Miniaturization of UWB Patch Antenna with Band Notch Characteristics

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Abstract: ***In this paper, a single feed ultra wide-band micro-strip patch antenna with band notched characteristics is presented. The antenna presented here rejects Wi-max band to remove the interference from 3.3 to 4.3 GHz and antenna operates in the frequency range of 3-12 GHz. The antenna is designed on FR-4 substrate with thickness of 1.6 mm. The antenna has a compact structure of size 15.2*13.6 mm^2.The antenna is simulated on HFSS software based on electromagnetic (EM) simulation. The antenna is investigated in terms of frequency domain characteristics. Notch is achieved by inserting rectangular slots on patch & notch position is achieved by varying the size & position of rectangular slot. Partial ground plane along with stair case design is used for patch .The antenna is achieved with maximum gain of 3.5 dBi.***

Keywords: HFSS, UWB technology, Band –notching, Compact size

1. Introduction

During the past three decades ,wireless communication has drastically increased the demand of various antennas which is sound enough to be embedded in portable and handheld devices for using in various bands of wireless communication.UWB (Ultra-wide band) was first reserved only for military use since 2002.But after the declaration of Federal Communication Commission (FCC),frequency band of 3.1-10.6 GHz can be used for commercial purposes, so researchers from academic as well as industry start focusing in the areas of UWB technology.[1]

Now –a – days ,UWB has become one of fast emerging technology with its promising advanced features such as high data rate ,low cost implementation ,high efficiency and miniaturization of antenna and its application find use in the wireless communication has provided biggest spectrum for using in various fields such as ground penetrating radars, medical imaging system, positioning and tracking and wireless home networks.[2]

But some other spectrum such as WLAN (5.15-5.82) and Wi-max (3.3-3.6) are regularly interfering in the UWB range, so they affect the performance of UWB antenna, hence thereby decreasing the efficiency. So to overcome this interference problem, band reject filters can be used ,but they increases the complexity of overall system. So from this point of view, the need of the hour is to design antenna with band notching characteristics so as to make it effective from all point of view. Different methods have been used for band notching in antenna. They include C-slot,[3-6] U-slot, polygon slot on patch ,L-slot, T-slot, inverted L shape slot on ground plane, EBG and DGS structures. E-slot, V slot, complementary split ring resonators (CSRR),a quarter wavelength tuning stub, parasitic elements or slits around patch ,semi-circular, elliptical patch design, etc.[7-10]

In this paper, a UWB patch antenna with band notching characteristics is proposed. The notching characteristics of designed antenna is accomplished by etching a rectangular slot on rectangular patch. Simulations have been done to get optimized results. Section II of this paper gives a brief idea of antenna design. Section III deals with results and simulations and at last paper is concluded in Section IV.

2. Antenna Design and Analysis

The proposed design for band notching is shown in figure 1 and it is analysed using software Ansoft HFSS 12.1 which is based on electromagnetic (EM) simulation. The proposed design is printed using FR-4 substrate with dielectric constant (ϵ_r) of 4.4 and thickness of 1.6 mm and loss tangent of 0.02.The antenna design is divided into three parts:
Firstly "+ " shape slot and rectangular slot on rectangular patch.
Secondly stair case pattern for radiating patch.
Thirdly partial ground plane along with micro-strip feed line.

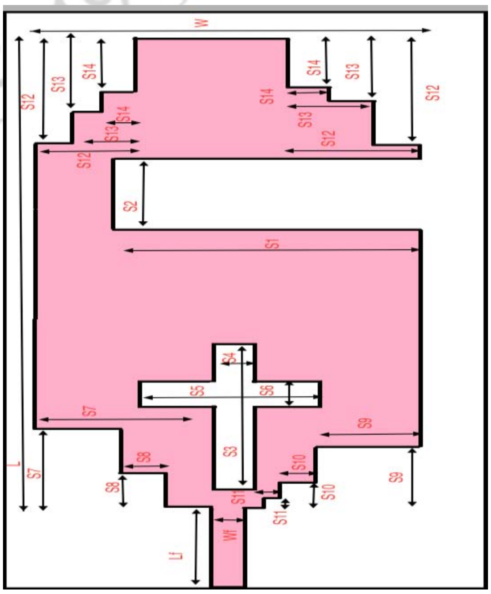
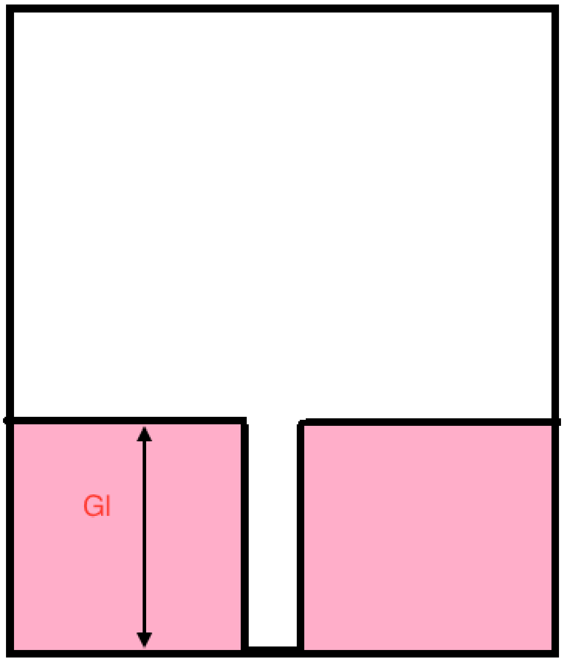


Figure 1: Proposed antenna design (a) Front view



(b) Back view

The dimensions for complete proposed UWB notched antenna design are tabulised in table 1.The proposed antenna has substrate dimensions of 24 * 24 mm^2.The feedline has a total width of 2.5 mm so as to achieve 50Ω for impedance matching. This proposed antenna has a partial ground of length 9.6 mm and width 24 mm as shown in figure 1." + shape slot" has length and width of 1 mm * 4.8 mm. The stair case design on upper and lower sides of radiating patch and partial ground plane is used for making antenna work in UWB region i.e from 3.1 to 10.6 GHz. To achieve band notching characteristic in proposed design for Wi-Max band, we have first cut a rectangular slot S on upper side of + shape slot on patch with S_1= 12 mm and S_2= 3 mm. which helps in notching of frequency band from 3.3 to4.3 GHz. From figure 1 and figure 2, the design will become more clear and understandable.

The design steps of both + shape slot and rectangular slot is shown in figure 2.

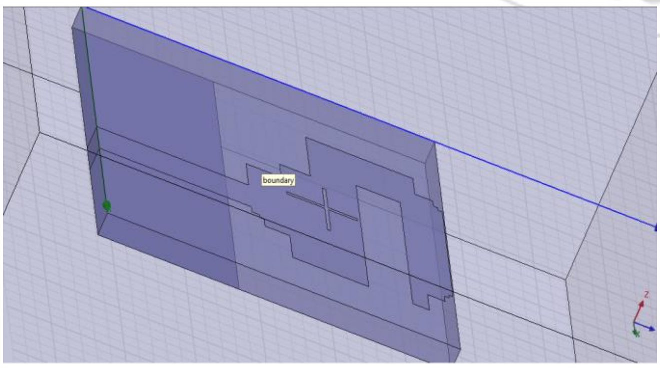


Figure 2: Proposed software design

Table 1: Optimised Dimensions Of Proposed Antenna

Parameter	*Unit(mm)*
L	15.2
W	13.6
S1	12
S2	3
S3	4.8
S4	1
S5	4.8
S6	0.5
Gl	9.6
S7	4.5
S8	2.4
S9	2.5
S10	1
S11	0.5
S12	1.8
S13	1
S14	0.5
Lf	10.33
Wf	2.5

3. Results and Discussions

Simulated result of proposed designed antenna has been shown in figure 3 and figure 4.The antenna with rectangular slot successfully exhibits single band notch of frequency band from 3.3 to 4.3 GHz.The return loss & VSWR of the antenna with and without rectangular slot is shown in figure 3(a) & (b) and figure 4(a) & (b) respectively.

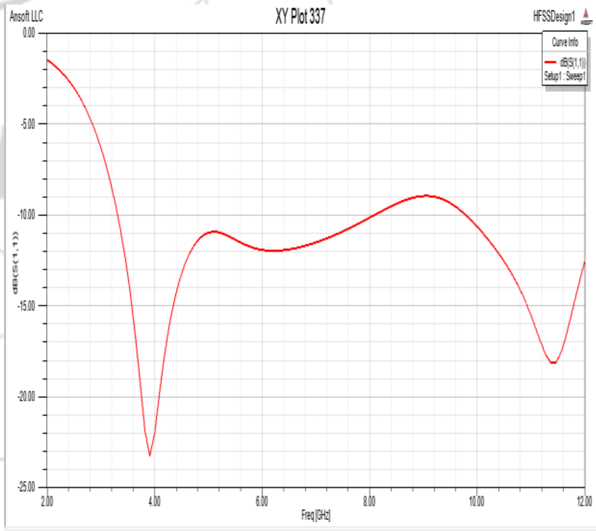


Figure 3: a) Return loss without slot

b) Return loss with slot

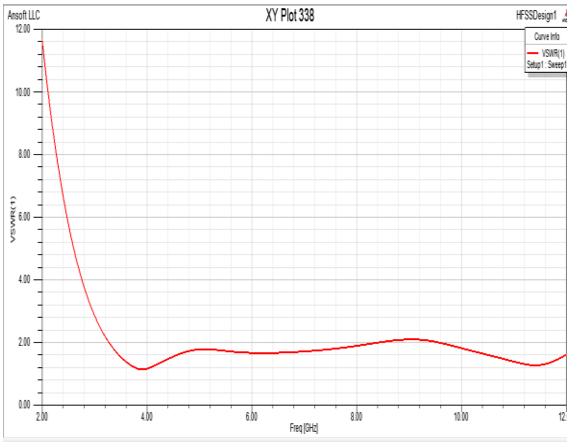
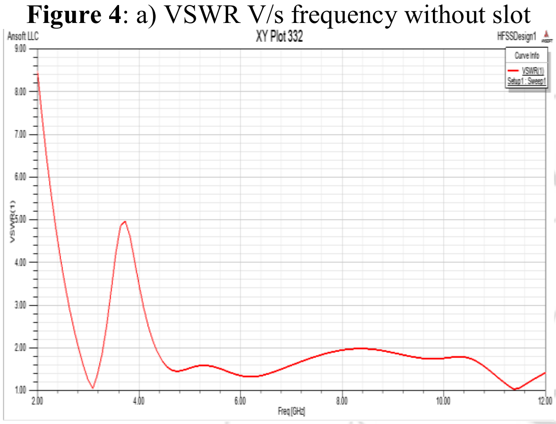


Figure 4: a) VSWR V/s frequency without slot



b) VSWR V/s frequency with slot

From the above figure ,it is clear that notch is developed only for Wi-Max band and except this all other bands are passed smoothly. The maximum return loss obtained is -32.52 dB at frequency of 11.36 GHz . It represents that antenna has wide bandwidth that ranges from 2.8 to 12 GHz.The antenna shows good omnidirectional radiation patterns at different frequency of 3.09 GHz and 11.45 GHz on all values of ϕ = 0 and ϕ=90 i.e H plane & E plane.

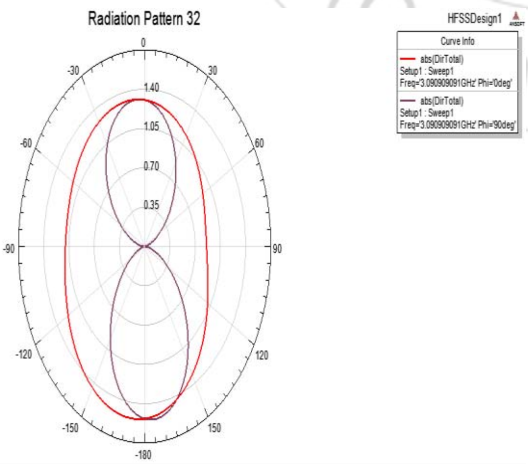
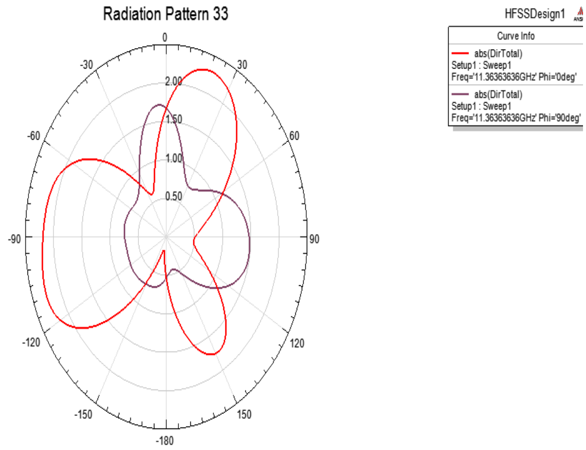


Figure 5: a) Simulated radiation pattern in azimuthal and elevation plane at f=3.09 GHz



b) Simulated radiation pattern in azimuthal and elevation plane at f=11.36 GHz

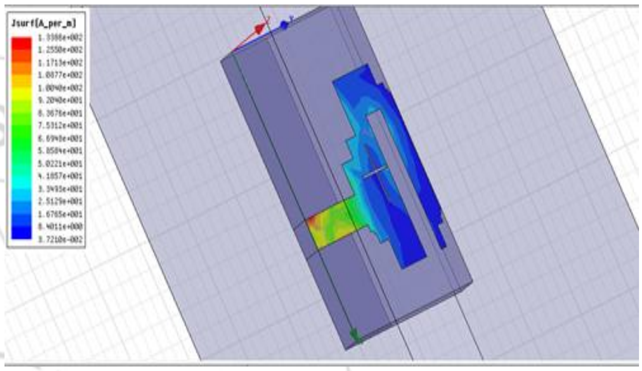


Figure 6: Current distribution of proposed design

This rectangular slot helps in rejecting the frequency band of 3.3 to 4.3 GHz,so interference caused by Wi-max can be avoided.Surface current distributions along rectangular & + shape slot at frequency of 11.36 GHz are given in figure 6.Strong current distributions is concentrated near feed line. After seeing the gain V/s frequency graph in figure 7,it is clear that the gain undergoes a sharp decrease at notching frequency but performing good at other frequencies .The maximum peak gain attained is 4.2 at frequency of 2 GHz.

Radiation efficiency of overall antenna is also good, it is in between 80%-90% but somewhat less in notching band.

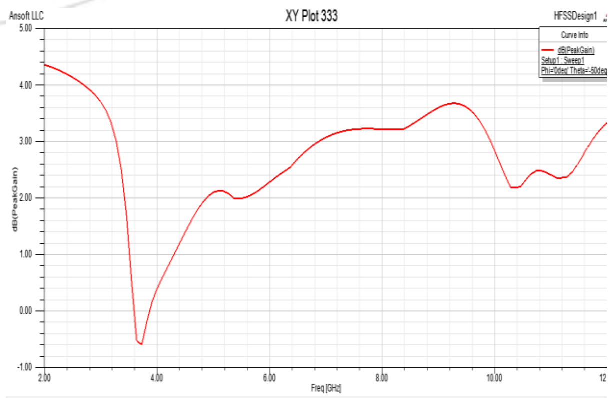


Figure 7: Simulated antenna gain

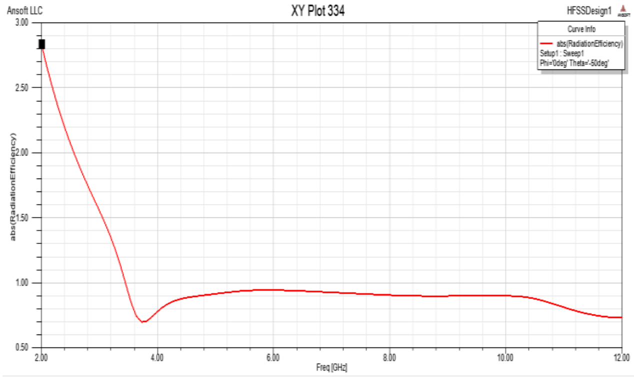


Figure 8: Simulated radiation efficiency of proposed antenna

4. Conclusion

A very compact single band notching UWB antenna is presented in this paper. Proposed design covers frequency range of 2 to 12 GHz i.e it includes UWB range from 3.1 to 10.6 GHz and it also help in preventing interferences from Wi-Max band. After going through simulations, return loss & VSWR is found to be satisfactory & the size of antenna is also very compact and miniatured which is added as biggest advantage. The overall performance of antenna finds it appropriate for use in future applications. The antenna has very vast applicability in different fields of communication with a very broad bandwidth of it provides advantages for its simple and compact design, wide bandwidth and improves the overall performance of antenna.

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