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Octagonal Monopole Antenna with Band-Notched characteristics for UWB applications

By

Ahmed A.Ibrahim
Hesham F.A.Hamed
Sama Ahmed
Mai Hany
Rania Emad

Abstract:

Octagonal shape monopole antenna with dual band notched features which is used for ultra wide band applications is presented. The monopole antenna has good impedance matching from 3.4 GHz to 12 GHz. The dual bands notched are achieved by using U-shaped parasitic strip and meandered slot etched in the radiating patch. The first band notched is achieved using meandered slot to reduce the interference with WIMAX from 3.3 GHz to 3.9GHz.The second band notched is achieved using U-shaped parasitic strip which is placed above the ground plane to eliminate the interference with WLAN from 5.2GHz to 5.9GHz . The proposed antenna has VSWR < 2 except the notched bands. The simulated results confirm that the proposed antenna is suitable for UWB applications.

Keywords:

UWB antenna, dual band frequency notches, U-shaped parasitic strip, meandered slot

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* Egyptian Armed Forces

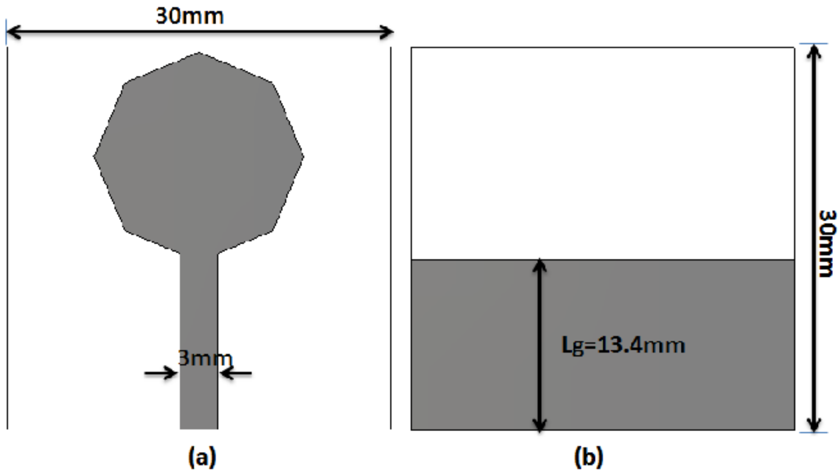
1. Introduction:

The Federal Communications Commission (FCC) is approved rules for the commercial operation of ultra wide band (UWB) within the range of 3.1 GHz to 10.6 GHz [1] .So, the design and implementation of UWB systems have been attracted much attention for communication systems. The UWB communication systems have several advantages such as enabling high data rates, increased communication security, low power consumption and simple hardware configuration in practical applications [2]. The UWB antenna has to achieve many requirements such as small size, omnidirectional radiation patterns, high and stable gain across the whole band and they can be made compatible with the RF components [3-8]. The Wireless LAN applications (5 GHz – 6 GHz) and WiMAX applications (3.3 GHz–3.9 GHz) technologies are occupying small portions of the UWB band, which introduce interference between them. In order to eliminate this interference, the antenna is designed to have band-notched features. Researchers have proposed several techniques to design the band notched antenna [9–14].

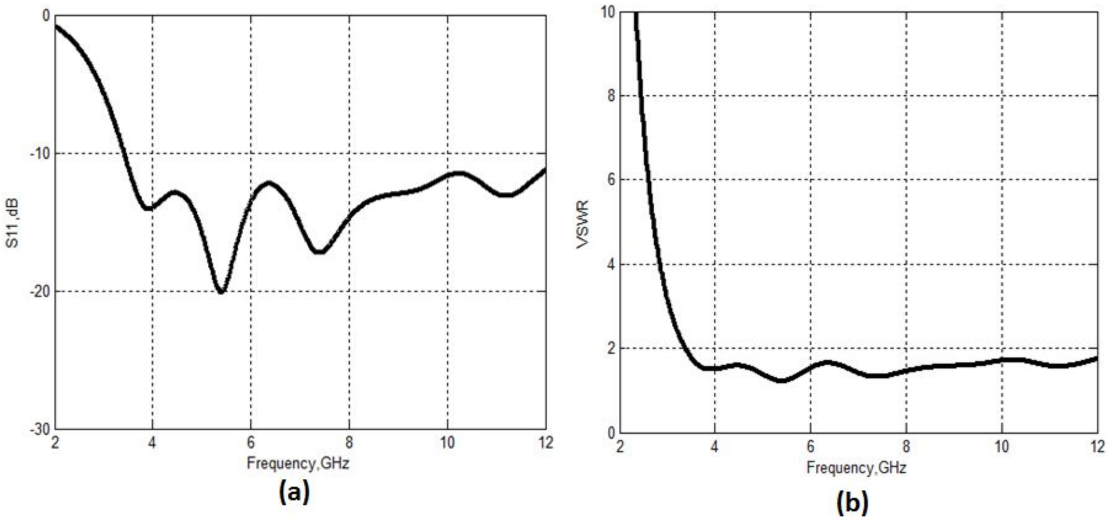
In this paper, UWB antenna with dual notched characteristics is presented. First, a UWB antenna is designed, which exhibits radiating characteristics in the frequency band 3.3 GHz -12 GHz. Second, U-shaped parasitic strip and meandered slot are used to achieve the band-notched characteristics. The first notch is achieved at frequency band (3.3 GHz- 4.1GHz). The second notch is achieved at frequency band (5.1 GHz – 6 GHz). The detail design of the antenna is introduced. The commercial software CST microwave studio was employed in the full wave simulations.

2 UWB Antenna Configuration:

The configuration of the UWB octagonal monopole antenna is illustrated in Fig.1. The radiating element is designed in the form of octagonal shape and the antenna is fed using 50 Ω microstrip line. The octagonal monopole antenna is chosen due to it has wide band characteristics and it has good radiation features. The octagonal monopole antenna is printed on substrate FR4 with relative permittivity (εr) =4.4, and thickness (h) =1.6 mm. From Fig.1 (b) the partial ground plan is used to enhance the matched impedance of the UWB antenna from 3.3 GHz to 12 GHz. The simulated results of return loss and VSWR of the UWB antenna are shown in Fig.2. From the simulated result the antenna has good impedance matching and VSWR lower than 2 from 3.3 GHz up to 12GHz.



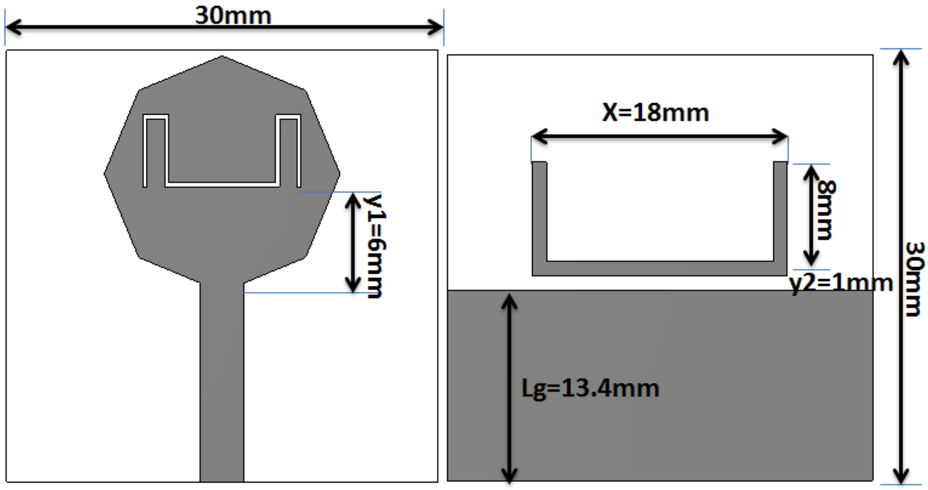
***Figure(1):**. 2-D layout of the octoganal monopole antenna (a)Top veiw (b) back veiw*



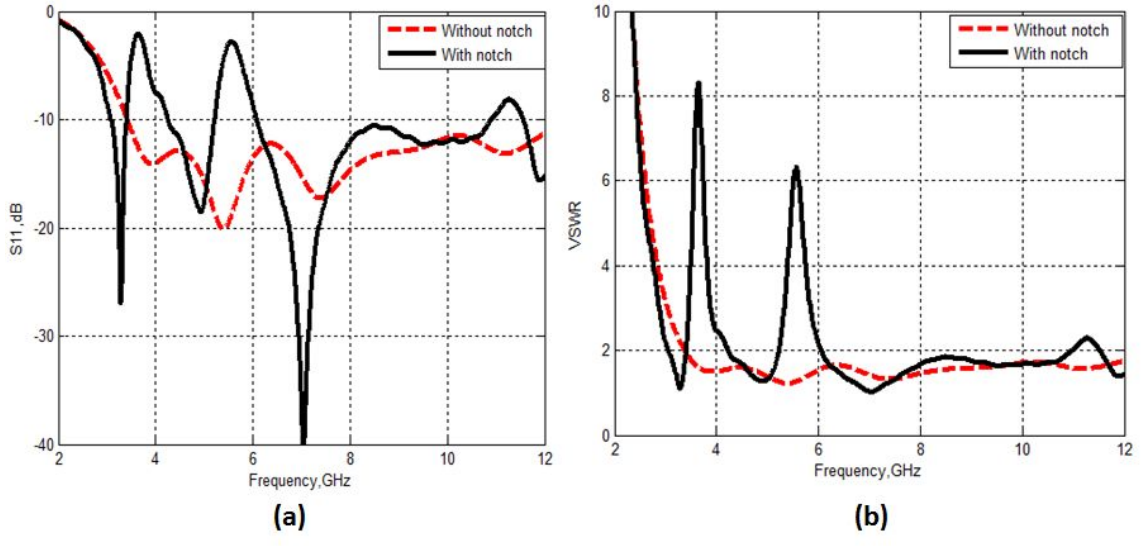
***Figure(2):** Simulated results of UWB antenna response (a) Return Loss (b)VSWR*

3. Proposed Antenna with Dual Band-Notched Features:

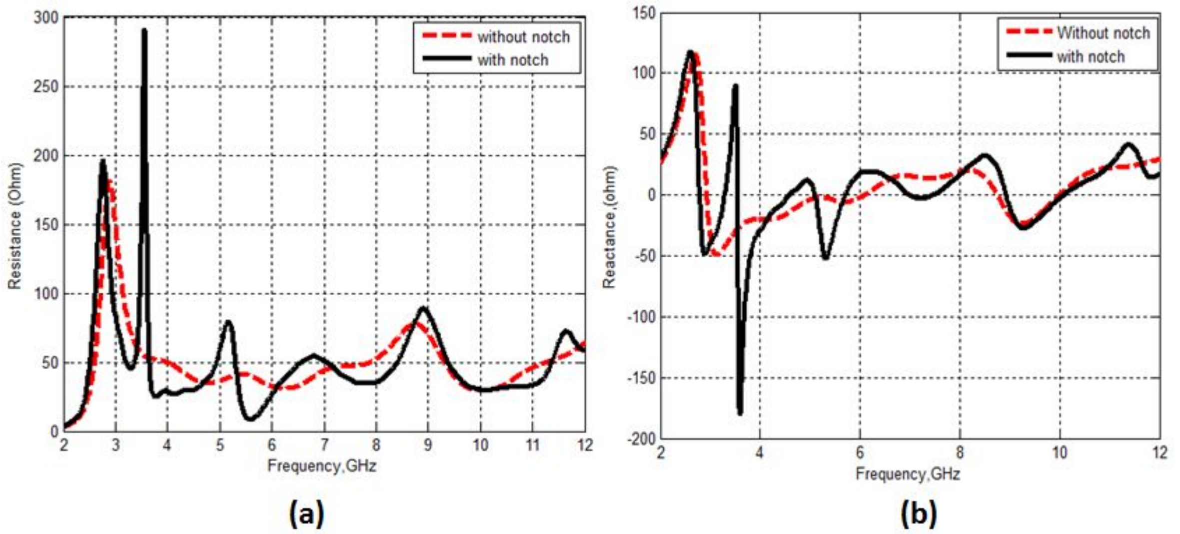
The 2-D layout of the proposed UWB antenna is illustrated in Fig.3. To achieve the desired frequency band notch from 3.3 GHz - 3.9 GHz (WIMAX applications), meandered slot which equals to quarter wavelength of the notched frequency is etched in radiating patch as illustrated in Fig.3 (a). Also in order to rejecting frequency band of WLAN from 5.2 GHz - 5.9 GHz), The U-shape parasitic strip which equals half wavelength of the notched frequency is employee above the ground plane as demonstrated in Fig.3 (b). This frequency band notched is designed to reduce the interference between the WIMAX, WLAN applications and the UWB operations. The simulated results of return loss and VSWR are shown in Fig.4 (a) and Fig.4 (b) respectively. It is obvious that there are two notches at the desired frequency band. From the simulated results the return loss and VSWR of the proposed antenna lower than 2 from 3 GHz to 10.8 GHz except the band notched region from 3.3 GHz to 4.1GHz and from 5.1GHz to 6 GHz.



Figure(3): *2-D layout of the proposed UWB antenna (a)Top veiw (b) back veiw*



Figure(4):. *Simulated results of proposed UWB antenna response (a) Return Loss (b)VSWR*

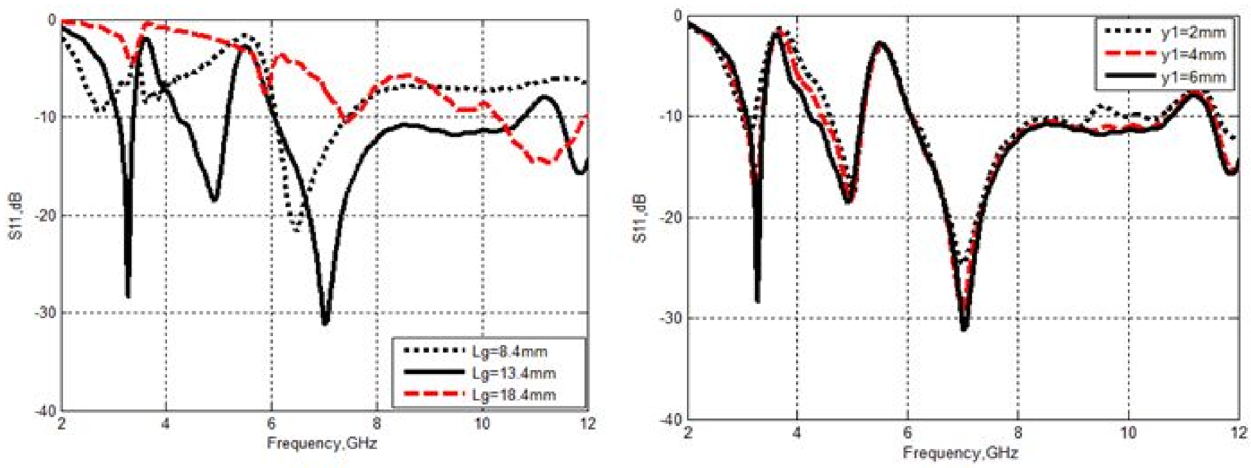


Figure(5): *The Simulated input impeadeance of the UWB antenna (a) Resistance (b) Reactance*

The real (resistive) and imaginary (reactive) components of the antenna's input impedance are are illustrated in Fig.5 (a) and Fig.5 (b) respectively. From Fig.5(a) and Fig.5(b) it is seen that from the dashed red curve (without notch) the resistive component fluctuate around 50 ohms and the reactive component fluctuate around 0 ohm. Also from From Fig.5(a) and Fig.5(b) it is clear that from the solid black curve (withnotch) the resistive component jumps to 300 ohms and the reactive component becomes - 150 ohms from 3.3 GHz to 4.1 GHz the first notch and the resistance jumb again to 80 ohm and the reactance to -50 ohm from 5 GHz to 6 GHz the second notch. In this case the matching is destroyed and a high value of return loss will appear.

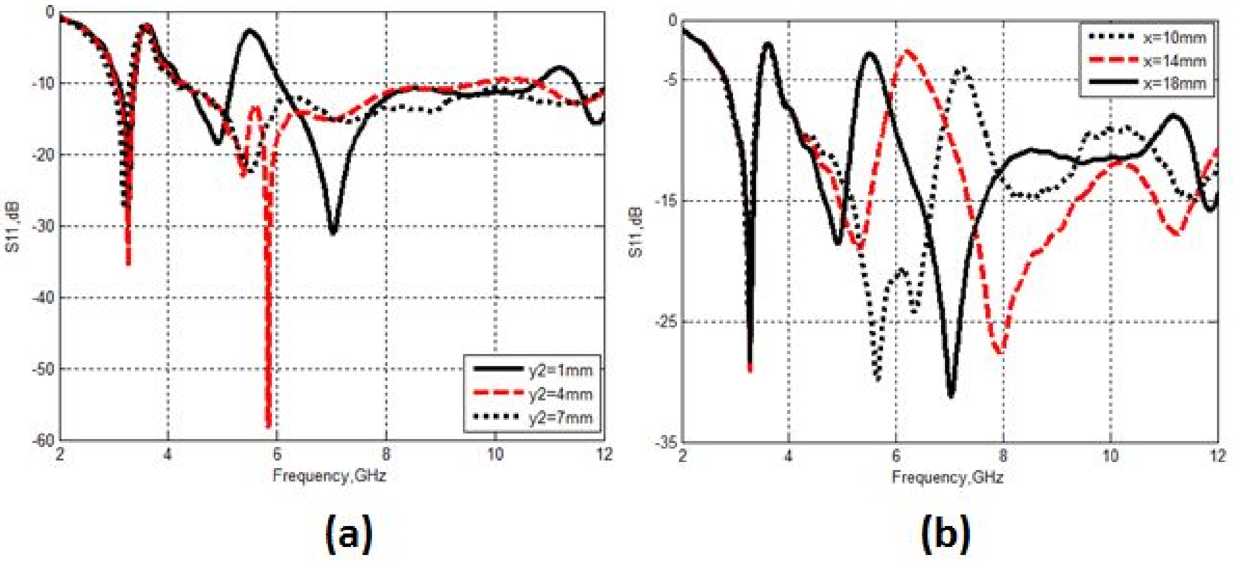
4. Parametric Analysis:

The important criteria in the design of the desired UWB antenna are adjusting the impedance bandwidth and the desired center frequency of the notched band. In the previous section, dual band notched is designed by using meandered slot and U-shape parasitic strip to provide notched band at center frequency of 3.5 GHz for WIMAX applications and 5.5 GHz for WLAN applications. There are several parameters affect the behavior of the proposed antenna and some of them have strong affect than others. Therefore, in this parametric study the parameter which has significant effect on the antenna performance such as the position of the slot distance higher than feed line with distance (y1), the distance of U-shaped above ground plane with distance (y2) , the length of the ground length (Lg) and the length of the U-shape parasitic strip (x) is investigated. First, The effect of the ground plane length (Lg) on the proposed antenna performance when y1=6 mm, y2=1 mm and x=18mm is illustrated in Fig.6 (a). It is obvious that, the length of Lg has strong effect on the antenna bandwidth. Also the notched band affected by the length of the Lg. The optimized length of the Lg=13.4 mm. Second, the effect of the meandered slot position (y1) is shown in Fig.6 (b). It is clear that, the bandwidth of the notch is decreased with increasing in the position (y1) and the optimized position is chosen to be 6 mm when the y2=1mm and the Lg=13.4 mm and x=18mm. Third, the effect of the position of the U-shape parasitic strip (y2) above the ground plane on the antenna return loss is studied as shown in Fig.7 (a). From Fig.7 (a) it is obvious that, when the distance (y1) is increased above the ground plane the effect of the U-shaped strip on the return loss wasn't appear .Therefore, the optimized place to the U-shaped strip was 1 mm above the ground plan to achieve the required notched frequency band. Finally, the effect of the length of the U-shape parasitic strip (x) is demonstrated in Fig.7 (b) .The length of the U-shape parasitic strip acts as the inductance. Therefore, when the length of the resonator increases the resonance frequency of the notch decreases. The resonance frequency is decreased from 6.7 GHz to 5.5GHz when the length of the U- shape is increased from 10mm to 18 mm.



(a) (b)

Figure(6): *Simulated return loss of UWB antenna (a) at different ground legnth(Lg) (b)at diffrend slot position (y1)*



Figure(7): *Simulated return loss of UWB antenna (a) at different U-shape position (y2)*

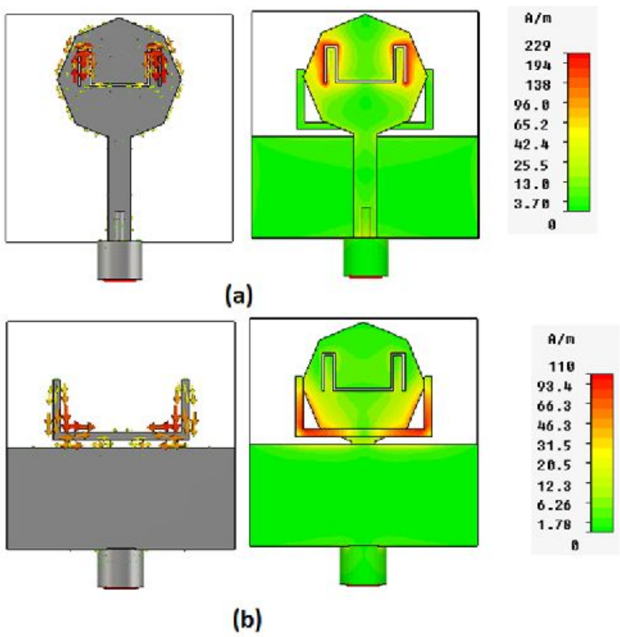
(b) at diffrend U-shape legnth (x)

5. Current Distributions and Radiation Pattern:

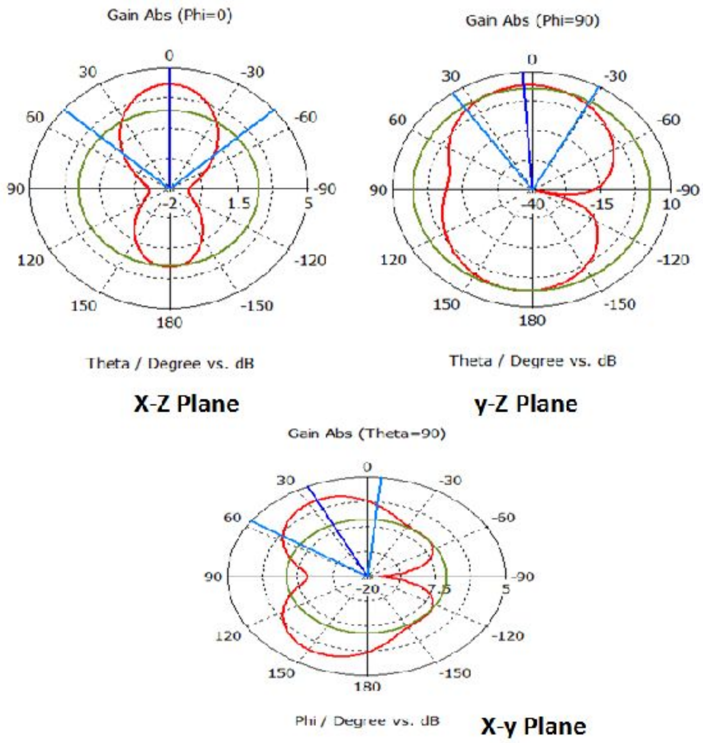
In order to understand the behavior of the band-notched characteristics, the simulated current distributions of the proposed antenna at 3.5 GHz and 5.5 GHz are investigated as shown in Fig8. First, from Fig.8 (a) the current at frequency 3.5 GHz which is considered the center of the band notched of the WIMAX applications is concentrated around the meandered slot. Also from Fig.8 (b) it is obvious that the surface current is concentrated around the U-shape parasitic strip at 5.5 GHz which is the center of the WLAN frequency band. From two figures it is concluded that the antenna didn't radiate at these frequency bands.

The simulated radiation patterns for the x-z, y-z and x-y planes of the proposed antenna at 7 GHz and 9.5GHz are shown in Fig. 9 and Fig.10 respectively. It is clear that, the antenna has nearly Omni-directional patterns in x-y and y-z planes and a bi-directional in the x-z plane.

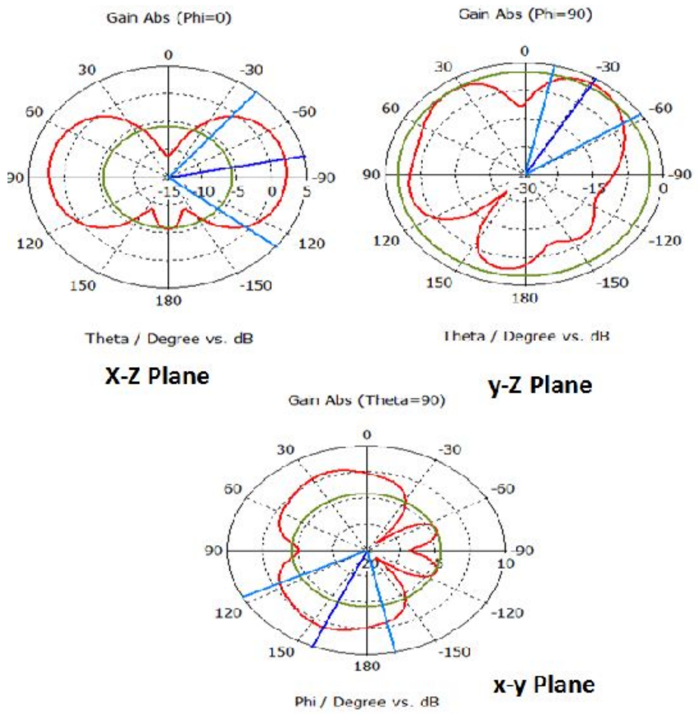
A comparison between the simulated peak gain and efficiency of the proposed antenna with and without notch is illustrated in Fig.11 (a), and Fig.11 (a) (b), respectively. As shown in the figure, it is clear that in case of the absence of the notch the average gain equals 3dB, approximately, and the averaged efficiency equals 85%. On the other hand the average peak gain and efficiency equals 3dB and 80% except the two notched frequency band the peak gain and efficiency equal -3dB, -2dB and -12%,-10%, respectively in the case of the presence of the notch.



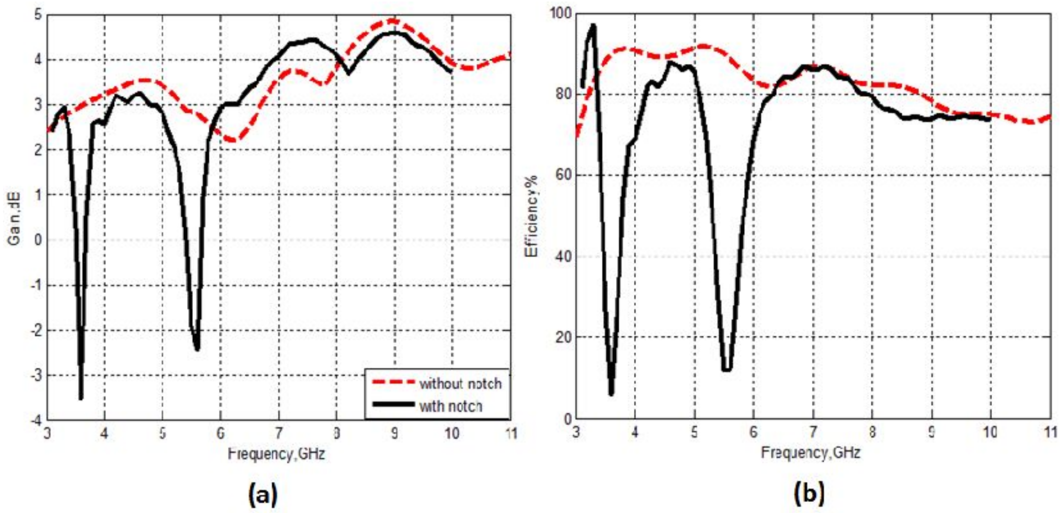
Figure(8): *Simulated surface current distributions of proposed UWB (a) at f=3.5GHz (b) at f=5.5GHz*



Figure(9): *The simulated gain of the proposed antenna at 7 GHz*



Figure(10): *The simulated gain of the proposed antenna at 9.5 GHz*



Figure(11): *(a) Simulated peak gain of the UWB antenna (b) Simulated efficiencyof the UWB antenna*

6. Conclusions:

Monopole antenna with octagonal shape radiator has been introduced. The proposed antenna has been used for ultra wide band applications with dual band notched characteristics. The dual bands notched have been achieved by employing U-shaped parasitic strip and meandered slot etched in the octagonal radiating patch. The interference with WIMAX applications from 3.3 GHz to 3.9 GHz and WLAN applications from 5.2 GHz to 5.9 GHz has been reduced by using meandered slot and U-shaped parasitic strip respectively. The simulated results confirm that the proposed antenna is suitable for UWB applications.

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