Mehran University Research Journal of Engineering & Technology
Vol. 38, No. 2, 335-340 April 2019
p-ISSN: 0254-7821, e-ISSN: 2413-7219
DOI: 10.22581/muet1982.1902.08

Hexagonal Printed Monopole Antenna with Triple Stop Bands for UWB Applications

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RECEIVED ON 29.01.2018 ACCEPTED ON 25.05.2018

ABSTRACT

Inherently UWB (Ultra Wideband) communication systems comes with interference problem with some of the existing narrowband communication systems. These bands are stopped with the help of band-stop filter in order to reduce electromagnetic interference. However, the complexity and limitations are increased due to these filters, hence this solution is turned down in those applications where design complications and complexity is of concern. Introducing various slots of specific shapes and exact dimensions however, have solved this issue for the researchers around the world. This paper presents a hexagonal PMA (Printed Monopole Antenna) with triple stop bands. The antenna is used for UWB application. The antenna is stopped the WiMAX (Worldwide Interoperability for Microwave Access), WLAN (Wireless Local Area Network) and ITU (International Telecommunication Union) bands. The antenna dimensions are 30x28x16 mm^3. FR4 is used between ground and radiating patch with relative permittivity of 4.4. The VSWR (Voltage Standing Wave Ratio) is less than 2 between 3-11 GHz except WiMAX (3.1-3.7 GHz), WLAN (5.1-5.8 GHz) and the ITU frequency band (7.95-8.4 GHz). The antenna is design in CST software.

Key Words: **Computer Simulation Technology, Voltage Standard Wave Ratio, Worldwide Interoperability for Microwave Access, Wireless Local Area Network, Ultra Wideband, International Telecommunication Union.**

1. INTRODUCTION

UWB communication is under consideration in last decade due to wide bandwidth, short range, simple implementation and high data rate [1]. FCC (Federal Communication Commission) [2] allocated the frequency spectrum from 3.1-10.6 GHz. UWB has very larger bandwidth so interference occurred with existing narrow bands. The narrow bands are WLAN, WiMAX and ITU. These bands are stopped with the help of band-stop filter in order to reduce electromagnetic interference. However, the complexity and limitations are increased due to these filters. Therefore, the PMA with notched characteristics is required to reduce the interference, which is very simple, low profile, compact in size, easy in installation and fabrication.

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The stop band antenna with size of 30x30x1.6 mm^3 is propounded, the dual band are stopped with the help of slots in radiator and ground [3]. The PMA with stop band characteristic is presented, the size of the antenna is 48.7x42mm [4]. Liu et. al. [5] designed notched band antenna with large size of 40x40mm. The dual stop band circular design with size of 35.5x30x1.6mm is propounded, the antenna is printed on FR4 substrate [6]. The U shaped antenna with dual notched band is proposed, the bands is stopped with CSRR (Complementary Split Ring Resonator) and T shaped slot and the size of antenna is 24.6x38.1 mm^2 [7]. The triple notched band antenna with dimension of 24x34.6 mm is designed, the height of substrate is .8mm [8]. The circular antenna is presented to stop triple bands by using square short resonator, the size of the antenna is 40x20x0.508 mm^3 [9]. The PMA with size of 60x60x1.6 mm^3 is designed, the author used various shaped slot and F shaped stub to stop various bands [10]. The PMA is proposed with the rejection of two bands with the help of two slots, the dimension of the design is 31x31x1.15 mm^3 [11]. The single stop band PMA with circular slot is propounded, the size of the antenna is 50x50x0.5 mm^3 [12].

Recently various stop band printed antennas are reported where the band are stopped due to SRR, CSRR, open loop resonator, parasitic strips and embedded T shaped stub [13-16]. The interference of existing narrow bands are also reduce due to introducing different shapes of slot in radiator patch, ground and feed line such as T-shaped, E-shaped slot, symmetrical elliptical slots, fractal shaped slot, C-shaped slots, inverted C-shaped slots, semi-elliptical slot, U-shaped slot, L-shaped slot, circular slot and rectangular slot [17-24]. The detailed comparison is given in the **Table 1**.

In this paper, simple hexagonal PMA is presented which is designed on FR4 dielectric substrate. The size of the antenna is 30x28x0.6mm. The antenna is simulated in CST software. The slots are introduced to stop the bands of WiMAX (3.1-3.7 GHz), WLAN (5.1-5.8 GHz) and the ITU frequency band (7.95-8.4 GHz).

2. ANTENNA DESIGN

Proposed Hexagonal shaped PMA with stop band is presented. The size of the antenna is 30x28x1.6 mm^3. The proposed antenna has hexagonal shaped radiating patch with each side of 10mm. The hexagonal PMA have three slots such as rectangular slot, U shaped slot and inverting U shaped slot in feed line. The rectangular slot has 12.5 mm length and 0.3 mm width which filtered the band of WiMAX. The size of the U shaped slot is 18.7x0.5 mm, stopped the band of WLAN. The dimensions of the inverting U shaped slot is 12.3x0.6 mm, stopped the band of ITU 8 GHz. The feed line is 3mm wide and 8 mm long. The height of the ground is 8mm and width is 28mm and various other parameter is discussed in Table 2. The antenna is fed with 50&! transmission line. The complete antenna design is depicted in Fig. 1(a-b) and its S_{11} is shown in Fig. 2. The VSWR of proposed antenna is also illustration in Fig. 3. The length of slots can be calculated from bellow postulate [3].

$$L_{s1} = \frac{c}{4f_n\sqrt{\left(\frac{s_r+1}{2}\right)}} \tag{1}$$

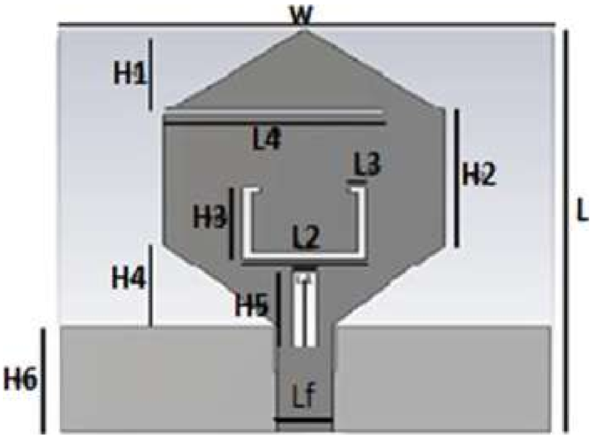
TABLE 1. COMPARISON BETWEEN PROPOSED ANTENNA AND AVAILABLE IN THE LITERATURE

No.	Author	Size (mm^3)	Stop Bands
1.	Sarkar et. al. [25]	35x35x1.6	3
2.	Shi et. al. [6]	35.5x30x1.6	2
3.	Gao et. al. [7]	24.6x38.1x1.5	2
4.	Sarkar et. al. [8]	24x34.6x0.8	3
5.	Proposed Hexagonal PMA	32x30x1.6	3

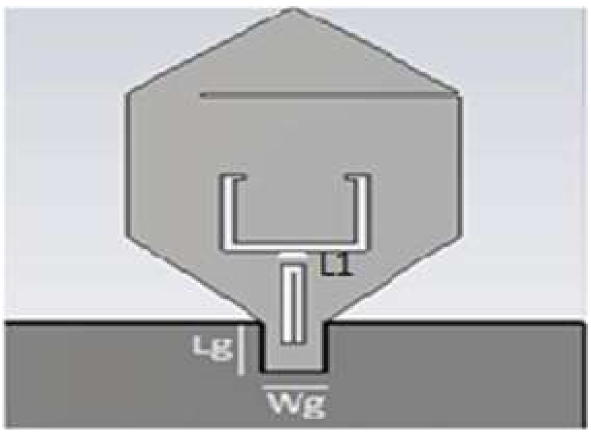
$$L_{s2} = \frac{c}{2 f_n \sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}} \qquad (2)$$

TABLE 2. PARAMETER OF PROPOSED HEXAGONAL PMA

Parameters	Value (mm)	Parameters	Value (mm)
L	30	L3	1
W	28	H6	8
Lg_1	3.5	L1	1
H_2	10	L4	12.5
Lg_2	3.5	H1	6
H_4	6	H3	5.5
W_g	3.3	Wf	3
L_2	7	H5	5.5



(a) TOP VIEW



(b) BOTTOM VIEW

FIG. 1. PROPOSED PMA

L_{s1} denotes the length of rectangular slot, L_{s2} denotes the length of U shaped slot, f_n is notch frequency and ε_r is relative permittivity. The rectangular slot is λ/4 at stop band frequencies and remain two slots are λ/2 at stop band frequencies.

3. RESULTS AND DISUCUSION

The VSWR is less than 2 between 3-11GHz except WiMAX (3.1-3.7GHz), WLAN (5.1-5.8GHz) and the ITU frequency band (7.95-8.4GHz). The impedance bandwidth of proposed PMA is 8 GHz which can be justified from Fig. 2. The antenna Gain is higher at resonating frequency as compared to notched frequencies which is shown in Fig. 4. The E and H-plane radiation pattern at various frequencies are depicted in Fig. 5(a-c). In E-plane the pattern is same to dipole antenna and in H-plane the pattern is nearly omni-directional.

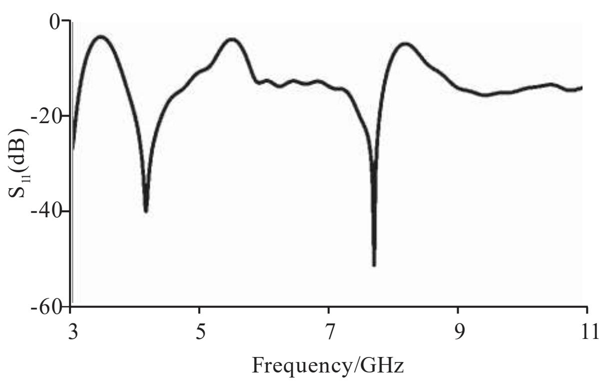


FIG. 2. SIMULATED S_{11} (DB) OF HEXAGONAL PMA

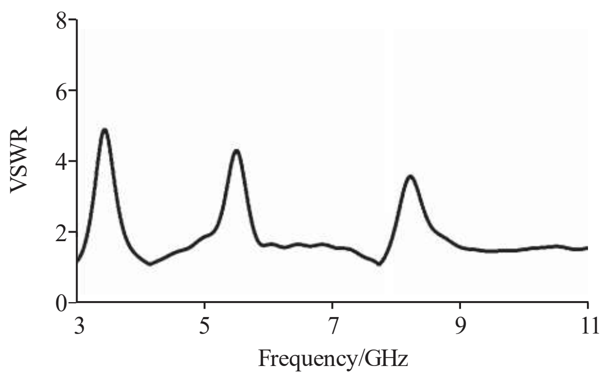


FIG. 3. SIMULATED VSWR OF PROPOSED PMA

The vector current distribution at different notched frequencies are given in Fig. 6(a-c). The current is flowing around rectangular slot but in opposite direction which cancelled effect of each other and stop band occurred at 3.5GHz due to this phenomenon. Similarly, the 5.5 and 8.1GHz band are stop due to U shaped and inverted U shaped slot which is clearly illustrated in Fig. 6.

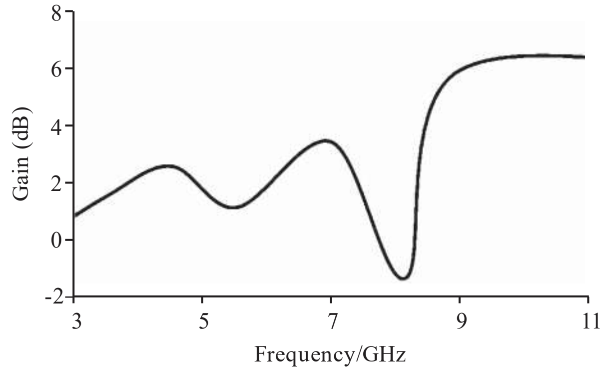
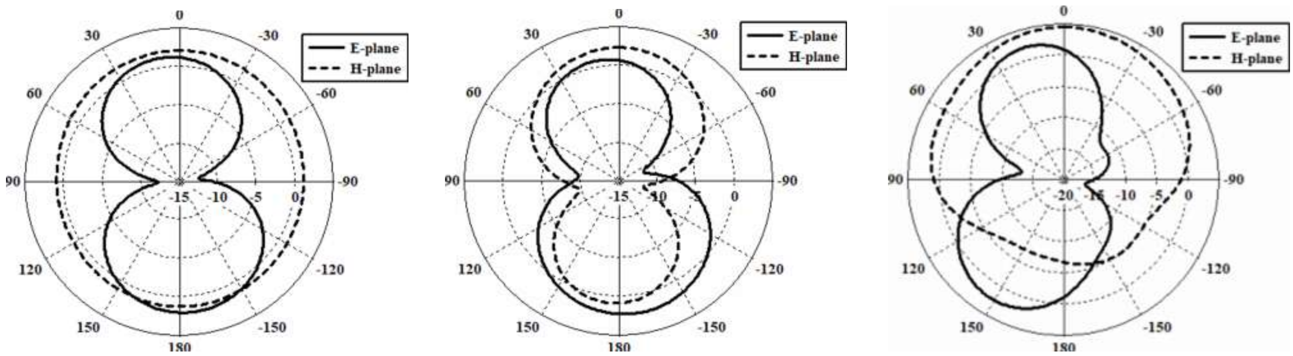


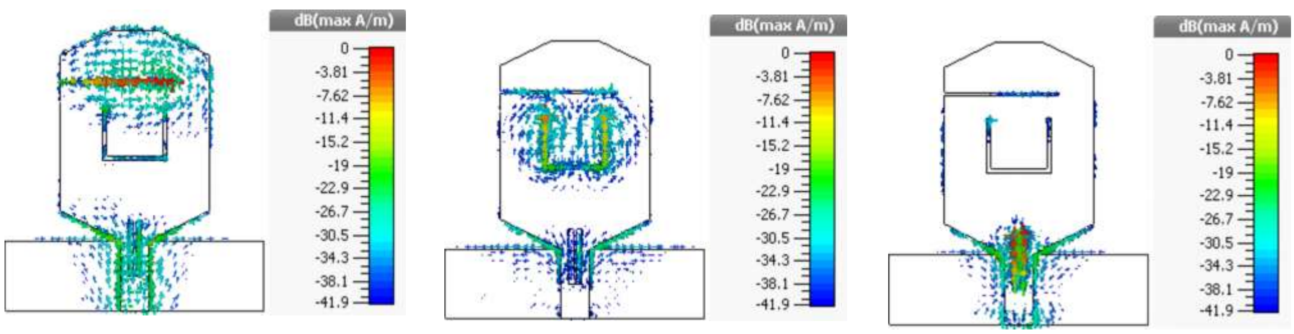
FIG. 4. SIMULATED GAIN OF TRIPLE STOP BAND PMA

The photographical image of presented design is depicted in Fig. 7(a-b). The design is tested through Agilent Technologies Network Analyzer N5242A. The measured and simulated S_{11} and VSWR is shown in Figs. 8-9 respectively. The slight shift occurred due to SMA connecter and Fabrication error.



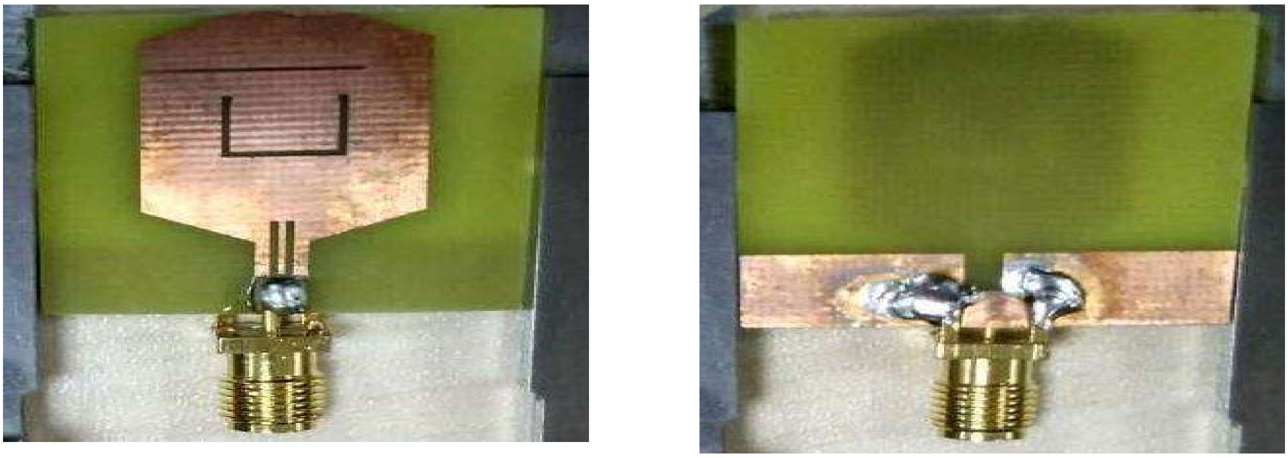
(a) 3.1GHZ *(b) 4.1GHZ* *(c) 7.7GHZ*

FIG. 5. SIMULATED RADIATION PATTERN OF TRIPLE STOP BAND PMA



(a) 3.5GHZ *(b) 5.5GHZ* *(c) 8.1GHZ*

FIG. 6. SURFACE CURRENT DISTRIBUTION OF TRIPLE STOP BAND PMA



(a) TOP VIEW (b) BOTTOM VIEW

FIG. 7. PHOTOGRAPHIC IMAGE OF TRIPLE STOP BAND PMA

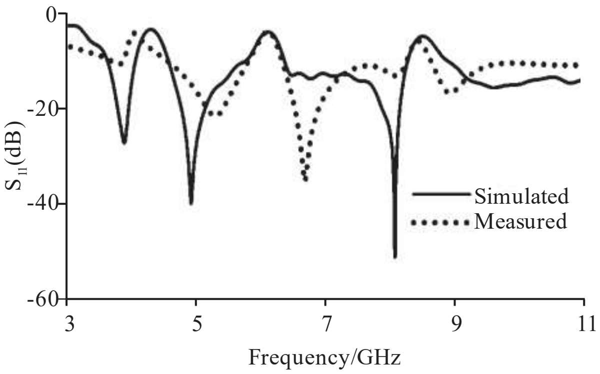


FIG. 8. SIMULATED AND MEASURED S_{11}(DB) OF HEXAGONAL PMA

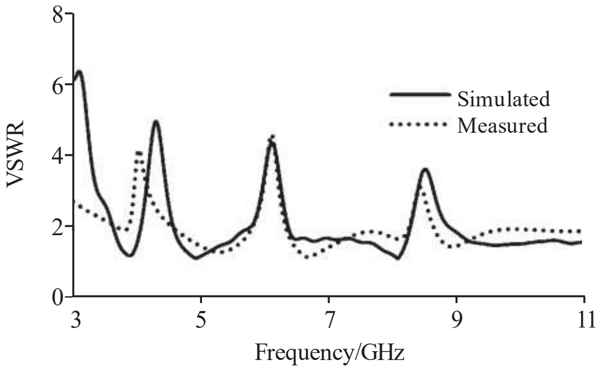


FIG. 9. SIMULATED AND MEASURED VSWR OF TRIPLE STOP BAND PMA

4. CONCLUSION

UWB communication systems have interference problem with existing narrowband communication systems. These bands are stopped with the help of band-stop filter in order to reduce electromagnetic interference. However, the complexity and limitations are increased due to these filters. The aim of the research is to design compact size PMA with band stop characteristics to reduce interference with existing narrow bands. Therefore, the PMA with notched characteristics is required to reduce the interference, which is very simple, low profile, compact in size, easy in installation and fabrication. The antenna is resonating from 3-11 GHz except stop bands. The slots are introduced to stop the bands of WiMAX, WLAN and the ITU frequency band.

ACKNOELEDGEMENT

Authors acknowledge the support given by the Microwave and Antenna Research Group, Department of Electrical Engineering, University of Engineering & Technology, Kohat Campus, Peshawar, Pakistan. This support was in the form of access to the recent good quality research papers and also in the form of valuable comments whenever required regarding the concept of the research field.

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