International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 7 (2015) pp. 16815-16823

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Design And Optimization Of Single Notched UWB Antenna Using Genetic Algorithm

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Abstract

A monopole Ultra-Wideband (UWB) antenna with single notched band at WLAN is proposed. Initially, a basic UWB monopole antenna is developed and its dimensions optimized using Genetic Algorithm (GA) to get best possible frequency characteristics. Later, a U-shaped slot is etched in the radiating patch to generate notch at WLAN. A parametric study of the slot dimension on the notch position is provided. Finally, the antenna and U-shaped slot dimensions are optimized using GA and the values obtained are quite close to the ones obtained manually. The proposed structure is fabricated and tested for response against the simulated data. The proposed antenna is small in size and is efficient.

Keywords: Antenna, Co-planar waveguide (CPW), Genetic Algorithm (GA), Ultra-wideband (UWB).

I. Introduction

The present scenario of wireless communication requires passive microwave devices which are compact and efficient. These days wireless personal area communication is in vogue. In the progress of that particular demand patch antennas operating over the Ultra-Wideband (UWB) range of 3.1GHz to 10.6 GHz became a necessity [1]. Recently, several antenna structures were developed in this context [2-7, 9-10]. Initially, simple UWB antennas were proposed and later some parametric changes were done to improve the overall performance. Change was incorporated in form of notches which helped to avoid interference from other RF sources like WLAN, C band, etc. The proposed structures implemented slots of different shapes like U, V shape to generate the passband notch. These shapes were designed based on the approach provided in [8]. Recently wide notched band antenna is designed by using an extended strip and

a loaded strip [9]. A compact Co-planar waveguide monopole antenna with folded T-shaped resonator to embed band notch is proposed in [10]. However, they used iterative method to achieve the same. This manuscript proposes a UWB rectangular patch antenna with notched band. Initially a basic UWB monopole antenna is developed. Later, a U shaped slot on the radiating structure is embedded which introduces notch at WLAN (5.15 GHz to 5.85 GHz) and makes it compatible to licensed ranges. Also, in this research work the dimension of antenna as well as that of U-shaped slot has been optimized through Genetic Algorithm (GA).

II. Antenna Design

1. Basic UWB Antenna Design

The proposed single notched band UWB antenna is depicted in Fig. 1. The proposed structure is built on substrate FR4 of dielectric constant 4.4 and height 1.6 mm. FR4 is used because of its cheap cost and easy availability. It is designed using commercial full wave EM software IE3D. The process of designing the basic UWB antenna is explained subsequently. Initially, the basic monopole antenna structure, shown in Fig. 2(a) (case (i)), is constructed and its frequency characteristics plotted. From the return loss plotted in Fig. 2(b), it is observed that the passband exists from 2.8 to 10.7 GHz, but the return loss from 4 to 5.5 GHz is quite poor. In order to improve the same, two rectangular slots are cut on the top edge of the radiating planes and a rectangular slot is cut in the ground as shown in case (ii) of Fig. 2(a). The steps help in improve matching and enhance gain [2]. Fig. 2(b) depicts an improved passband response from 3 to 11

GHz with return loss greater than 10 dB. To further improve the passband response two more slots are cut on the top so as to form steps as shown in case (iii) of Fig. 2(a). This provides a passband response better than that achieved by single step structure, as shown in Fig. 2(b). Adding step at the lower edge of the radiating patch (case (iv) of Fig. 1(a)) produces a deeper and wider passband extending from 3 to 12 GHz, as shown in Fig. 2(b). The improvement in return loss for all the cases is due to the overlapping of current modes at these steps. This structure is then used as a basic structure for generating a notched band UWB antenna.

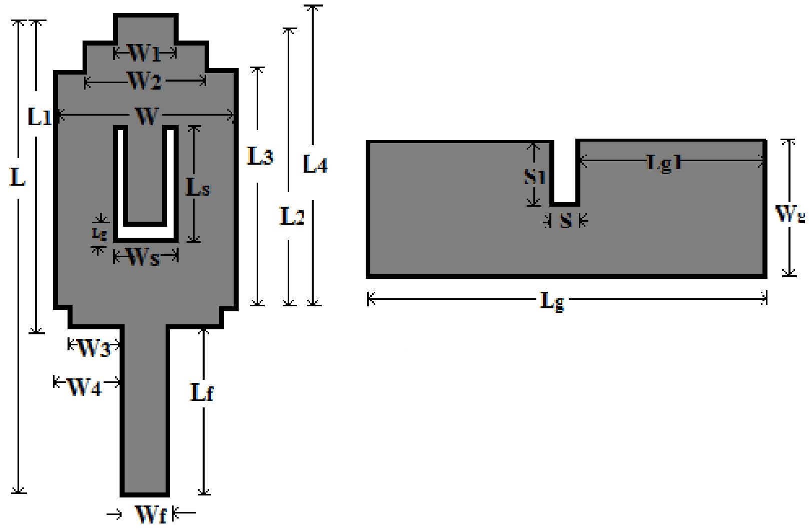
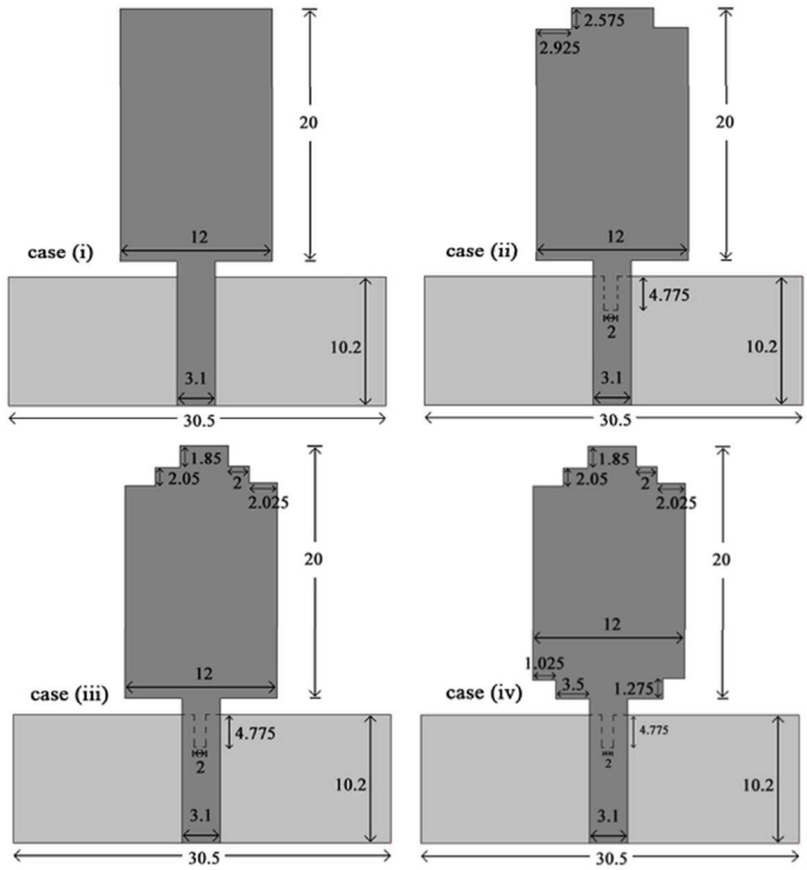
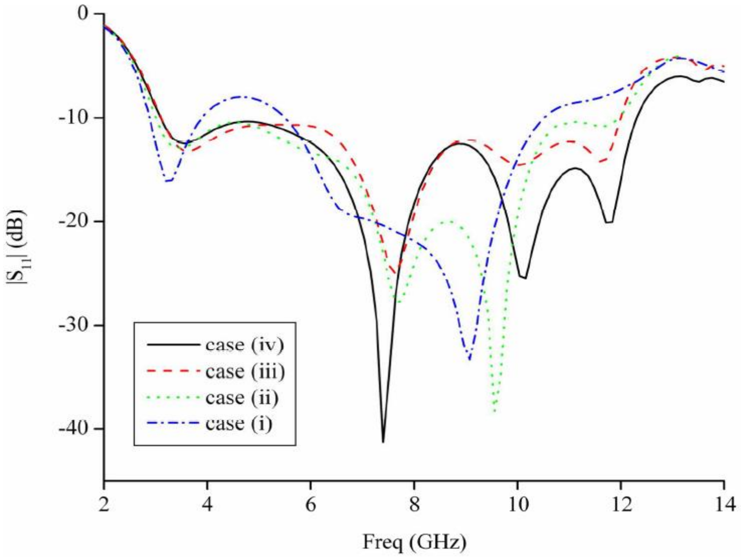


Fig 1. Geometry of the proposed structure.



(a)



(b)

Fig. 2 (a) Four different cases corresponding to step by step development of the basic UWB antenna. (b) Comparative return loss for the four different cases.

2. Notched band UWB Antenna

The UWB systems are prone to interference from other wireless service providers like WLAN, C, RFID band etc. In order to circumvent these interferences stopband characteristics needs to be integrated with the antenna. Here we do that by embedding U-shaped slot in the radiating patch so as to introduce a notch at WLAN (5.15GHz to 5.85GHz), as shown in Fig 3(a). This paper makes use of genetic algorithm (GA, a module integrated within IE3D Zeland) to optimize the antenna and slot dimensions and thereby improve performance. GA mimics the principles of natural genetics and selection to constitute search and optimization procedures [11]. In the present work parametric study of slot has been done which justifies the results obtained through GA.

Fig. 3(b, c) depicts the effect on notch position due to slot width and length. It can be seen from Fig. 3(b) that as the slot width *Ws* is increased the notch shifts to lower frequency whereas for reduced slot length *Ls* the notch shifts to higher frequency, as shown in Fig. 3(c). The optimized dimension of the slot in order to generate notch at WLAN is *Ws* = 4.0 mm and *Ls* = 7.0 mm as seen from Fig. 3. The current distribution (Fig. 3(d)), of the proposed structure at 5.8 GHz depicts current concentrated around the slot at the notch frequency. The dimensions of the proposed structure, depicted in Fig. 1, are finally optimized using GA and the values obtained are. *L* = 32.5, *w* = 12.1, *Lf* = 11.6, *wf* = 3, *w3* = 3.525, *w4* = 4.525, *L4* = 20.9, *L3* = 15.7, *L2* = 17.8, *L1* = 19.7, *w1* = 4, *w2* = 8, *Lg* = 30.5, *wg* = 9.85, *Lg1* = 14.025, *S1*= 4.75, *S* = 2, *Ls* = 3.475, *Ws* = 4, *g* = 1.35. The frequency characteristics of the proposed structure is plotted in Fig. 4 from which it can be seen that the passband extends from 3 to 11 GHz with a return loss greater than 10 dB in the passband except for the notch.

3. Fabrication and Measurement

The picture of the proposed antenna, shown in Fig. 5, is fabricated on low-cost FR4 substrate of dielectric constant 4.4 and loss tangent 0.02. A comparative illustration between the simulated and measured return loss is plotted in Fig. 6(a). The measured response depicts the antenna having an impedance bandwidth from 2.52 to 14.8 GHz with notch-band at 5.8 GHz which corresponds to WLAN. The comparative response shows mismatch between simulation and measured results. This can be attributed to the fluctuation in relative permittivity of the substrate used [12].

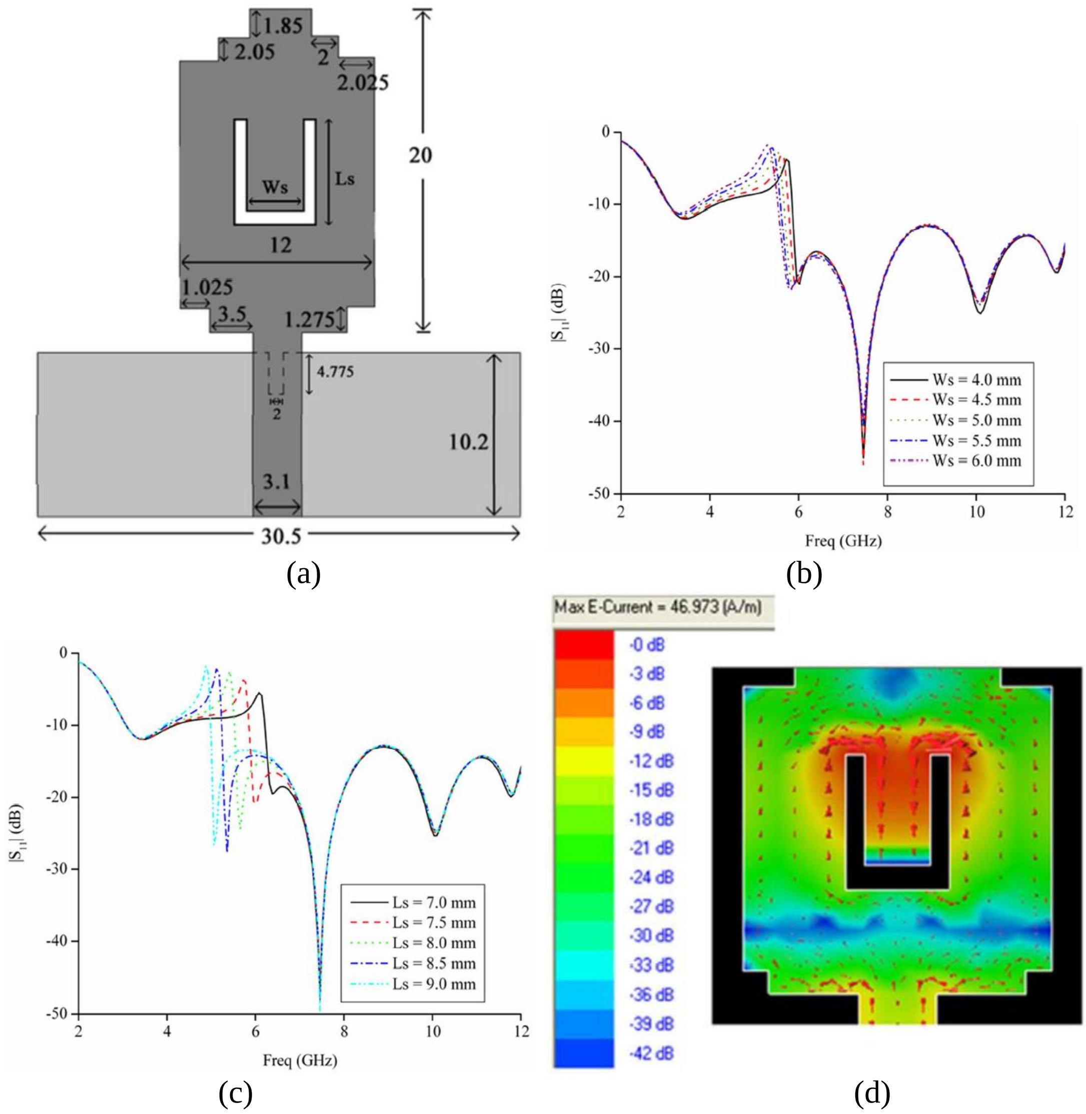


Fig. 3 (a) U shaped slot embedded in the radiating patch. (b) Return loss variation due to slot width. (c) Return loss variation due to slot length. (d) Current distribution at 5.8 GHz.

The comparative measured and simulated gain of the proposed single notch antenna is depicted in Fig. 6(b) from which it is seen that the antenna has dip in gain at the notched band whereas at the remaining frequencies the gain has good response. Fig. 7(a) shows the comparative 2-D normalized radiation patterns of the antenna for 6 and 7.45 GHz, in the yz and xy planes respectively. Fig. 7(b) shows the variation of realized gain with frequency for the proposed antenna over UWB frequency range (2–12 GHz) along with that of the simulated UWB antenna.

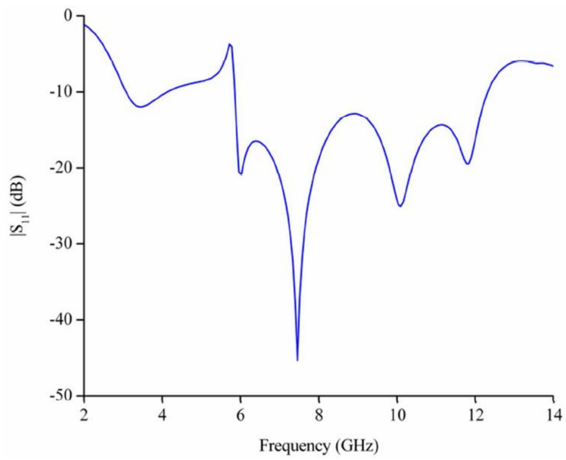
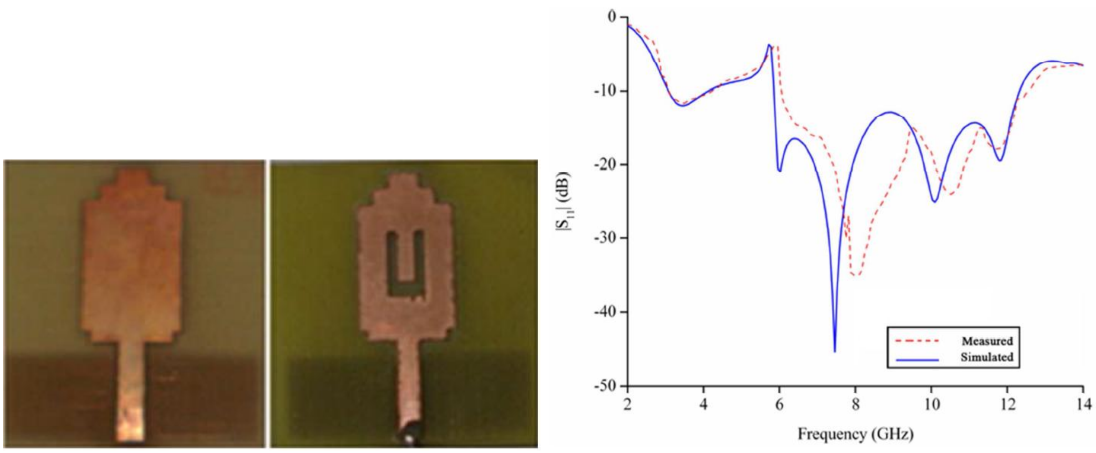
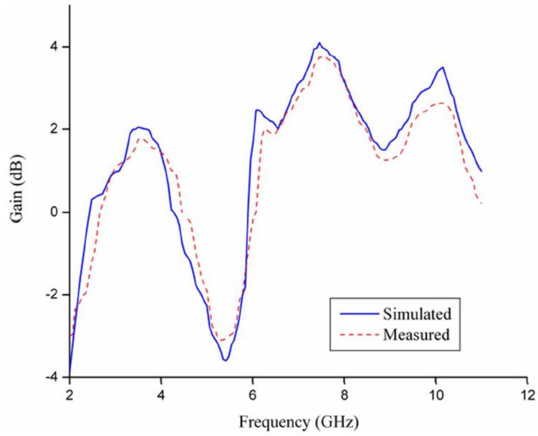


Fig. 4 Return loss of the proposed antenna.

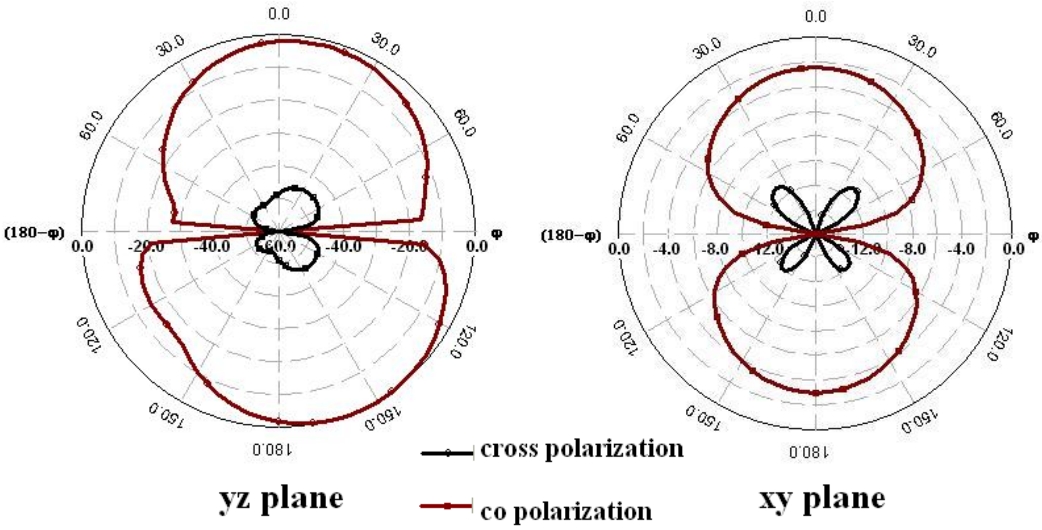


(a) (b)

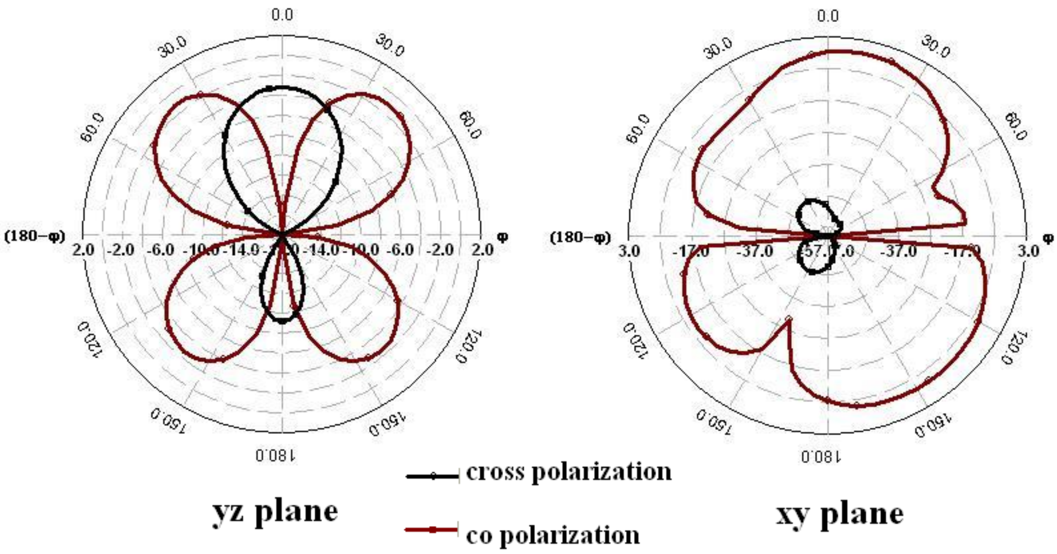


(c)

Fig. 5 (a) Picture of the basic and proposed UWB antenna. (b) Comparative measured and simulated return loss. (c) Comparative measured and simulated gain.



(a)



(b)

Fig. 6 Radiation pattern at (a) 6 GHz and (b) 7.45 GHz.

V. Conclusion

In this work a compact UWB monopole antenna with WLAN rejection has been introduced.

Genetic Algorithm was used to optimize the antenna dimensions and the dimensions obtained were better than that of iterative method. As through GA numbers of iteration can be performed simultaneously hence resulting the better result. Also, both antenna with and without notch have been fabricated and its result has been cross examined through the simulated one. Hence this proposed antenna can be used as a bench mark for further development.

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