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Design Of Compact UWB Antenna With Dual Band Notched Using Two C-Shaped And U-Slot For WLAN And X-Band Rejection

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Abstract

In this paper, two C-shaped and U-shaped slot UWB antenna with dual Band-notched characteristic is proposed. This structures are etched into a compact coplanar-waveguide-fed (CPW) single-layer printed antenna with an ultra-wideband (UWB) rectangular monopole radiator. The operating frequency range is from 4Ghz to 12 Ghz. Two C-shaped of copper strip are etched onto the substrate to filter out 5.1-5.85Ghz frequency for wireless Local Area Network (WLAN) applications, and U-Shaped slot inserted into radiating element to filter 7.25-8.39Ghz Frequency band for X-band satellite communication. The UWB antenna is printed on 20mm×25mm×1mm FR4 substrate with a dielectric constant $\varepsilon_r = 4.3$.

Keywords: *U-Shaped slot; C-Shaped copper strip ; ultra-wideband (UWB); Band-notched ; WLAN ; X-band satellite communication.*

1.Introduction

Ultra-wideband (UWB) technology has various advantages: high transmission rate, high capacity, and low power consumption [1]. This lead to an increased demands on the UWB systems and stimulate the research activities in various UWB antenna [19],[20]. Various coplanar waveguide (CPW)-fed monopoles with differently shaped radiators are drawing more and more attention due to their attractive characteristics: compact structure, omnidirectional radiation pattern, and compatibility with the printed circuit board (PCB) [2]. Printed microstrip antenna are usefel for UWB wireless communication due to their simple structure, low cost fabrication, compact size and light weight[8]. In the literature, various techniques have been applied in the UWB antenna designs to achieve the single band-notched function [4],[5] using the parasitic elements [6], and the electromagnetic band-gap structure [7]. Dual band-notched UWB antennas based on electromagnetic band-gap (EBG) structures closed to the feed line [22] and Dual band-notched small monopole antennas with novel W-shaped conductor backed-plane and novel T-shaped slot for UWB applications [25] was studied. To obtain multiple band-notched functions, another method [21], which had introduced a substrate integrated waveguide (SIW) cavity within the feed line of an UWB monopole antenna, was proposed. But it may lead to increase the antenna size. The popular approaches to achieve band-notched designs were embedding half-wavelength slots with different shapes, U-shaped [9], [10], and arc-shaped [11], [12], quarter-wavelength open-ended slots [13]. Some designs with dual band-notched property are achieved by using a couple of half-wavelength parasitic elements in an open rectangular slot [3], embedding dual C-shaped slots on the radiator [14] structure, based on defected ground structure (DGS), by cutting two E-shaped slots on the ground plane [25]. Moreover, the triple band-notched function [15] and multiple band-notched UWB antenna with band-rejected elements integrated in the feed line[18] are studied. The use of narrowband resonators embedded in wideband antennas has been significantly extended. Thus, resonant slots embedded in wideband planar monopole antennas have focused much attention lately, due to the fact that the insertion of the narrowband slots has proved to produce a frequency-notch feature in the antenna

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response[23],[24]. However, further information about the interaction between the wideband and narrowband structures (the effect of the slot position) can be obtained by means of an innovative approach based on the theory of characteristic modes [26]. Hence, the possibility of providing a frequency-notched characteristic in the antenna itself to mitigate the unwanted interference from wireless LAN systems results extraordinarily attractive.

In this paper, a compact coplanar-waveguide-fed (CPW) single-layer printed antenna with an ultra-wideband (UWB) rectangular monopole radiator [2] with dual Band-notched is obtained by etching two C-shaped in the substrate and U-shaped slot in the radiating element. The notch is designed in such a way to adjust the total length of the slot and shaped to be approximately half-wavelength at the intended notch frequency.

Thus, the current distribution flows around two C-shaped to reject WLAN frequency band and around U-slot to reject frequency X-band satellite communications upper band witch the voltage standing wave ratio (VSWR>2) and the reflection coefficient parameter (S11>-10 dB) with negative gain. In this condition, a caustic interference of the excited surface currents in the antenna will occur, causing the band notched. The bands rejected can be controlled by adjusting the lengths of the shaped and slots.the antenna has been simulated by CST MW[17] software witch use the finite diffirence time domain method (FDTD) and validated by the HFSS[29] software witch use the finite element method (FEM). For S-parameter and VSWR.

2. ANTENNA DESIGN:

Fig. 1(b) shows the geometry of the proposed UWB antenna with dual band notched. The antenna is constructed on FR4 substrate with permittivity of 4.3 and dielectric loss tangent of 0.025. The feed line is the 50 SMA connector. The radiating element is performed by U-shaped slot and the substrate is etched by two C-shaped inverted. Fig. 1(a) shows the dimension of the reference UWB antenna. In the proposed structure, band-notch characteristic is obtained for 5.1-5.85GHz (WLAN systems) by using a pair of C-shaped inverted etched in the substrate in order to generate an additional resonance frequency, and for 7.25-8.39GHz (X-band satellite communication) is achieved by cutting a U-shaped slot on the radiating patch. The dimensions of the designed antenna are listed in Table I.

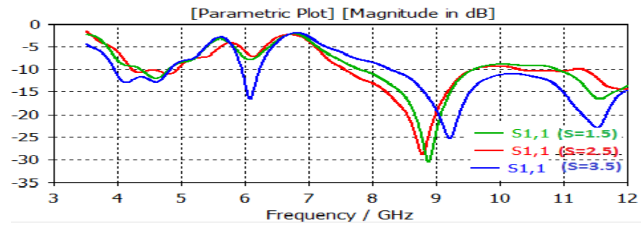


Fig. 1: The geometry of:(a) The reference UWB antenna , (b) The proposed dual-band notched antenna

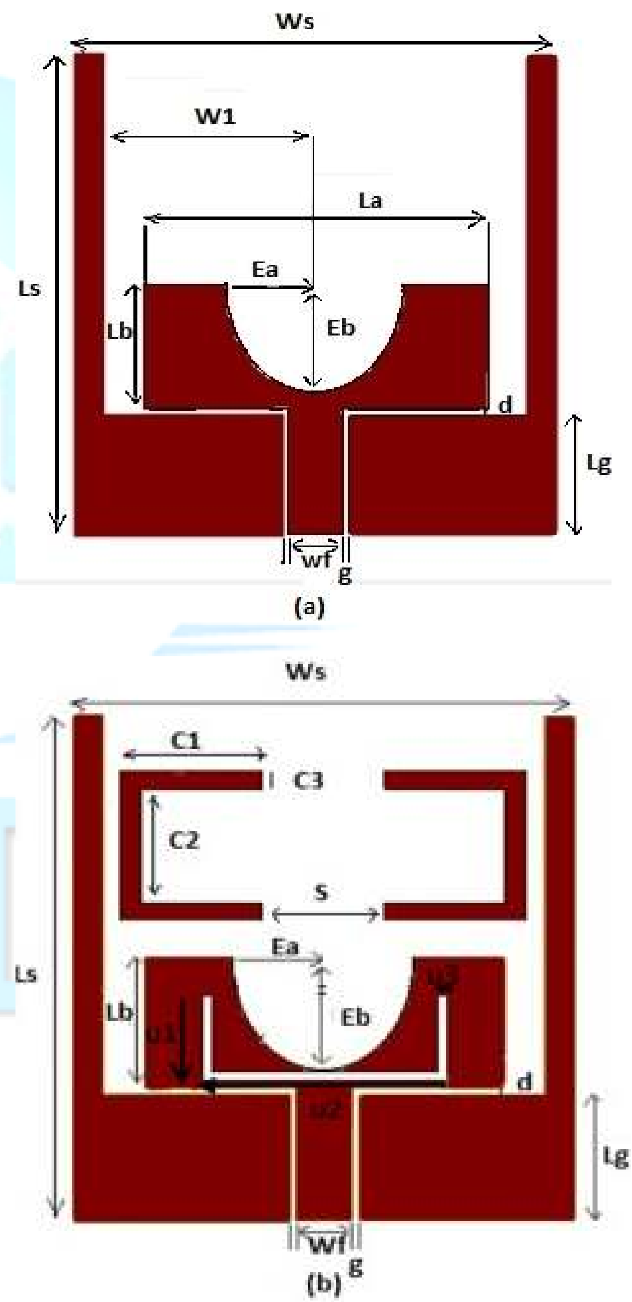


Table I: The dimension parameters (mm) of the proposed dual-band notched antenna

Ws	Ls	Lg	Lb	La	Ea	Eb	Wf
20	25	7	6	11	3	5	2.8
W1	g	C1	C2	C3	U1	U2	U3
18	0.3	6.3	6.1	0.2	3.05	6.2	0.1

The notch frequency is given by:

$$f_{notch} = \frac{c}{2 \times L \times \sqrt{\varepsilon_{eff}}} \qquad (1)$$

when L is the total length of two C-shaped at 5.72Ghz and the total length of U-slot at 7.5Ghz, and ε_{eff} is the effective dielectric constant, and C is the velocity of the light in free space. Therefore, by adjusting the dimensions of the U-slot and two C-shaped the notched band can be shifted to the desired frequency range.

3. RESULTS AND DISCUSION

3.A. SIMULATED RETURN LOSS

Fig. 2 shows the simulated reflection coefficient for the reference antenna and our dual band-notched uwb antenna. It can be seen that the proposed antenna satisfies the UWB (4– 12 GHz) applications for S11<-10Db whith two frequency bands rejection: the 5–6 GHz for WLAN and 7.25-8.39 Ghz for X-band applications.

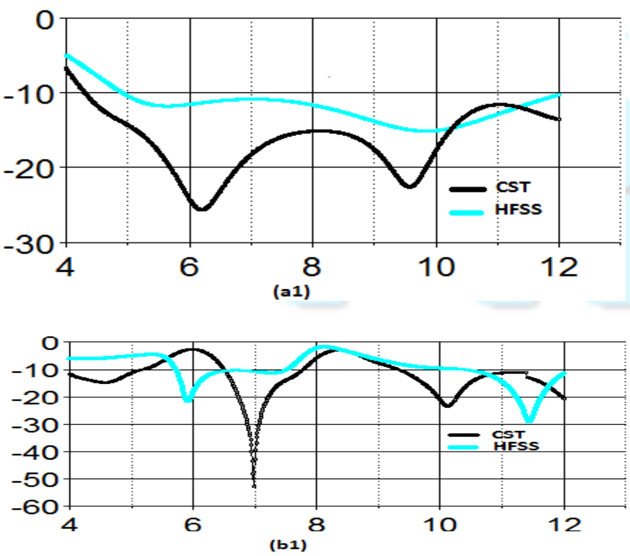


Fig. 2: The return loss of the reference UWB antenna (a1) and the proposed antenna (b1)

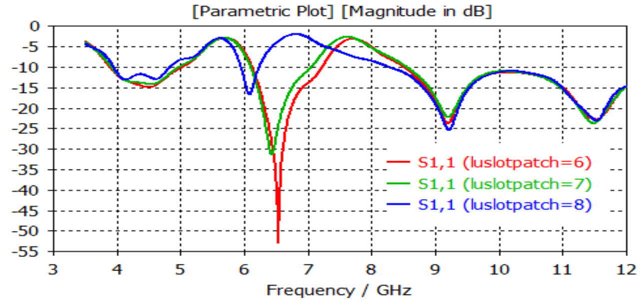


Fig. 3: The effect of the separation between two C-Shaped.

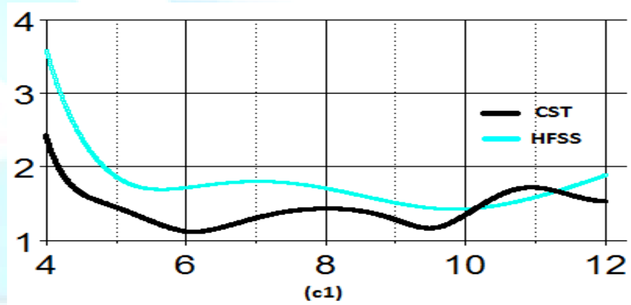


Fig. 4: The effect of de width of the U-slot.

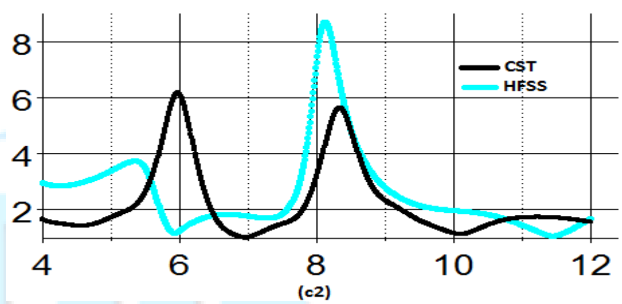


Fig. 5: The voltage standing wave ratio (VSWR) for the reference UWB antenna (c1) and the proposed antenna (c2).

Fig.5 shows the simulated voltage standing wave ratio(VSWR) for the reference UWB antenna and the proposed dual band- notched antenna .Simulated results for the proposed antenna show that the operating frequency range covers the bandwidth from 4-12 GHz with dual band rejection at 5.1-5.85Ghz and 7.25-8.39 GHz.

3.B-THE EFFECT OF SEPARATION DISTANCE BETWEEN C-SHAPED AND THE WIDTH OF U-SLOT

This section presents the parametric study of S (the separation between two C-shaped) and U2 (the width of U-slot) to study the effect of the U-slot width and the distance between tow C-shaped as shown in fig.3 . We can see that the center frequency of the lower rejected band moves to the low frequency when S increases, while the higher notch band changes slightly. This is because the increased S lengthens the resonance length of the two C-shaped, and increases the current path along the two C-shaped. Fig. 4 illustrates the simulated reflection coefficients for various U2 values. A proper choice of the U2 width parameter led to obtain desired center frequencies to reject the 7.25-8.39 Ghz band.

the dual notch-band for rejecting the high frequency band for WLAN applications is shifted by almost 300 MHz band to the lower frequency in HFSS SOFTWARE as compared to simulation in CST Microwave[17] . This can be attributed to the method of calculation or the first resonant frequency of antenna witch has been 4Ghz in CST and 4.5Ghz in HFSS[29].

Fig.9 and fig.11 show the effect U2 width on the peak of realized gain and efficiency. We can see that the center frequency of the higher notch band moves to the low frequency when U2 width increases. The width of U-slot affect significantly the center frequency of the band notched for X-band satellite communication.

3.C.THE GAIN AND CURRENTDISTRIBUTION

Fig. 6 shows the current distribution on the proposed antenna. The current flows around U-slot to reject X-band satellite communication (fig. 6(c)) and around two C-shaped to reject WLAN band (fig. 6(d)). The important effects of the stubs and the slot in achieving the band-notched properties is observed. Nevertheless, the presence of the slot produces an additional resonant mode in the structure, called slot mode, which is responsible for the degradation of the input impedance of the antenna at some frequencies within the notched frequency band [26]. These modes would be intensely affected by the presence of the slot near to the base of the monopole, and hence the effect of the notched-band would become stronger, as shown in [27]. The curve of the characteristic angle associated to this mode presents a very steep slope, what entails a narrowband behavior for this mode. Moreover, it can also be noted that its resonant frequency coincides with the center of the rejected band, as expected [26], the slot mode appears and leads to an abrupt anti-resonance [28], due to the strong inductive behavior exhibited by this mode after its resonance. As observed, since the slot mode presents a narrow band, its influence on the total admittance is reduced to a short range of frequencies [26].

After the resonance of the slot mode, the higher modes are excited. In Fig.2, an alternative shape for the slot and shaped are proposed, with the purpose of being able to control the excitation of the slot mode. In this case, the slot and shaped consists of the U-slot as shown in the fig.2 and table I. Thus the slot mode can be excited by allowing the passage of current to the internal part of the slot to filter 7.25-

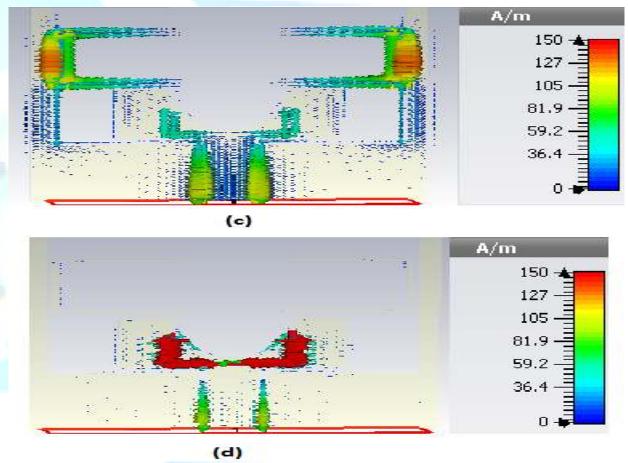
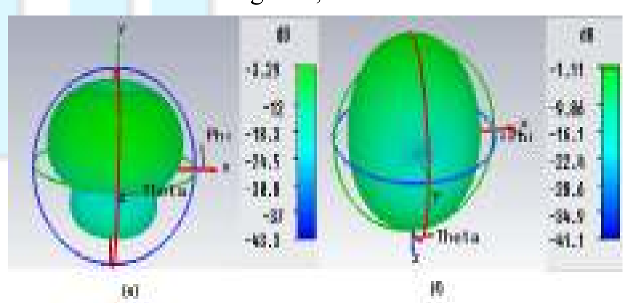


Fig. 6: Simulated current distribution of the proposed dual-band notched antenna at 7.5Ghz (c) and at 5.72Ghz (d)

8.39Ghz band (fig.6.c) and to the internal part of the two C-shaped to reject 5.1-5.85Ghz frequency band (fig.6.d) . It can be found that the gain in the center frequency of the notched band is negative, ie -3.29 dB at 5.72Ghz and



-1.11dB at 7.5Ghz.

Fig. 7: The gain of proposed dual-band notched antenna at 5.72Ghz (e) and 7.5Ghz (f).

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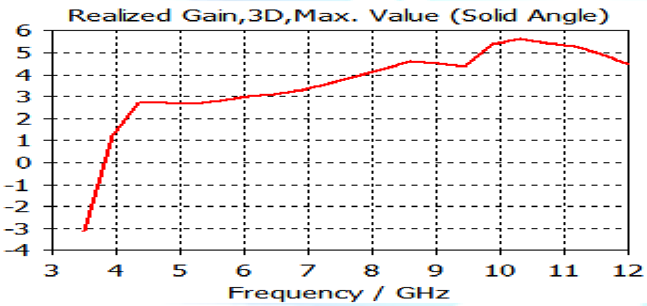
As observed, the slot dimensions have been adjusted to introduce a band-notch around 5.72GHz, and two C-shaped have been adjusted to introduce a band-notch around 7.5Ghz. Fig. 7 shows the effects of a pair of C-shaped inverted etched on substrate and U-shaped slot performed in the radiating patch on the maximum gain in comparison to the same antenna without these structures. The peak gain changes as the frequency is varied within the notch band. This effect can be seen more clearly in comparing fig.8 (a) and (b).It can be observed in Fig. 8 that by using these structures, two sharp decreases of maximum realized gain occur at the notched frequencies (which are 2.8dB and 3.9dB in 5.72GHz and 7.5GHz respectively for reference antenna) of -3.29dB and -1.11dB in 5.72GHz and 7.5GHz respectively. It is clear that the gain of the antenna varies significantly within the



notched band, and that the variation is asymmetric between the two principal planes.

Fig. 8 : Simulated gain: (a) the reference UWB antenna and (b) The proposed dual-band notched antenna

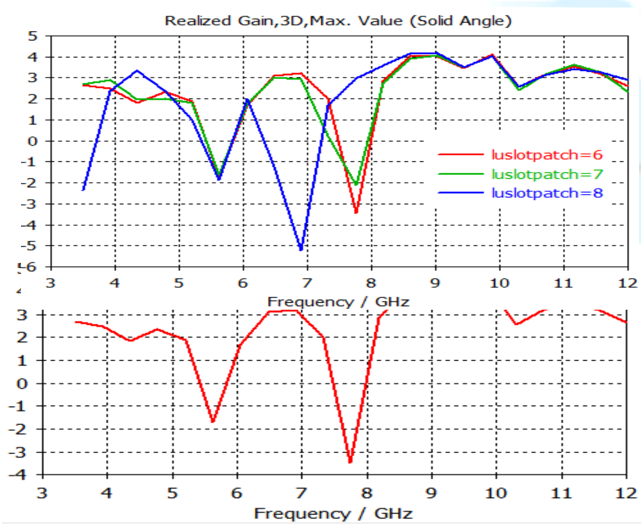
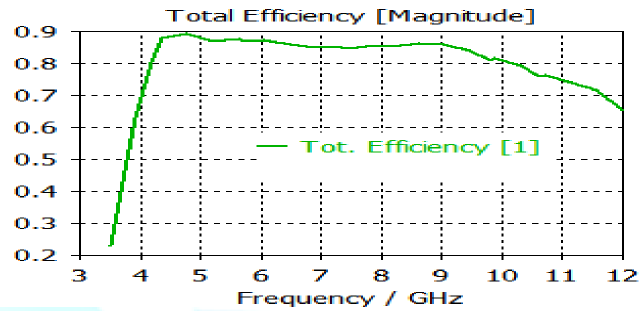


Fig. 9: The effect of the width U2 on the gain for proposed dual-band notched antenna

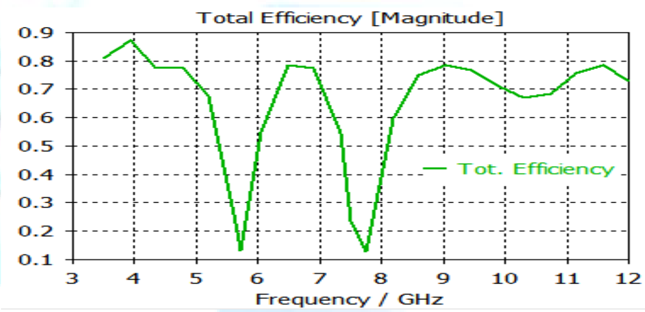
In fig. 11, the peak efficiency changes significantly within the notched band.

The radiation patterns at 5.72GHz and 7.5GHz in H-



plane and E-plane for both reference antenna and proposed antenna are presented in Fig. 12.

(a)



(b)

Fig. 10: Simulated efficiency: (a) reference antenna, and (b) the proposed antenna

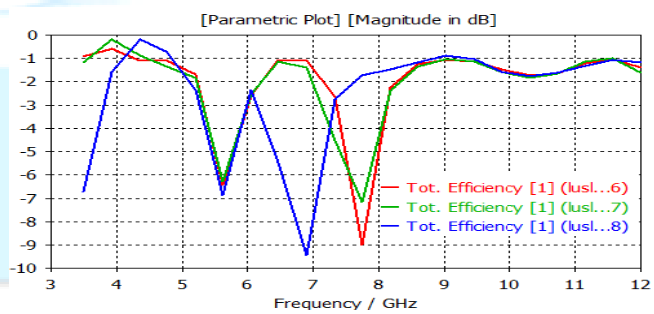


Fig. 11: The effect of the width of U-slot on the efficiency for proposed dual-band notched antenna

TABLE II: The simulated results at the center notched frequency for both reference and proposed antennas(CST SOFTWARE)

parameter	Reference antenna		Proposed Dual- band antenna	
Frequency(GHz)	5.72 GHz	7.5 GHz	5.72 GHz	7.5 GHz
Return loss(dB)	-18dB	-16 dB	-2.86 dB	-3.19 dB
VSWR	1.2	1.4	6.2	5.5
Gain(dB)	2.8 dB	3.9 dB	-3.29 dB	-1.11
efficiency	0.88	0.87	0.12	0.13
Current distribution	64.5 A/m	77.6 A/m	150 A/m	150 A/m

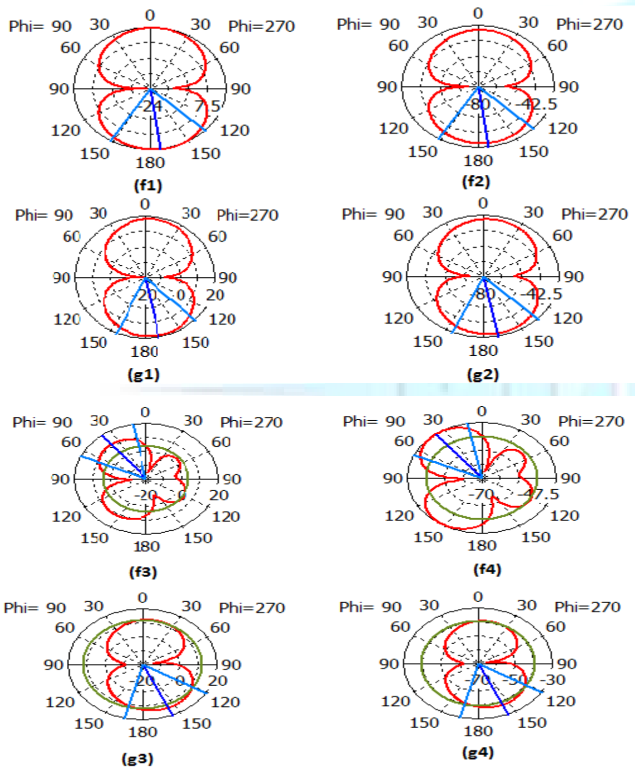


Fig. 12: Simulated radiation patterns for unnotched frequency [(f1),(f2),(g1),(g2)] and notched frequency [(f3),(f4),(g3),(g4)] at 5.72GHz and 7.5GHz in E-plane (left side) and h-plane (right side) :(f1,f2,f3,f4) at 5.72GHZ ; (g1,g2,g3,g4) at 7.5GHz

4. CONCLUSION

In this paper, a novel dual band-notched UWB antenna have been presented and analyzed. These antennas can avoid the interferences with WLAN band (5.155.35 GHz - 5.7255.825 GHz) and X-band satellite communication (7.25 GHz - 8.39 GHz). Band- notch characteristic for WLAN systems is obtained by a pair of C-shaped inverted etched in substrate, while X-band rejection is achieved by cutting a U-shaped slot on the radiating patch.

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