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Design of Compact UWB Slotted Hexagonal Monopole Antenna with 3.5/5.5 GHz Dual Band Rejection

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A design of compact ultra-wideband (UWB) monopole antenna with dual band-notched characteristics has been reported in this article. The band-notch effect is extremely important for any UWB system to avoid interference with existing narrowband applications such as WiMAX and WLAN. A hexagonal-shaped radiating element has been considered in this design. Two unequal U-shaped slots on the radiating patch have been implemented to achieve dual band-notched filter characteristics. An inverted U-shaped slot has been etched out on the hexagonal patch to achieve band-notch attributes for WiMAX (3.2-3.8 GHz) band. Another slot of having a U-shape has also been engraved on the patch to attain a notched band for WLAN (5.1-5.8 GHz) band. The proposed antenna having a total dimension of 38× 56 mm². Arlon AD300 has been chosen as the substrate which has dielectric permittivity $\varepsilon_r = 3$. The height of the substrate is $h = 1.524$ mm. Full-wave electromagnetic simulation software Ansys HFSS has been used to analyze the radiation characteristics of the structure. The proposed antenna successfully covers the FCC allocated UWB frequency spectrum by operating over the frequency band between 2.6 GHz to 11.4 GHz (VSWR < 2) which depicts the bandwidth of 120 %. The designed antenna exhibits good gain and bidirectional radiation patterns.

Keywords: UWB, Dual band notched, Compact.

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1. INTRODUCTION

Recent elevation on research in UWB antenna has exhibited noticeable interest among researchers after the allocation of Ultra-Wide Band (UWB) by FCC. The frequency spectrum ranging from 3.1 GHz to 10.6 GHz has many potential applications due to its inherent properties like robustness, flexibility, high throughput, etc. Narrowband applications, such as WiMAX (3.2-3.8 GHz) and WLAN (5.15-5.825 GHz) are also fall under this spectrum. So, it will affect interference with each other, which is not desirable. Suppressing those bands in a system will mitigate the solution to the problem. UWB antenna with band-notch characteristics will be a potential application to realize the goal.

Many articles have been published related to the notch effect on the frequency response of a UWB antenna. In the article [1] by Emadian et al., a UWB antenna with slots both on the radiating patch and ground plane has been proposed. Here U-shape slots on the patch and L-shape slot on the ground have produced band notch effect for WLAN and WiMAX applications. Similar notch properties have been reported in the articles [2-12] by etching different types of slots, the addition of stubs, parasitic elements, defected ground structure, modified feed line, EBG structure etc. In [2], a T-shape stubs and a pair of U-shaped parasitic elements have been introduced to achieve dual notched band. A design of dual notched band UWB antenna has been proposed in [3], where microstrip line resonator at the ground plane along with T-shape stub have been implemented. A circular monopole antenna with a partial annular slot having dual notch characteristics is proposed in the article [4]. A unilateral stepped structure has been utilized in the ground to achieve enhanced impedance bandwidth and dual notched band characteristics has been found by applying E-shaped defected ground structure which is presented in [5]. Azim et al. [6] have implemented a novel tri-arm resonator structure on the ground plane to achieve the notches for WiMAX and WLAN bands. A pair of I shape strips along with a pair of rotated T-shape strips on the backside of the radiating element resulted in a dual band-notch property for WLAN and X-band satellite communication system as proposed by Ojaroudi et al. [7]. The paper by Fakharian et al. [8] reported a band-notch effect using C-shape slots with a circular arc on the patch. An F-shape feedline has been reported in the article [9] to achieve suppression of the band. Yadav et al. [10] have proposed a slot-loaded UWB antenna to get a similar kind of frequency response. Peddakrishna et al. [11] have investigated a band-notched UWB antenna with a PI-shape slot on the radiating element and EBG slots on the ground plane. Recently Yadav et al. [12] have stated an article with CSRR and U slots on the patch to achieve a similar goal.

In this article, a hexagonal UWB monopole antenna with wide bandwidth together with the stated stopband is proposed. Two U-shape slots on the metallic radiating patch have been etched out to obtain the desired band-notch effect. The inverted U slot is responsible for eliminating the WiMAX band. Rejection of the WLAN band is realized by using another slot. The effective length of the slot is less as compared to the previous one. This indicates that the resonant frequency at notch-band is related to the length of the slot.

2. ANTENNA DESIGN AND STRUCTURE

The structure of the proposed antenna is shown in Fig. 1. It has been designed using electromagnetic solver Ansys HFSS. Arlon AD300A has been chosen as substrate which has dielectric constant $\varepsilon_r = 3$, thickness

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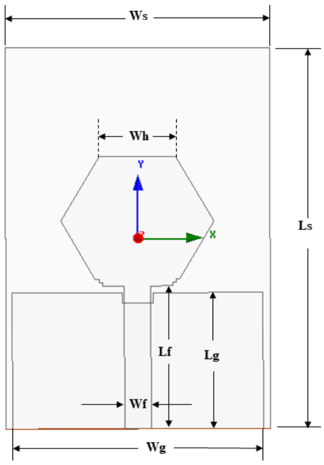
h = 1.524 mm, and loss tangent is 0.002. A hexagonal structure has been considered here as radiating element. Initially, the antenna has been designed without any slots on the radiating elements. The simulation result is depicted in Fig. 2 and shows that the reference antenna provides an ultra-wide bandwidth form 2.6-11.4 GHz. It has a good impedance matching over entire operating band. The sidearm length of the hexagon is 11 mm. Here a microstrip feed line has been used to excite the patch. The width and the length of the feed line are 3.8 mm and 21 mm, respectively. To obtain band notch effect for WiMAX band, it has been etched out a slot of inverted U-shape over the hexagon. The dimensions are given in Table 1. Further, by introducing another U-shape slot, successful suppression of WLAN band has been achieved. In this case, the total slot length is lesser as compared to the previous one.

Table 1 – Design parameters of the proposed antenna (units are in mm)

Parameters	Values	Parameters	Values
Ls	56	*L*2	8.5
Ws	38	*L*3	6.8
Lg	20	*L*4	6.4
Wg	36	*W*1	0.5
Lc	1.5	*W*2	0.5
Wc	4.5	*CL*1	0.5
Lf	21	*CL*2	0.6
Wf	3.8	*CW*1	0.6
Wh	11	*CW*2	0.5
*L*1	12.4	–	–



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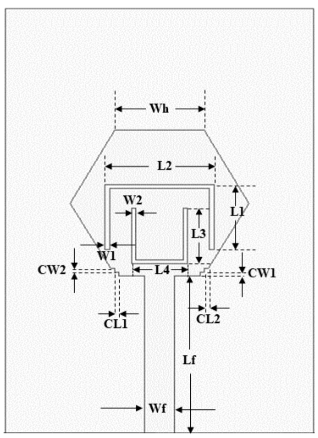

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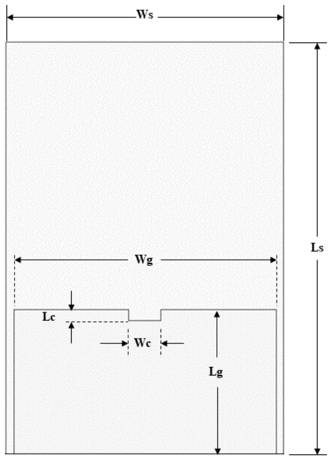


c

Fig. 1 – Structure of the reference antenna (a), proposed antenna radiating plane (b), and the ground plane (c)

3. RESULTS AND DISCUSSION

Simulated frequency vs S11 graph of the reference and proposed antennas has been shown in Fig. 2. Both antennas possess wide impedance bandwidth of 125 %, shown in Table 2. Due to the inclusion of inverted U slot on the patch, notch band over the frequency range from 3.15-3.81 GHz has been obtained. Another notch band from 4.90-5.86 GHz has been found due to another U-shaped slot. The mentioned notches will correspond to WiMAX and WLAN bands, respectively. The variation of gain with frequency of proposed antenna has been shown in Fig. 3. The maximum realized gain at the center frequency of the two rejection bands are – 5.4 dBi for WiMAX and – 2.6 dBi for WLAN.

Table 2 – Simulated results for the reference and proposed antennas

	Bandwidth (GHz), %	Rejection band at lower band (GHz)	Rejection band at higher band (GHz)
Ref. antenna	2.6-11.4, 125 %	–	–
Prop. antenna	2.4-10.6, 126 %	3.15-3.81	4.90-5.86

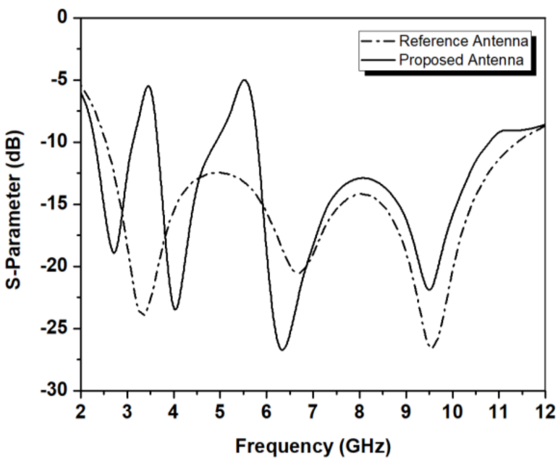


Fig. 2 – Frequency vs return loss graph of the antenna

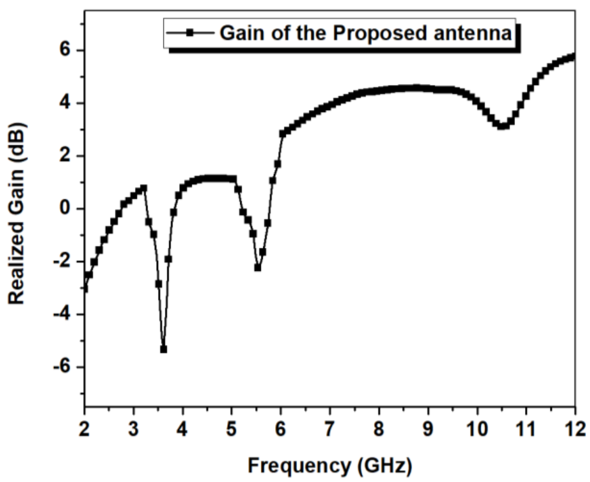
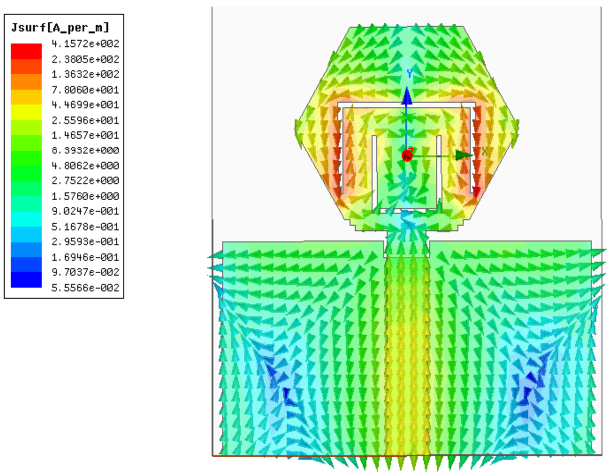


Fig. 3 – Frequency vs gain graph of the proposed antenna



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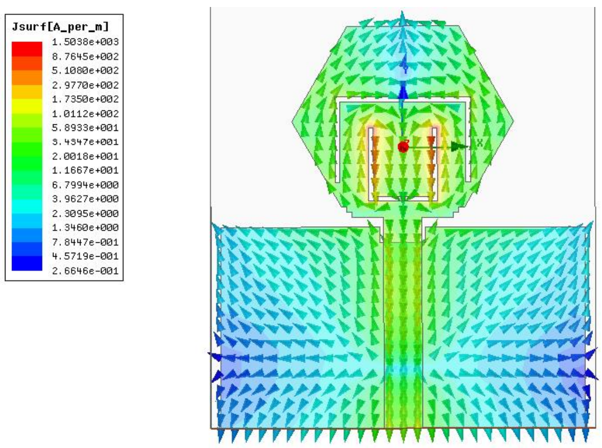
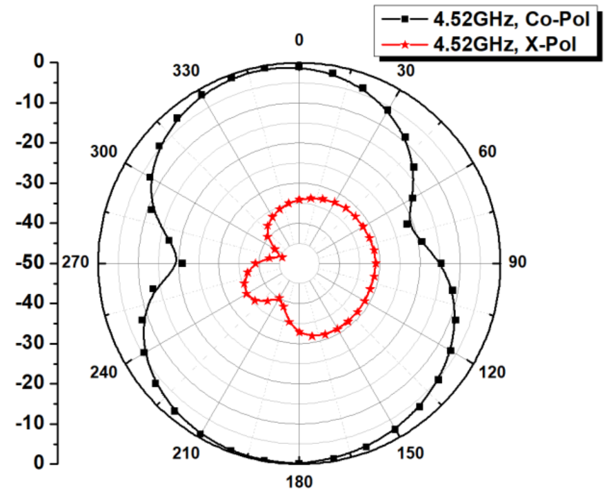


b

Fig. 4 – Current distribution of the antenna at 3.5 GHz (a) and 5.56 GHz (b)

The surface current distribution of the designed antenna at 3.5 GHz and 5.56 GHz is shown in Fig. 4.

The simulated co-polarization and cross-polarization of E-plane radiation patterns for the proposed antenna at 4.52 GHz, 7.45 GHz, and 10.08 GHz are respectively shown in Fig. 5a, Fig. 5b, and Fig. 5c, where good bidirectional radiation pattern has been observed.



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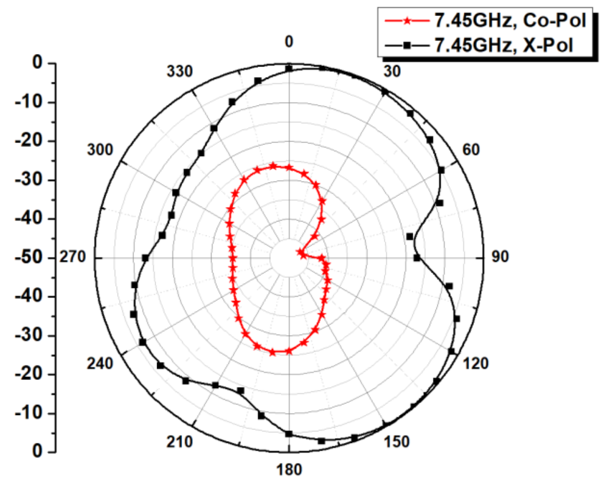

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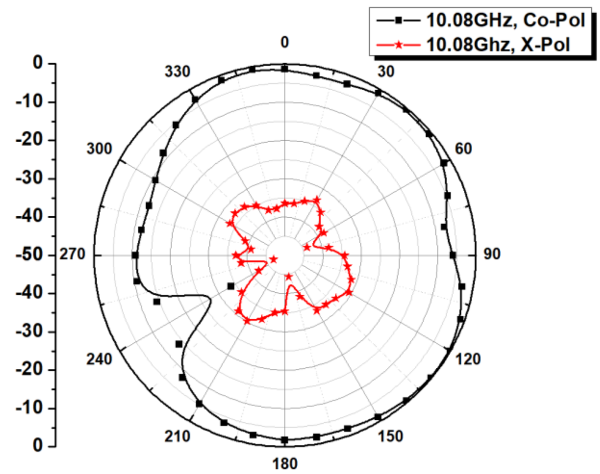

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Fig. 5 – Radiation pattern of the proposed antenna at 4.52 GHz (a), 7.45 GHz (b), and 10.08 GHz (c)

4. CONCLUSIONS

In this article, a design of compact ultra-wideband microstrip antenna with dual notch band characteristics and utilizing two U shaped slots on the patch has been designed and studied extensively. The reference antenna and proposed antenna have been designed in commercially available electromagnetic simulation software. In the proposed design the dimensions of the U-shaped slots have been determined by several parametric studies to achieve the desired results. The hexagonal monopole proposed antenna provides wide bandwidth covering the entire UWB spectrum (3.1-10.6 GHz), and the rejection notch bands of 3.2-3.8 GHz (WiMAX) and 5.15-5.85 GHz (WLAN) have been found due to incorporation of two U-shaped slots.

REFERENCES

1. Seyed Ramin Emadian, Changiz Ghobadi, Javad Nourinia, *Microw. Opt. Technol. Lett.* **54** No 6, 1365 (2012).
2. Wen Jiang, Wenquan Che, *IEEE Anten. Wireless Propag. Lett.* **11**, 293 (2012).
3. Xiang Long Liu, Ying Zeng Yin, Jun Hui Wang, and Jiao Jiao Xie, *Prog. Electromag. Res. C* **41**, 55 (2013).
4. Rezaul Azim, Mohammad Tariqul Islam, *Prog. Electromag. Res.* **133**, 391 (2013).
5. Mohammad Akbari, Neda Rojhani, Mehdi Saberi, Reza Movahedinia, *The Journal of Engineering* **2014** No. 8, 415 (2014).
6. Rezaul Azim, Mohammad Tariqul Islam, Ahmed Toaha Mobashsher, *IEEE Anten. Wireless Propag. Lett.* **13**, 670 (2014).
7. Yasser Ojaroudi, Sajjad Ojaroudi, Nasser Ojaroudi, *Wireless Pers. Commun.* **81**, 319 (2015).
8. Mohammad M. Fakharian, Pejman Rezaei, Aramn Azadi, *Wireless Pers. Commun.* **81**, 881 (2015).
9. Xiang Long Liu, Ying Zeng Yin, Jun Hui Wang, and Jiao Jiao Xie, *Prog. Electromag. Res. C* **47**, 147 (2014).
10. Ajay Yadav, Dinesh Sethi, R.K. Khanna, *AEU – International Journal of Electronics and Communications* **70** No 7, 331 (2016).
11. Samineni Peddakrishna, Taimoor Khan, *AEU – International Journal of Electronics and Communications* **96**, 107 (2018).
12. Ajay Yadav, Mamta D. Sharma, Rajendra P. Yadav, *Prog. Electromag. Res. C* **89**, 221 (2019).

Конструкція компактної гексагональної несиметричної антени UWB діапазону зі щілинним отвором і двосмуговим (3.5/5.5 ГГц) режектором

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У статті описана конструкція компактної несиметричної антени надширокосмугового (UWB) діапазону з двома смуговими режекторними характеристиками. Ефект режекторних смуг надзвичайно важливий для будь-якої UWB системи, щоб уникнути перешкод існуючим вузькосмуговим додаткам, таким як WiMAX та WLAN. У запропонованій конструкції розглядався випромінюючий елемент шестикутної форми. Дві неоднакові U-подібні щілини на випромінювальному патчі були реалізовані для досягнення характеристик подвійного режекторного фільтра. Перевернута U-подібна щілина витравлювалася на гексагональному патчі для досягнення режекторних характеристик для смуги WiMAX (3,2-3,8 ГГц). Ще одна щілина, що має U-подібну форму, також була вигравірувана на патчі, щоб досягти режекторних характеристик для смуги WLAN (5,1-5,8 ГГц). Запропонована антена має загальний розмір 38×56 мм². Arlon AD300, який має діелектричну проникність $\varepsilon_r = 3$, був обраний як матеріал підкладки. Товщина підкладки h = 1,524 мм. Програмне забезпечення для повнохвильового електромагнітного моделювання Ansys HFSS було використано для аналізу радіаційних характеристик конструкції. Запропонована антена успішно охоплює виділений частотний UWB спектр, працюючи в смузі частот від 2,6 ГГц до 11,4 ГГц (VSWR < 2), що відповідає смузі пропускання 120 %. Спроектована антена демонструє гарні коефіцієнти підсилення та двонаправлені діаграми спрямованості.

Ключові слова: UWB, Двосмуговий режекторний, Компактний.