DESIGN AND FABRICATION OF DUAL NOTCH ANTENNA IN ULTRA-WIDEBAND FOR WLAN/WIMAX APPLICATIONS

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Abstract

Double notch ultra-wideband antenna is proposed in this paper. Ultra-wide band has range as of 3.1 to 11 GHz as allowed by FCC for commercial purpose. ISM band (peak at 5.8 GHz) and WLAN band (5-5.75 GHz) are very close in frequency band, so rejection of ISM band is needed. A notch band is needed to reduce interference between WLAN and WiMAX. ISM band 5.8 GHz and 3.8-4.9 GHz band are notch bands obtained by etching slot and ring resonators. Resonators length and width have inverse relation to the notching frequency. In this proposed antenna inverted U slot gives wide range of rejection frequency i.e. it rejects the band of 3.8-4.9 GHz and half elliptical ring resonator rejects the ISM (peak at 5.8 GHz) band. This antenna reduces the interference between ISM (peak at 5.8 GHz) band and WLAN (peak at 5.2 GHz) band for WLAN applications. Notching of 3.8-4.9 GHz band minimizes the interference between WLAN and WiMAX. The result of antenna in terms of VSWR (5 to 8) for notching frequency bands shows that the dual notch occurs in simulated and fabricated one. The outcome of this antenna suggests that it can be applicable to WLAN, WiMAX and communication systems of UWB.

Index terms*:* Antennas, Industrial Scientific and Medical (ISM), Notch band, Ultra-wideband (UWB), Wireless Local area network (WLAN), World-wide interoperability for Microwave access (WiMAX).

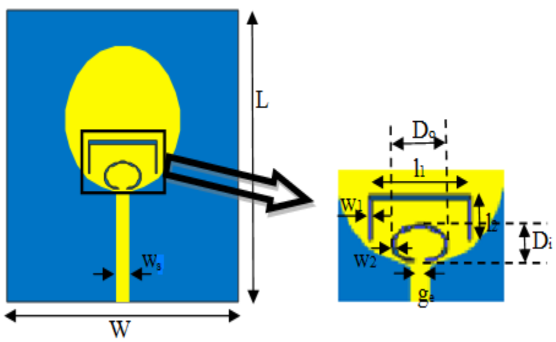
I. INTRODUCTION

Federal Communications Commission (FCC) allows using ultra wide band of 3.1 to 11 GHz for profitable purpose [1]. Ultra wide band contains various bands like C, WLAN, WiMAX, X band etc. UWB has wide range of frequencies so many researchers are looking for new innovations in these bands. For higher data rate narrow band communication, WLAN as 5-5.75 GHz and WiMAX as 3.3-3.6 GHz are applications in this antenna design. There is band of 3.8 to 4.9 GHz that may interfere in WLAN and WiMAX, so there is need to reject this band from antenna. Also one of the ISM band at 5.8 GHz interfere with WLAN band at 5 to 5.75 GHz. For reducing interferences in UWB, there are different techniques like slot, ring resonator used in patch as well as grounding of antenna.

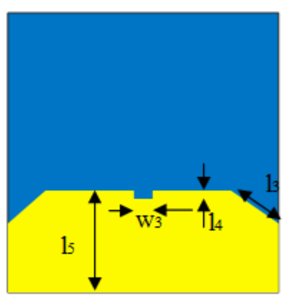
Multiple notch band antennas reported in recent literature. 3.25-3.8 GHz, 5-5.75 GHz and 7.9-8.4 GHz bands are notched with half elliptical slot resonators in patch and rectangular rings near to feed line used in [2]. Antenna with 5-5.7 GHz band notched with circular ring slots but it has wide band notch. It has small dimension and high Q operation in [3]. Using H shaped, fork shaped and capacitive loaded loop resonator with different patch, multiple bands are notched in [5]-[8]. These shapes have wide band notch, I want dual notch with one wide band and other narrow band.

In this paper, I proposed a plain low cost antenna with double notch band. The half elliptic ring has narrow band notches compared to circular, rectangular as used in [2]-[5]. Half elliptic ring reduces interference to WLAN band because ISM 5.8 GHz band is notched. Inverted U shape rectangular slot notch has wide band notch so that we used for 3.8 to 5 GHz band notch which minimizes interference between WLAN and WiMAX bands. The proposed antenna has notches on patch and some defects on ground shows change in impedance bandwidth.

II. ANTENNA DESIGN CONFIGURATION



(a)



(b)

Fig. 1. Geometry of proposed dual notch antenna (a) Top view (b) Bottom view

Fig.1 shows geometry of proposed antenna with dual notch. Antenna designed on low cost Flame Retardant-4 substrate height of 1.6 mm with permittivity of 4.4. The proposed antenna is 40 (W) × 40 (L) × 1.6 (h) mm^3 in size. The whole antenna is designed and simulated in Ansoft's HFSS v.13. This antenna fed by microstripline of size 2.4mm width for matching with SMA connector ensures better impedance matching over UWB frequency range. Antenna design has circular structured patch and small defective ground. The radiating patch is designed using following equations (1) and (2) which gives radius of patch at resonant frequency (f_r) of 5 GHz from [10].

$$r = \frac{G}{\left\{1+\frac{2h}{\pi\varepsilon_r G}\left[ln\left(\frac{\pi G}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad (1)$$

$$G = \frac{8.791\times10^{9}}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

In the radiating patch of antenna notches are created with different shape of slots. Inverted U shaped rectangular slot and half elliptic ring used for notching two frequency bands and they are designed using following equations (3) to (6) from [2].

$$C_e = B_e\pi(0.5D_i - w_2) = \frac{c}{2fn_2\sqrt{\varepsilon_e}} \quad (3)$$

$$B_e = 3(1+b) - \sqrt{(3+b)(1+3b)} \quad (4)$$

$$\varepsilon_e = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+\frac{12h}{w_s}\right)^{-0.5} \quad (5)$$

$$L_r = 2(l_1 + l_2 - 2w_1) = \frac{c}{2fn_1\sqrt{\varepsilon_e}} \quad (6)$$

C_e and L_r are calculated using above equations at different notch frequencies where c is speed of light. From these equations C_e comes 14.3mm for 5.8 GHz notching frequency and L_r is length of U shaped rectangular slot; it comes 18mm for 4.7 GHz notching frequency. These two notching bands half elliptic ring and U shaped slot used in radiating patch for getting narrow and wide notch bands respectively. The size of final calculated antenna be as following: L= 40mm, W= 40mm, h= 1.6mm, r= 10mm, C_e= 14.3mm, L_r= 18mm, w_s= 2.4mm, f_r= 5 GHz, fn_1=4.6 GHz, fn_2=5.8 GHz, B_e= 2.81, b= D_o/D_i= 1.76, D_o= 6.5mm, D_i= 3.7mm, w_2= 0.23mm, g_e= 1.12mm, l_1= 7mm, l_2= 3mm, w_1= 0.5mm, l_3= 8mm, l_4= 1mm, w_3= 3mm, l_5= 14.5mm.

III. RESULTS AND DISCUSSION

(A) (B)

FIG. 2. FABRICATED DUAL NOTCH ANTENNA (A) TOP VIEW (B) BOTTOM VIEW

Fig. 2 shows the double notching micro strip antenna made-up on Flame Retardant-4 substrate with permittivity of 4.4. The fabricated antenna has 3.1 to 11 GHz wide UWB frequency range and impedance bandwidth in which two notch bands are obtained. Two notched bands of simulated antenna have frequency range of 3.8-4.9 GHz with summit VSWR at 4.7 GHz and 5.6-6.2 GHz with summit VSWR at 5.8 GHz as revealed in fig. 3.

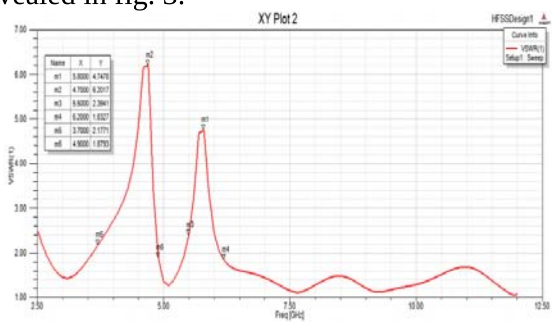


Fig. 3. Simulated VSWR result of dual notch antenna

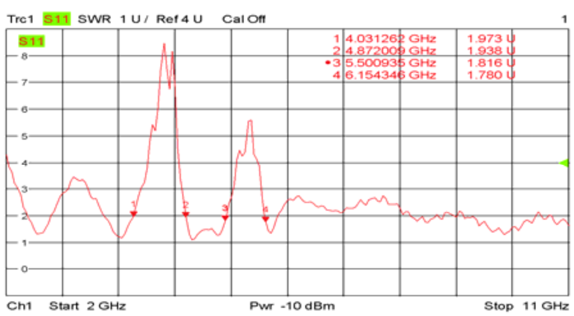


Fig. 4. Measured VSWR result of dual notch antenna

From fig. 3 of VSWR show that wide band notch occurred due to inverted U shape rectangular slot and narrow band notch occurred due to half elliptic ring. Measured VSWR of fabricated notch antenna frequency bands are 5 to 8 as shown in fig. 4 and which shows that these two bands are notched. The notching band 3.8-4.9 GHz minimizes interference between WLAN (5-5.7 GHz) and WiMAX (peak at 3.5 GHz). Another notching band 5.6-6.2 GHz (ISM band at 5.8 GHz) minimizes interference to WLAN (5-5.7 GHz) frequency band. From fig. 3 and 4 shows that the designed antenna is properly working for WLAN and WiMAX frequency bands. Table I shows proposed antenna has better results, return loss is well above -3 dB and VSWR is greater than 5 which is good notching of frequency bands. Proposed antenna has gain 4 as calculated in HFSS, which is better than other antennas as given in table I.

IV. CONCLUSION

A double notched micro-strip antenna is planned, simulated and made-up on Flame Retardant-4 epoxy substrate. The inverted rectangular slot is used in the antenna to construct a notch band from 3.8 to 4.9 GHz frequency band and half elliptical slot creates a notch at 5.8 GHz central frequency (ISM Band), therefore these particular notches reduce interference with WLAN and WiMAX frequency bands. These two frequency bands have VSWR from 5 to 8 which show that these two bands are notched. The VSWR of fabricated antenna illustrate a better match with simulated prevision. Proposed antenna has better results compared with others as given in table. This antenna can be a better choice for various applications offering minimum interference in UWB.

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TABLE I: COMPARISON BETWEEN REFERENCE PAPER ANTENNAS AND PROPOSED ANTENNA

Antenna	Notching frequency bands in GHz	Shapes of slots	Simulated VSWR	Measured VSWR	Gain in dB
[2]	3.3-3.8, 5-5.75 and 7.8-8.4	Elliptical and rectangular	4.5 to 6.6	4.2 to 5.6	2.7 at 5 GHz
[3]	4.8-5.6	Circular	5.8	5.6	3.4 at 5 GHz
[4]	Centre at 5.2	Elliptical	4.4	4.2	3.8 at 5 GHz
Proposed antenna	3.8-4.9 and 5.-6.2	Half elliptical and inverted U shape	4.75 to 6.3	5.5 to 8.1	4 at 5.2 GHz