

# Triple Notched Band Characteristics UWB Antenna Using C-Shaped Slots and Slot-Type Capacitively-Loaded Loop (CLL)

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## ABSTRACT

Ultra wide bands antennas with notched bands characteristics have recently been considered for efficient communication between devices. In this paper, a compact ultra-wideband antenna (UWB) for UWB applications with triple band-notched characteristics is presented. The proposed antenna consists of a square patch with four truncated corners and a partial ground plane with a rectangular slit. The operation bandwidth of the designed antenna is from 2.66 GHz to more than 13.5 GHz. Band-notched characteristics of antenna to reject the frequency band of 3.18 - 3.59 GHz and 4.70 - 5.88 GHz, is realized by inserting two C-shaped slots in the patch, the third band of 9.54 - 12.22 GHz is achieved by slot-type capacitively-loaded loop (CLL) inserted in the patch near the feed line. Details of the proposed antenna design and simulated results are presented and discussed.

**Keywords:** Microstrip Antenna; Ultra-Wideband Antenna; UWB; C-Shaped Slot; Capacitively-Loaded Loop (CLL); Three-Band Notched Characteristics

## 1. Introduction

Ultra-wideband (UWB) communication systems have become one of the most fascinating wireless topic since the commercial uses of frequency band from 3.1 GHz to 10.6 GHz were approved by Federal Communications Commission (FCC) in 2002 [1].

However, to satisfy the increasing demand for wireless communication, various ultra-wideband antennas have been studied [2]. But the frequency range for UWB systems will cause interference to the existing wireless communication systems, such as world interoperability for microwave access (WiMAX) service from 3.3 to 3.6 GHz; WLAN in USA (5.15 - 5.35 GHz, 5.725 - 5.825 GHz) and HIPERLAN/2 in Europe (5.15 - 5.35 GHz, 5.47 - 5.725 GHz) [3] and satellite service bands as the International Telecommunication Union (ITU) 8 GHz band and the Satellite Digital Multimedia Broadcasting (S-DMB) band 2.63 - 2.655 GHz [4]. Therefore the UWB antennas with a band-notched characteristic are required. To satisfy such requirement various ultra-wideband antennas with notched band have been studied

[5-17]. To introduce such a band-notched function, several methods have been proposed, including embedding a slot of different shapes in the radiating patch, or in the ground plane, using parasitic patches, embedding a slit in the feeding strip, or etching split ring resonator (SRR) coupled to the feed-line [9], or the CSRR (the negative image of SRR) structure [18]. However, the challenge in the band rejection function design is to provide satisfactory skirt characteristics, a sufficient rejection bandwidth and the ability to control bandwidth of the notched band.

In this paper, we propose a novel way to design a triple notched band UWB antenna. The four corners truncated in the patch and the partial ground plane with a rectangular slit are used to obtain ultra wideband operating for UWB applications and to increase the operating bandwidth. In order to realize the triple band notch characteristics, two C-shaped slots are embedded in the radiating patch to achieve the two first rejected bands, and a slot-type capacitively-loaded loop (CLL) to achieve the last notched band.

The simulation is performed using the commercially

available simulation software Ansoft High Frequency Structure Simulator (HFSS). The details of the proposed antenna are presented and the simulation of the VSWR and radiation patterns of antenna are also presented and examined.

## 2. Antenna Design

The geometry of the proposed tri-notched bands UWB antenna is shown in **Figure 1**. This antenna is composed of a square radiating patch with four truncated corners, and a partial ground plane with rectangular slot. The antenna, which has compact dimensions of  $20 \times 20 \text{ mm}^2$ , is printed in the front of FR4 epoxy substrate. Its thickness, relative permittivity, and loss tangent are respectively equal to 1.6, 4.4 and 0.02 mm. The microstrip feed line width, is fixed at 3 mm to achieve  $50 \Omega$  Characteristics impedance.

The truncated corners dimensions are  $8 \times 5 \text{ mm}^2$ . The ground plane dimensions are chosen to be  $30 \times 11.5 \text{ mm}^2$  in this study. The antenna is fed by a 50 microstrip line printed on the partial ground plane.

The first notched band characteristics 3.18 - 3.59 GHz is obtained in this structure, by inserting a C-shaped slot into the radiating antenna patch. The C-shaped slot has total length 34.3 mm and is close to about  $0.4\lambda$  at the center frequency of the desired notched frequency band (the center frequency of the desired notched frequency band is 3.5 GHz).

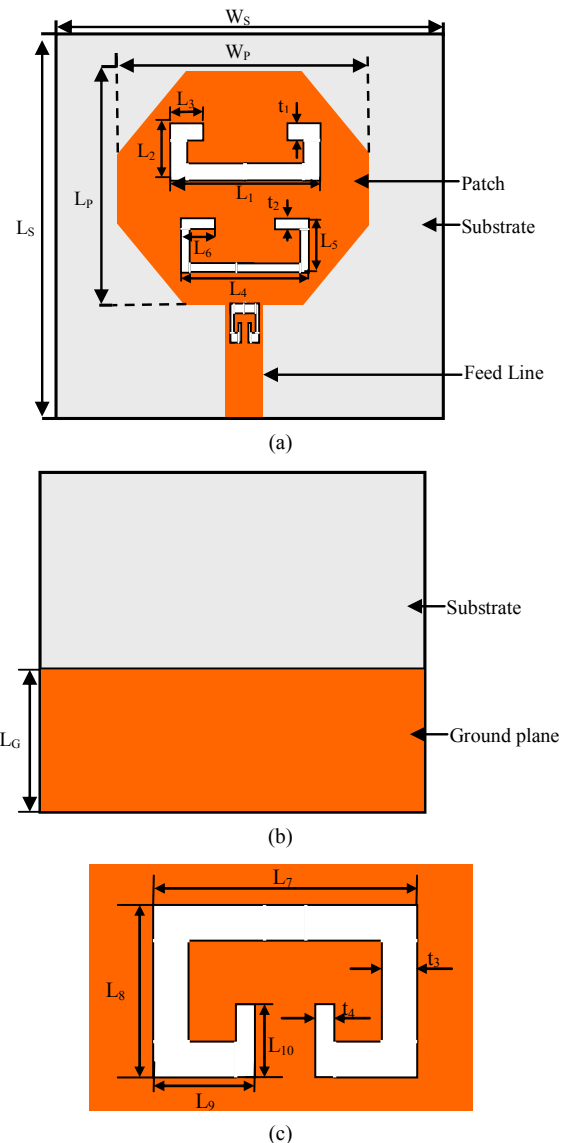
The second notched band characteristics 4.70 - 5.88 GHz is obtained, by embedding another C-shaped slot into the patch. The length of this C-shaped slot is chosen to be 21.8 mm which is about  $0.4\lambda$  at the center frequency of the notched frequency band (the center frequency is 5 GHz).

For the third notched band of 9.54 - 12.22 GHz, a slot type capacitively-loaded loop (CLLs) is introduced in the radiating patch. This slot has a total length of 11.3 mm with  $0.4\lambda$  at the center frequency of the notched band (10.8 GHz).

The bandwidth and the central frequency of the notched bands can be adjusted easily by proper selection of the parameters of C-shaped slot and slot type capacitively-loaded loop (CLLs).

The electromagnetic software high frequency structure simulation Ansoft HFSS is employed to perform the design and optimization of the proposed.

The final parameters of the antenna are:  $WS = 30 \text{ mm}$ ,  $LS = 35 \text{ mm}$ ,  $WP = 20 \text{ mm}$ ,  $LP = 20 \text{ mm}$ , and  $LG = 11.5 \text{ mm}$ . The dimensions of the C-shaped slots are:  $L1 = 11.8 \text{ mm}$ ;  $L2 = 7 \text{ mm}$ ,  $L3 = 4.25 \text{ mm}$ ,  $L4 = 9.5 \text{ mm}$ ,  $L5 = 3 \text{ mm}$   $L6 = 3.15 \text{ mm}$ ,  $t1 = 1 \text{ mm}$ ,  $t2 = 0.5 \text{ mm}$  and the dimensions of the CLLs are:  $L7 = 2.5 \text{ mm}$ ,  $L8 = 2.4 \text{ mm}$ ,  $L9 = 1 \text{ mm}$ ,  $L10 = 1 \text{ mm}$ ,  $t3 = 0.4 \text{ mm}$ ,  $t4 = 0.2 \text{ mm}$ .



**Figure 1. Configuration of the proposed UWB antenna: (a) Front view; (b) Back view; (c) CLLs.**

## 3. Results and Discussion

The curve of the simulated VSWR for proposed UWB antenna with and without slots is depicted in **Figure 2**. As shown in this figure from simulation result, it can be observed that the proposed antenna presents an impedance bandwidth with good matching for  $VSWR \leq 2$  from 2.66 GHz to more than 13.5 GHz, which covers the frequency band of UWB band (3.1 - 10.6 GHz) and with triple rejected bands ( $VSWR > 2$ ). The three notched bands are: 3.18 - 3.59 GHz ( $VSWR = 13.78$  at 3.4 GHz), 4.70 - 5.88 GHz ( $VSWR = 8.31$  at 5.26 GHz) and 9.54 - 12.2 GHz ( $VSWR = 7.77$  at 10.94 GHz). Results of the reference antenna without notched characteristics are also shown for comparison. Moreover, it can be observed that adding

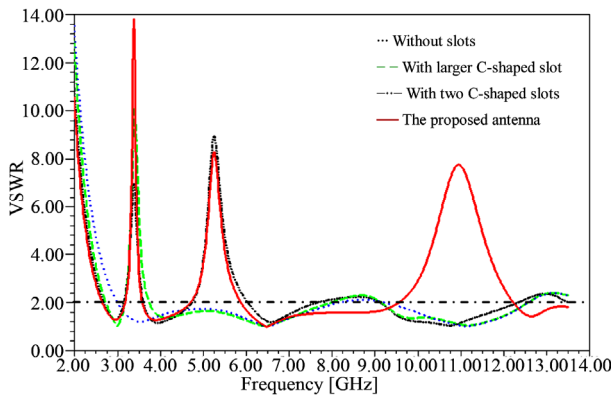


Figure 2. Simulated VSWR of the proposed antenna with and without C-shaped slots and CLLs slot.

slots can increase the impedance bandwidth.

The radiation patterns of the proposed antenna in the E and H-plane at 3 GHz, 4 GHz, 7 GHz, 9 GHz and 13 GHz respectively are shown in Figure 3. From the figure, we can see that the simulation radiation patterns of the proposed antenna are nearly omnidirectional in the E-plane, except for 3 GHz; which makes it a good candidate for UWB devices. While, in the H-plane, the radiation patterns are like dipole radiation pattern, however, these radiating patterns are subject to distortion at high frequencies.

#### 4. Conclusion

In this paper, a new compact planar ultra-wide band

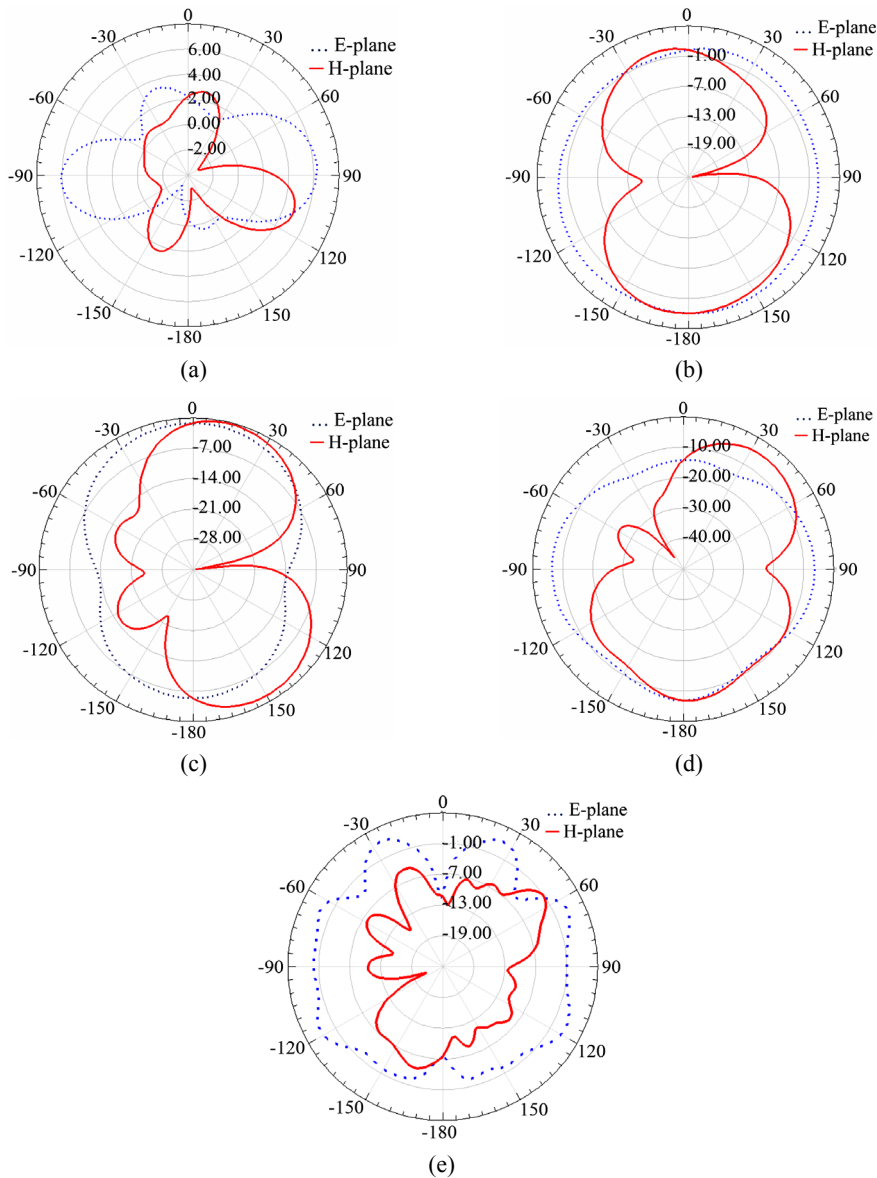


Figure 3. Simulated radiation patterns for proposed antenna at (a) 3 GHz, (b) 4 GHz, (c) 7 GHz, (d) 9 GHz, and (e) 13 GHz.

antenna with triple band notch characteristics has been proposed for UWB applications. The notches bands are realised by etching two C-shaped slots and a slot type capacitively-loaded loop (CLLs) in the radiating patch. The proposed antenna is studied and simulated by the Ansoft HFSS. It has a wide operating frequency band of 2.66 GHz to more than 13.5 GHz ( $VSWR < 2$ ) with three rejected bands of 3.18 - 3.59 GHz, 4.70 - 5.88 GHz and 9.54 - 12.2GHz ( $VSWR > 2$ ). The radiation pattern of the designed antenna shows good omnidirectional pattern over the operating frequency range, with good notched band characteristic. Accordingly, the proposed antenna is not only expected to find application in various UWB systems, but prevents interference with others communications systems.

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