Fig. 9, gain decreases drastically at the frequency bands of 3.5 and 5.5 GHz. Fig. 10 shows the measured radiation pattern in frequencies 3, 7 and 9.5 GHz, in H-plane(x-z plane) and E-plane(y-z plane). The figure is approximately indicative of omnidirectional radiation pattern in the x-z plane.

CONCLUSION

A printed monopole antenna with dual band-notched characteristics for UWB applications is proposed. Dual band-notched characteristic is achieved using an inverted E-shaped form in the radiation patch, which exempt from interfaces with

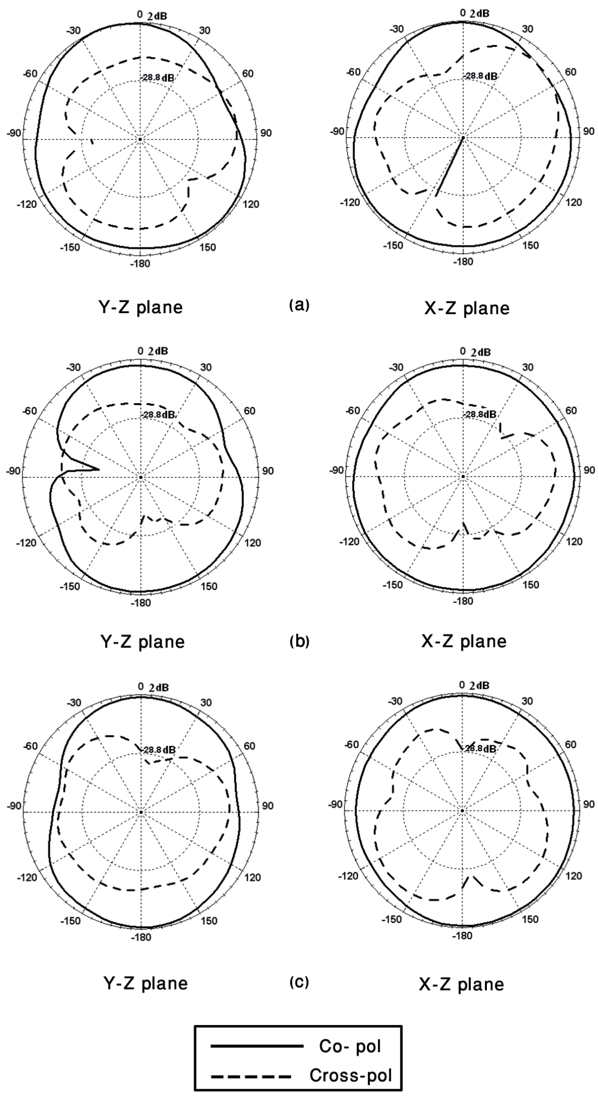


Fig. 10. Measured radiation pattern of the proposed antenna. (a) 3, (b) 7, and (c) 9.5GHz.

existing WiMAX, WLAN and C operating bands. Also, by inserting two notches in the corners on the ground plane with proper dimensions, a wide impedance bandwidth from 2.8 to 13.9 GHz is achieved. The size of the rectangular notches on the ground plane has been optimized. This antenna is suitable for ultra wideband systems with proper dimensions and aforementioned characteristics.

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