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A Band Notched Hexagonal Monopole UWB Antenna Using Open-Ended Slots

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***Abstract*— In this paper, a compact, hexagonal planar ultra wideband (UWB) monopole micro strip antenna is proposed that offers single band notch characteristics with enhanced rejection at frequency band centered at 5.5 GHz of 5-6 GHz. To realize this enhanced band notched characteristics at 5.5 GHz, the open-ended inverted L-slot is embedded on the feed line of the proposed UWB antenna. Step by step development of the antenna with its analysis in the frequency domain is presented. The effects of various design parameters on design have also been analyzed using CAD FEKO 6.2 simulator using MoM. The Hexagonal shaped antenna is simulated using FR4 dielectric substrate with dielectric constant of 4.4 and loss tangent of 0.02. The proposed antenna is of compact size 30mm × 30mm. The hexagonal antenna provides good impedance matching from frequency range of 3.1 GHz - 10.6 GHz.**

***Keywords*— CAD FEKO, Hexagonal Antanna, Monopole Antenna, Open-Ended Slot, Planer Microstrip Antenna,UWB, WLAN.**

1. INTRODUCTION

The UWB antenna is the main component in the UWB system because it acts as a filter which only passes the desired frequency components designated by the FCC. An excellent UWB antenna is one which is having characteristics of transmitting and receiving the frequencies over the bandwidth designated by FCC [1]. The proposed antenna must possess stable radiation characteristics and gain over the operating UWB band.

Many planer broadband antennas have been studied and reported for UWB applications that use a variety of antenna configuration. The printed planer monopole antennas which are newly proposed UWB antenna should be good candidate for future work. It has been received much attention for their compact size, omnidirectional radiation pattern, high radiation efficiency, easy to build and integrate with compact RF front ends as well as multitasking capability. Several printed monopole antennas have been proposed with different geometries [3,4,8]. Here we are using hexagonal patch antenna. It has compact size compared to square and circular microstrip antenna for given frequency. Compact size antenna is suitable for portable communication equipments. The printed planer monopole antennas fabricated on a substrate offer wide impedance bandwidth which can cover UWB. Moreover, other ways to improve the impedance bandwidth have been investigated [2-6]. This hexagonal antenna can obtained whole UWB spectrum, there exist some narrow bands for other communication system, such as IEEE 802.11a wireless local area network(WLAN) system operating at 5.15-5.825 GHz, HiperLAN2(5.47-5.725 GHz) and (7.25-7.75 GHz) for downlink of X-band satellite communication system which interfere with the UWB system. So to overcome this drawback notching is done.

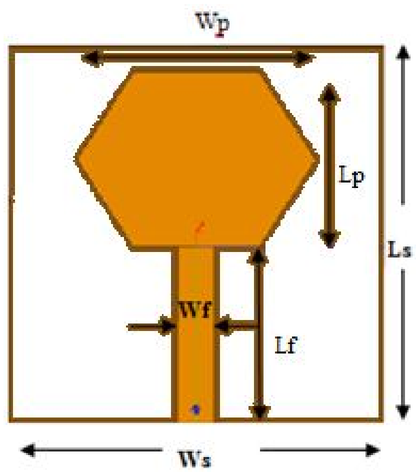
A number of strategies have been proposed to address the band-notch problem by inserting slots of different shapes and size, either in patch or ground.[2-12]. Typical slot shapes are: rectangular, C-shaped [6], pi-shaped, E-shaped, H-shaped and U-shaped [3, 4, 7]. Inserting parasitic elements [3, 11]. Using stub [2, 7, 9, 11]. A single band notched UWB antenna employing electromagnetic band-gap (EBG) structure near the feed line was also proposed [9].

In this paper, a compact hexagonal planer UWB monopole microstrip antenna is designed and simulated. To improve bandwidth two rectangular notches inserted on the ground plane. Here good band-notched performance with high level of signal rejection can be achieved by inserting the quarter-wavelength band-rejected elements within the feed line. The design of antenna is presented in the next section. Simulation is done using CAD FEKO electromagnetic software using method of moment is presented in section III. A conclusion of proposed antenna is given in last section.

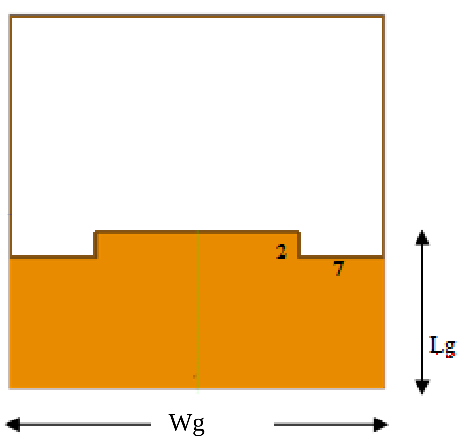
2. ANTENNA DESIGN

By adjusting the length of the slot to be about half-wavelength at the desired band notched frequency, a destructive interference can take place [10]. Compared to the half-wavelength slots or strips, the quarter-wavelength open-ended L-slot require less space and are promising for designing multiple band-notched antennas as it is difficult to apply multiple half-wavelength slots or strips due to limited space available within the antenna structure[11].

The geometry of proposed antenna is shown in Fig. 1 with varied dimensions. The radiating monopole and feeding mechanism are printed on the top side of the substrate, while the ground plane is printed on bottom side. This antenna is mounted on FR-4 printed circuit board(PCB) substrate 30 mm x 30 mm with a dielectric constant of 4.4 and thickness of h= 1.6mm. The microstrip feeding has a single strip with a dimension of 3 mm x 14 mm to achieve 50 Ω characteristics impedance. The ground plane dimensions are chosen to be 30mm × 13mm and the gap between patch and partial ground plane is 1mm, which is used to increase the bandwidth of antenna. The Figure 1, (a) and (b) shows the basic geometry of planned UWB antenna with hexagonal patch and partial ground plane. The Figure 2 shows the geometry of proposed antenna design with open-ended inverted L-slot. Figure 2 (a) shows inverted L-slot in the feed line. Figure 2 (b) shows structure of open-ended inverted L-slot. Table 1 and table 2 shows the optimized parameters of proposed geometry.



(a)

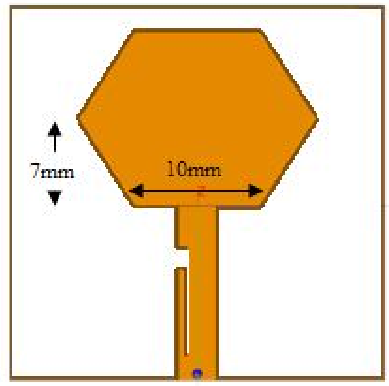


(b)

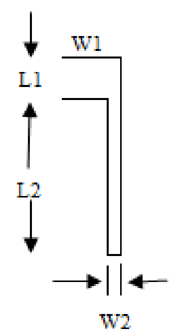
Figure 1: Configuration of the Hexagonal UWB antenna: (a) Front view; (b) Back view

Table 1: Optimized parameter of the proposed antenna.

Wp	Lp	Ws	Ls	Wg	Lg	Wf	Lf
19	14	30	30	30	13	3	14



(a)



(b)

Figure 2: The Geometry of Proposed antenna with band notch: (a) Geometry of the proposed antenna; (b) structure of open-ended inverted L-slot

Table 2: Optimized parameter of open-ended inverted L-slot

W1	W2	L1	L2
0.3	0.15	1	4.75

3. SIMULATION RESULTS AND DISCUSSIONS

In this section, UWB monopole antenna with various dimensions was designed. The parameter of this proposed antenna are studied by changing one parameter at a time and fixing the other. The simulated results are obtained using CAD FEKO suit (6.2) using Method Of Moment (MOM).

The curve of the simulated VSWR for hexagonal UWB antenna is shown in Fig 3. It shows that VSWR<= 2 for 3.2 to 10.7 GHz.

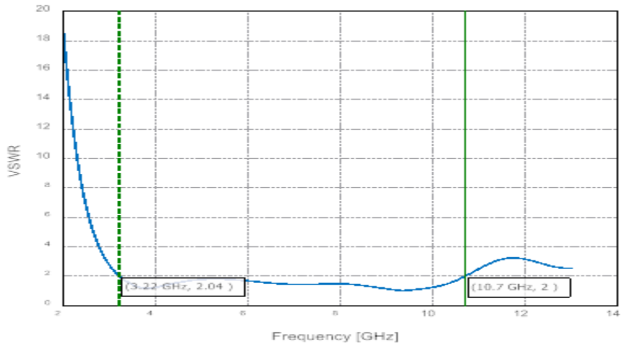


Figure 3: Simulated VSWR for Hexagonal UWB antenna

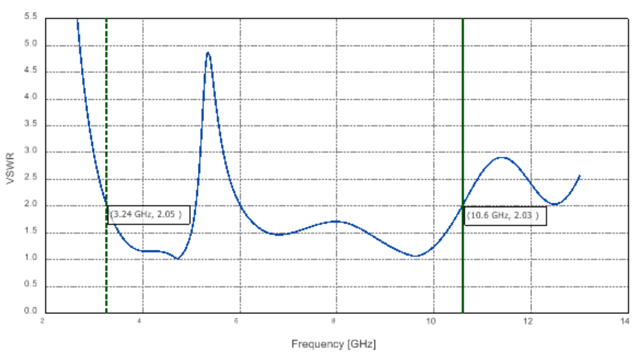


Figure 4: Simulated VSWR for proposed antenna with band notch

Above Figure 4 shows WLAN band notched characteristics by showing VSWR Vs Frequency graph i.e. from 5 GHz to 6 GHz with VSWR of up to 5. This is one of the narrow band systems interfering with UWB. The effects of three different parameter w1, w2, L2 on the VSWR of the proposed design are studied and shown in Figure 5-7, respectively.

In Figure 5, a wide notched band is obtained over the UWB frequency band when w1 is changing from 0.3 to 0.5 mm. 0.3 mm is chosen for w1 in the design as it occupy required band only. As shown in figure 6, w2 mostly affects the peak of the notched band. Here 0.15 mm for w2 is chosen. Next, figure 6 shows comparison of different w2 as 2, 1.8, 1.7 and got good notch for w2=2 mm.

In Figure 7, as L2 changes from 7.30 to7.5 mm notch band shifts towards left and is 5.15 to 6.1GHz for 7.30 mm. And almost same band notch of 5-6 GHZ for 7.45 and 7.5mm so in this design small length of 7.45mm is chosen for L2. Figure 7, gives comparison of various slot length which is giving approximately similar graph at WLAN lower edge.

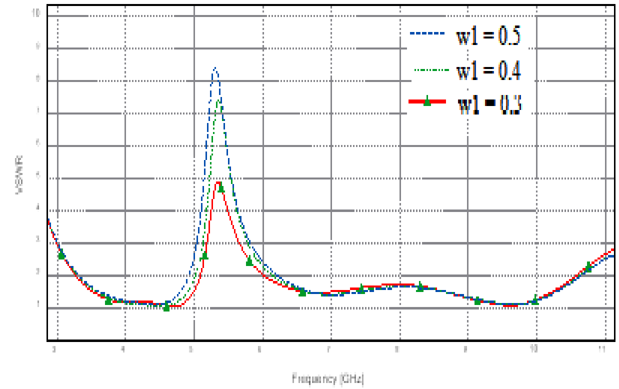


Figure 5: Simulated VSWR Characteristic for different values of w1

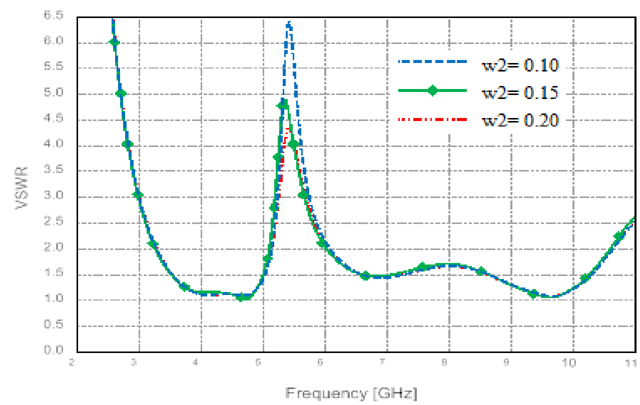


Figure 6: Simulated VSWR Characteristic for different values of w2

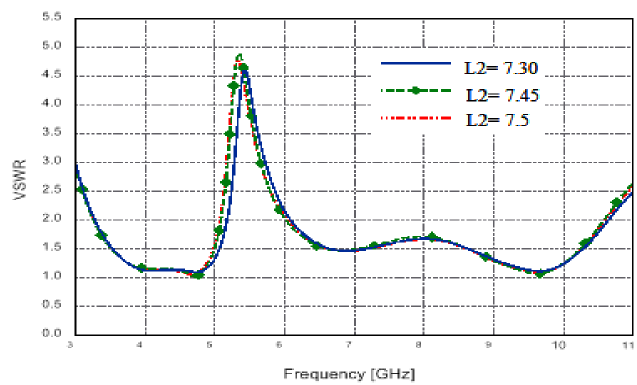


Figure 7: Simulated VSWR characteristic for different Slot width (L2)

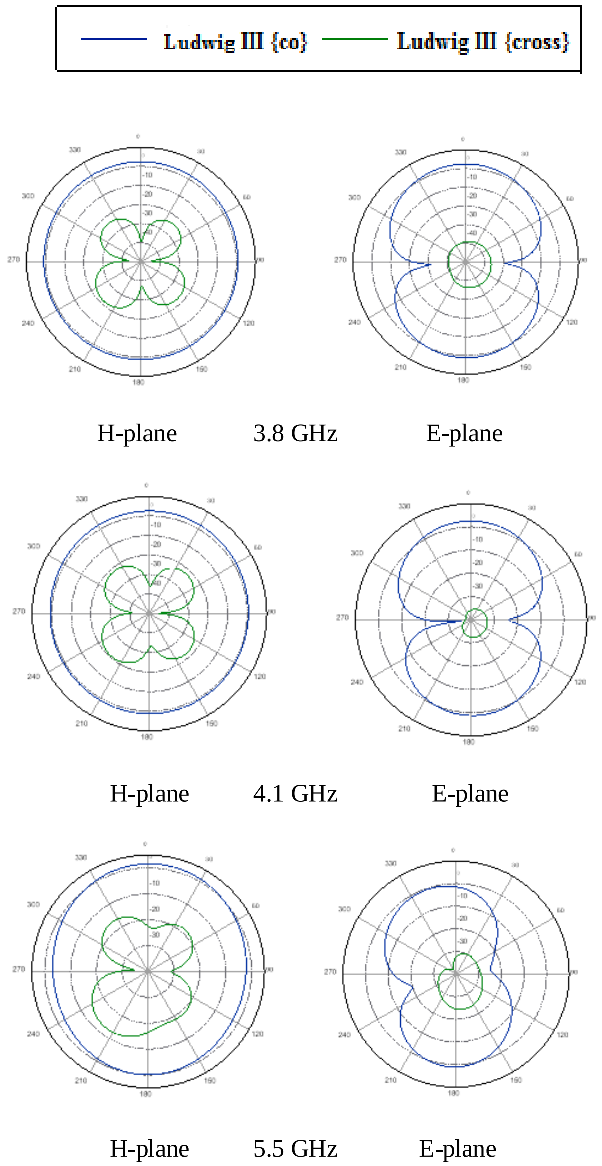


Figure 8: Radiation Pattern of the proposed antenna at 3.8, 4.1, 5.5 GHz

The radiation pattern is an important indicator of the antenna performance. Figure 8, illustrates the radiation patterns of the antenna depicted in Figure 2. Above Figure 8 shows radiation pattern in H-plane and E-plane at various frequencies. The antenna exhibits stable radiation properties as those of the conventional simple monopole antenna. It shows nearly omnidirectional radiation pattern in H-plane. In E-plane, the radiation pattern remains roughly a dumbbell shape over the frequency band. The cross-polarization levels are generally much lower than the co-polarization ones.

Figure 9 shows the current distribution at the notch frequency of 5.5GHz. In this fig, we can see more and strong current density in the edges of the L-slot than any other area at the notch frequency.

When the slots are open-ended, their lengths are only about quarter wavelength. At the notched frequency, current is mainly concentrated around the edges of the slot, and it leads the reflection to form the standing wave, which causes an impedance mismatch at the antenna feed [7].

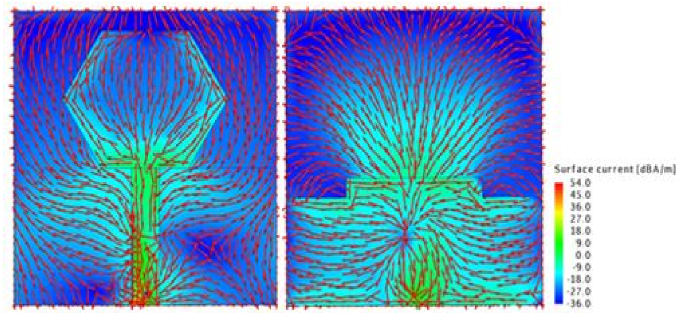


Figure 9: Current Distribution at notch frequency 5.5GHz

Figure 10 and Figure 11 shows gain and efficiency of proposed UWB antenna. Gain is nearly constant at lower frequencies and goes on decreasing in higher edge. A sharp decrease of antenna gain and efficiency is observed in the notch frequency. Efficiency is 90% at 4 GHz and 80% up to 9 GHz i.e above 75% expect notched band.

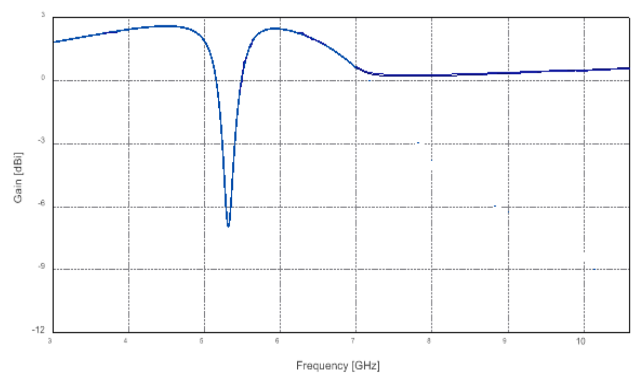


Figure 10: Antenna Gain over the frequency band

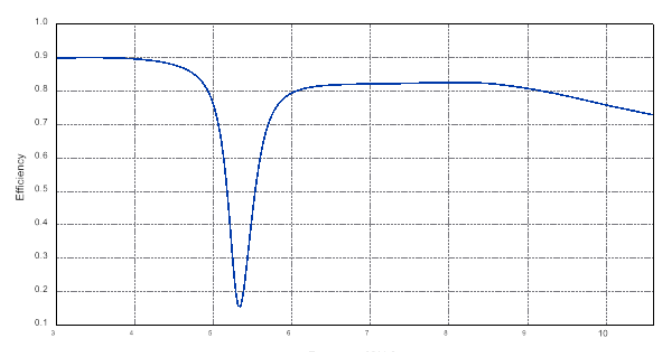


Figure 11: Antenna Efficiency over the frequency band

4. CONCLUSION

To minimize the potential interference between the UWB and narrow band systems, such as WLAN, a compact UWB antenna with enhanced single frequency notch characteristics is proposed and discussed. The open-ended inverted L-slot in the feed line provides the band notched characteristics at frequency 5.5 GHz within a range of 5 to 6 GHz. The notched bands can be controlled by adjusting the dimension and position of the slots. The frequency domain characteristics of the proposed UWB antenna have been discussed. The result shown here is simulated on CAD FEKO suit (6.2).

The designed hexagonal antenna shows good UWB performance and is good for UWB applications.

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