Ultra-Wideband Antenna using Inverted L Shaped Slots for WLAN Rejection Characteristics

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ABSTRACT
Planar ultrawideband antenna with WLAN rejection characteristics is studied in this paper. Rejection characteristic is achieved by a pair of inverted L shaped slots in the ground plane. The proposed antenna yields an impedance bandwidth of 2.6-12GHz with VSWR<2 except at the notched band. The antenna gain varies from 2.8 dBi to 5.2 dBi over the UWB band with dips at the rejection band. Numerical simulations of the proposed antenna demonstrate that the presented methodology is accurate and efficient to design compact band notch antenna for UWB applications.

Keywords
Ultra wideband (UWB), Wireless LAN (WLAN), Coplanar waveguide (CPW).

1. INTRODUCTION
With the definition and acceptance of the ultra wide-band (UWB) impulse radio technology in the USA [1], there has been considerable research effort put into UWB radio technology worldwide. Recently, the Federal Communication Commission (FCC)'s allocation of the frequency band 3.1–10.6GHz for commercial use has sparked attention on ultrawideband (UWB) antenna technology in the industry and academia. Several antenna configurations have been studied for UWB applications [2–4]. However, the frequency band of UWB communication systems includes the IEEE802.11a frequency band (5.15–5.825 GHz). Therefore, an UWB communication system suffers interference with IEEE802.11a. To overcome electromagnetic interference between UWB system and WLAN system, various UWB antennas with a notch function have been developed for UWB communication systems [5–12].

In this paper, a band-notched elliptical antenna is proposed for UWB applications. Desired notched frequency band is achieved by introducing inverted 'L' shaped slots in the ground plane. By properly adjusting the parameters, it is possible to tune desired band width and center frequency of notched band. The design is capable of producing a steeper rise in VSWR curve at the notch frequency. The designed antenna has a compact size of 41mm × 45mm × 0.762 mm. The simulated results show that the proposed antenna achieves a bandwidth ranging from 2.6 GHz to 12 GHz with notched band covering 5.15-5.85 GHz. The notched band can avoid the potential interference between the UWB systems and WLAN systems. The paper is organized as follows. Section 2 presents the configuration of proposed antenna and parametric study, final simulation results are discussed in Section 3, followed by conclusion in Section 4.

2. ANTENNA DESIGN AND PARAMETRIC STUDY
The geometry of the proposed band-notched UWB antenna is shown in Fig. 1. The proposed antenna is printed on substrate with the thickness of 0.762 mm and the dielectric constant of 2.2. The radiator patch consists of an elliptical section fed by a 50 Ohm CPW line. Two symmetrical inverted 'L' shaped slots are cut on the ground plane to obtain notch band from 5.15 to 5.85 GHz. The semi minor axis of the elliptical patch is obtained by using (1).

$$2 \times R_Y \approx \frac{\lambda_g}{4} \qquad (1)$$

Here λg is the guided wavelength corresponding to 2.6 GHz.
The semi major axis is chosen greater than semi minor to improve matching at lower frequencies. The dimensions are finally optimized using CST Microwave Studio™ [13] .
The total length of the inverted L shaped slot etched from the ground plane near the feed line is deduced as in (2). Moreover, the width and location of the slots can also adjust the rejection bands.

$$L\_SLOT1 = L_1 + L_2 - T_s \qquad (2)$$

$$L\_SLOT1 \approx \frac{c}{2 f_1 \sqrt{\varepsilon_{eff}}} \qquad (3)$$

Here f_1 stand for the centre frequency of WLAN systems that is 5.5GHz.
To understand the characteristics of the slots, parametric studies are carried out using CST Microwave Studio. Simulation results indicating VSWR with different values of L_1, L_2 and T_s are shown in Fig.2, Fig.3, and Fig.4 respectively. Fig.2 and Fig.3 shows that higher the value of L_1 and L_2 lower is the resonance frequency, whereas Fig.4 shows higher the

value of T_s higher is the resonance frequency and peak VSWR achieved.

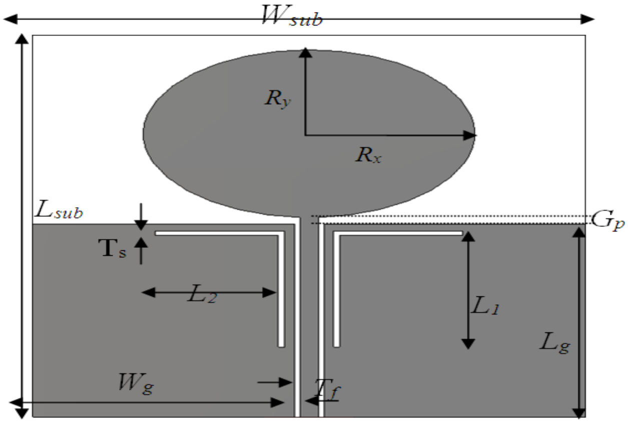


Fig. 1: Layout of proposed antenna.

It is observed from parametric study that the resonant frequency of the notched-band depends on the length of the slot, and notched bandwidth depends upon width of the slot. This property provides a great freedom to the designers to select the notched band for the antennas.

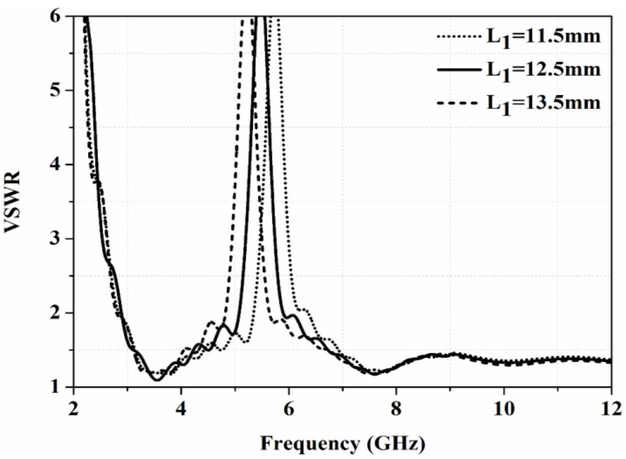


Fig. 2: Simulated VSWR for different values of L_1.

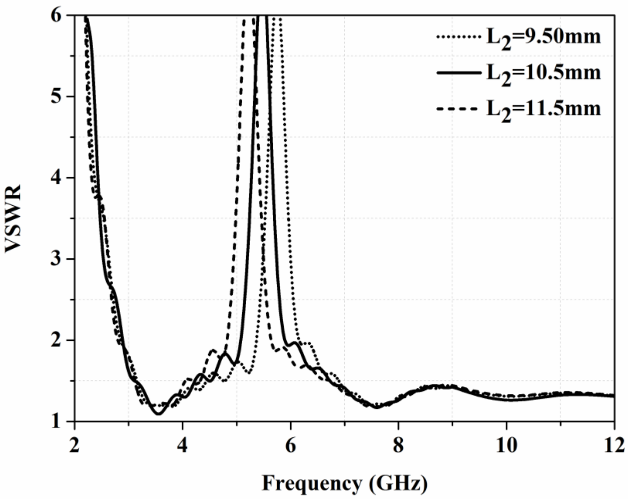


Fig. 3: Simulated VSWR for different values of L_2.

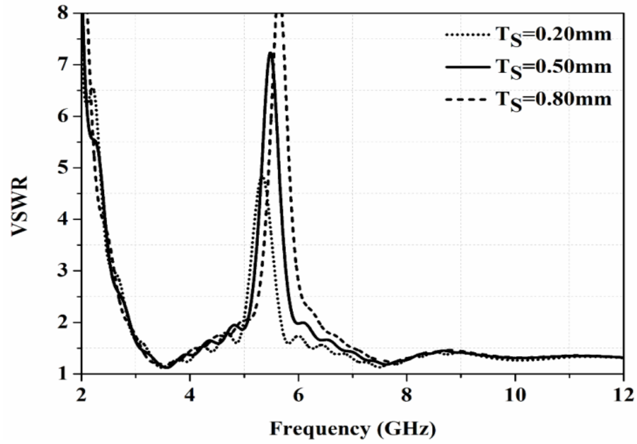


Fig. 4: Simulated VSWR for different values of *Ts*.

3. RESULTS AND DISCUSSIONS

The optimized parameters are enlisted in Table.1. The S11(dB) of the antenna is plotted versus in Fig.5 and it can be observed that the return loss of the antenna is below -10 dB from 2.6GHz to 12GHz (except of the notched band centred around 5.5GHz) and cover the entire UWB band (3.1-10.6GHz). It is very clear that the desired filtering property is achieved by introducing inverted L shaped slots in the antenna structure. The VSWR for the proposed antenna is plotted in Fig.6. The plot shows that VSWR is below 2 for the entire UWB band but experiences a sudden increase around the notch frequencies. Fig.7 shows the current distribution at 5.5GHz which is the central frequency of WLAN systems. It is clear from the figure that the slots start resonating at 5.5GHz and current density is maximum around these slots at the notch frequency.

For the UWB applications the antenna it is desirable to have omnidirectional radiation pattern. Fig.8 shows the E-plane and H-plane patterns of the given antenna at three different frequencies 3.1GHz, 6.85GHz, and 10.6GHz respectively.

Fig.8 shows that the H-plane radiation pattern is nearly omnidirectional around the central frequency of the UWB bandwidth.

Table. 1: Parameters of proposed antenna

Antenna parameters	**Value(mm)**
W_{sub}	45
L_{sub}	41
W_g	21.30
L_g	20.75
R_x	13.5
R_y	9
T_f	1.524
G_p	0.75
Slot Parameters	**Value(mm)**
L_1	12.5
L_2	10.5
T_s	0.5

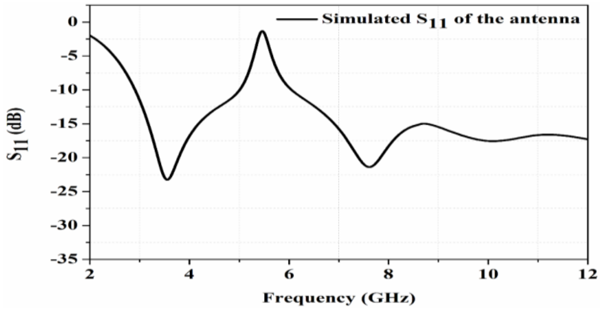


Fig. 5: Return loss of the proposed antenna.

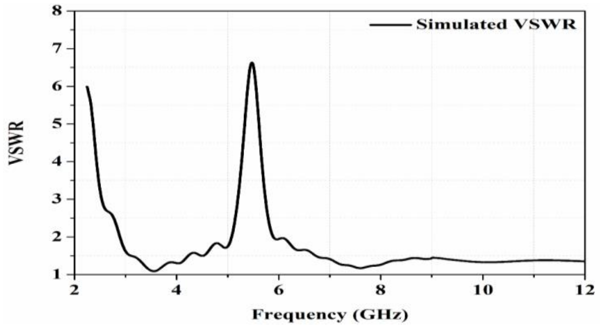


Fig. 6: VSWR of the proposed antenna.

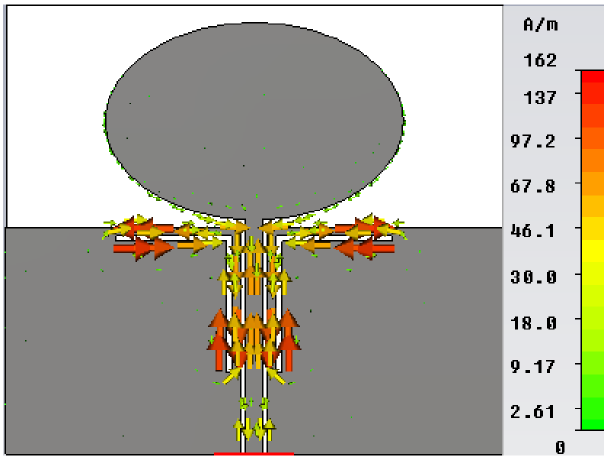
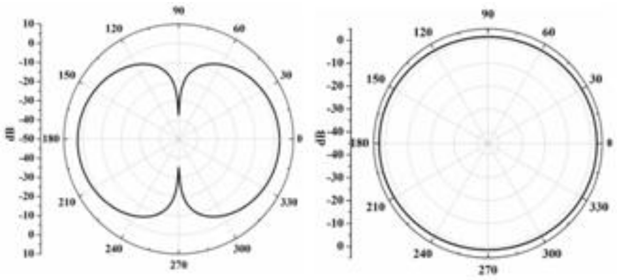
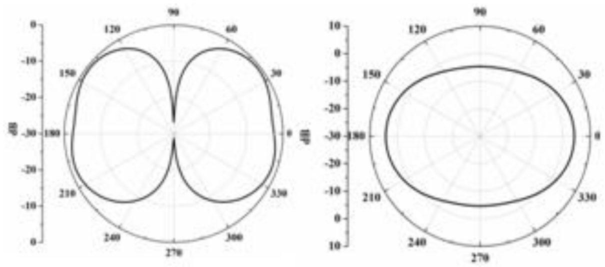


Fig. 7: Current distribution on the antenna at 5.5GHz.

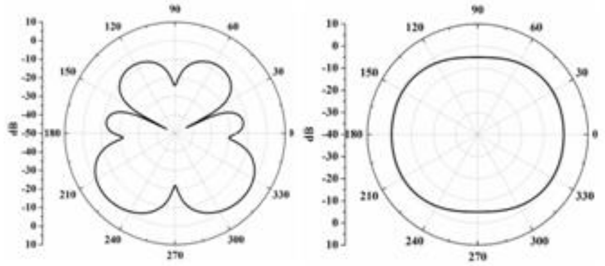
UWB antenna should be distortion free and to ensure this, temporal characterization is desirable. Fig.9 shows the group delay of the proposed antenna. The antenna shows nearly flat response in the UWB range except in notched band where group delay makes large excursion. The antenna gain varies from 2.8 dBi to 6.5 dBi over the band with the gain falling to about -3 dBi at the rejection frequencies.



(a)



(b)



(c)

Fig. 8: E and H plane patterns of the given UWM antenna at (a). 3.1GHz (b). 6.85GHz (c). 10.6GHz.

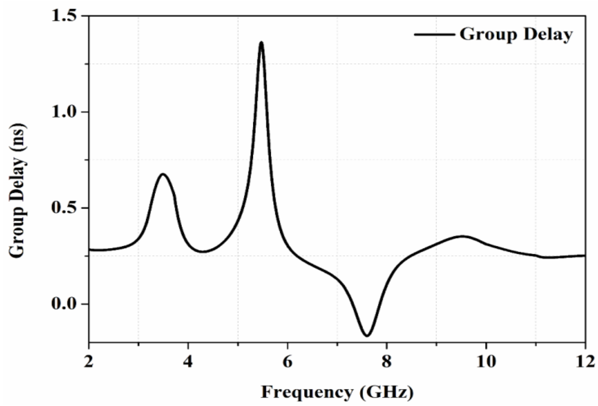


Fig. 9: Group delay of the antenna.

4. CONCLUSION

This paper proposes and analyzes a novel band rejection elliptical monopole ultrawideband antenna. By incorporating inverted L shaped slots in the ground plane, the antenna shows good suppression ability at WLAN with centre frequency 5.5GHz. The antenna gain varies from 2.8 dBi to 5.2 dBi over the band with dips at the rejection frequencies. The group delay excursion remains within 1 ns over the UWB region except at the rejection bands. Numerical simulations of VSWR, reflection coefficient, radiation pattern and group delay of the proposed antenna demonstrate that the presented methodology is accurate and efficient to design compact band notch antenna for UWB systems.

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