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Miniature UWB Antenna with Band Dispensation

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Abstract:
The Dual band notched antenna with compact dimensions which is suitable for UWB applications is proposed in this paper. The proposed antenna is able to notch band (5.1-5.8GHz) for WLAN application and (7.2-8.3GHz) of downlink X band satellite applications and International Tele communication Union (ITU) band applications. The required band notching is achieved by cutting U slot in the feed line and H slot on the patch. The simulation of the proposed antennas has been performed using ANSYS HFSS 15.0 software. The dual band notched antenna is fabricated using FR4 substrate material having thickness 1.6mm having dielectric constant of 4.4. Important antenna performance parameters like radiation pattern, Return losses (S11) , VSWR and gain are measured by simulation. The antenna is fabricated for the fabricated antenna VSWR, Return losses, Radiation pattern and gain are measured. The simulated and measured results are compared and reported.

Keywords:*Dual Band Notching, H Slot, U Slot, VSWR, Ultra-wide band (UWB).*

I. INTRODUCTION

In 2002 FCC approved a frequency band of (3.1-10.6GHz) for commercial applications[1-5,7-19].There are existing wireless technologies that use certain bands for their operation which lie within the (UWB).The existing wireless technologies are like WIMAX (Worldwide Interoperability for Microwave Access) from (3.326-3.612)GHz ,C band downlink frequency from (3.8-4.2)GHz, WLAN application from (5.1-5.822)GHz, X Band Satellite downlink communication application from(7.25-7.733)GHz and ITU band operations from(8.0-8.565)GHz. To avoid interference between these existing bands and UWB band notching characteristics are proposed.

In the recent years UWB antenna technology gained popularity due to its fast data rate over wide frequency bands at short transmission distance. The rapid development in wireless broadband technologies requires compact antennas.

The present work mainly focuses on a compact monopole antenna with dual band notched characteristics are proposed. To operate the antenna in UWB frequency range, bevel slots are made on rectangular patch. These bevel slots effects the current distribution on the patch. The defected ground plane is also going to affect the current distribution on the ground plane and on the patch. In the literature many techniques are reported to get compact dimensions like using higher dielectric substrate material, applying magneto inductive waveguide loading, EBG (Electromagnetic Band Gap) structures, PBG (Photonic Band Gap structure) without effecting gain and bandwidth. In which Defective Ground Structure (DGS) is the easiest techniques for achieving compact dimensions. In DGS techniques the gap between ground plane and patch is going to affect the radiation characteristics of the antenna. In the literature different slots are placed to achieve band notching characteristics like Etching C Shaped slot [10], U shaped slots and pair of L shaped slots[19],Rectangular slots[1],two pairs of L shaped slots[5], bended dual L Shaped branches [9],Hexagonal split ring resonators[3] and many other[2,3,4,7,8,11,12,13,14,15-18].

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II METHODOLOGY

The antenna units are designed using the design equations mentioned in literature [6]

With a resonant frequency of 5.5GHz using FR4 substrate having thickness of 1.6mm, a rectangular patch is designed. The dimensions are calculated using the design equations mentioned in literature [4] and are mentioned in Table 1

Antenna 1: Rectangular UWB monopole antenna.

Table 1: Dimensions of the patch

Parameter	Dimensions in mm
Resonant Frequency (f_r)	5.5GHZ
Width of substrate (W_s)	27
Substrate length (L_s)	29
Substrate height (H_s)	1.6
Patch Length (L)	17
Patch Width (W)	16
Feed Length (L_f)	9.5
Feed Width (W_f)	2.8

The performance of antenna is observed through simulation. To obtain wider band width bevel slots are cut on four corners of patch as given in Fig 1

To obtain optimum performance, simulations are carried out by varying bevel slot length and bevel slot width. Finally the dimensions of bevel slots are selected as length 2mm and width 4mm to get better results. The effect of bevel slot length and width on the performance of the antenna are shown in Figs 2, 3.

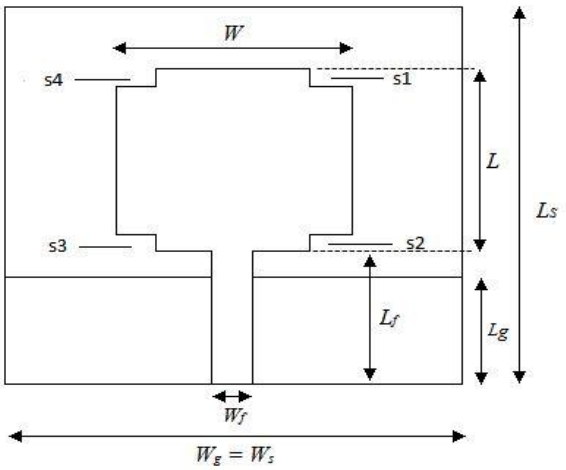

Fig 1 .Structure of Antenna 1

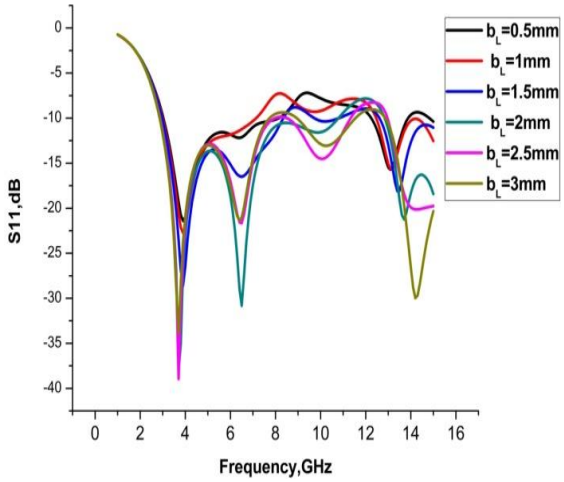

Fig 2.Effect of bevel slot length on Return losses Vs Frequency

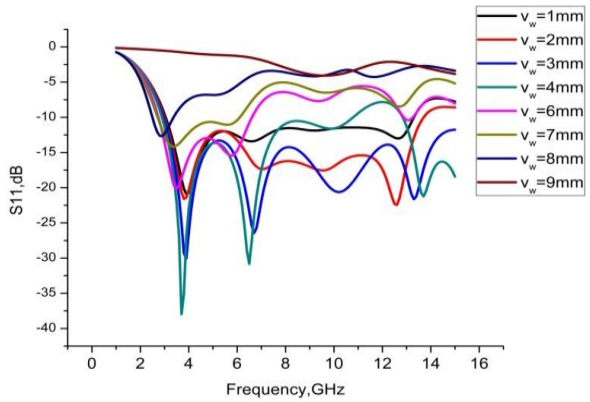

Fig 3.Effect of bevel slot width on Return losses VS Frequency

It is observed from the Figs 2, 3 when the bevel slot dimensions are 2mm x 4mm better results are obtained. The effect of ground plane dimensions on the performance of antenna is also observed.

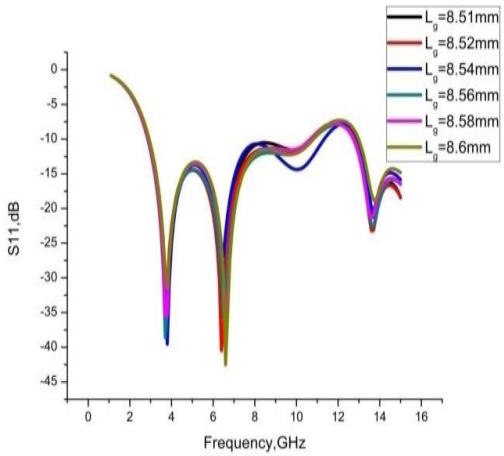

Fig .4 Effect of ground plane dimensions on Return losses Vs frequency

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The antenna is simulated using HFSS software. It is observed from the simulation results that the antenna is operating in the frequency band of 3-12 GHz. Radiation patterns at different frequencies are observed by simulation. The radiation patterns at different pass band frequencies like 3, 5, 7 and 9GHz are observed and the patterns are almost Omni directional in the pass band.

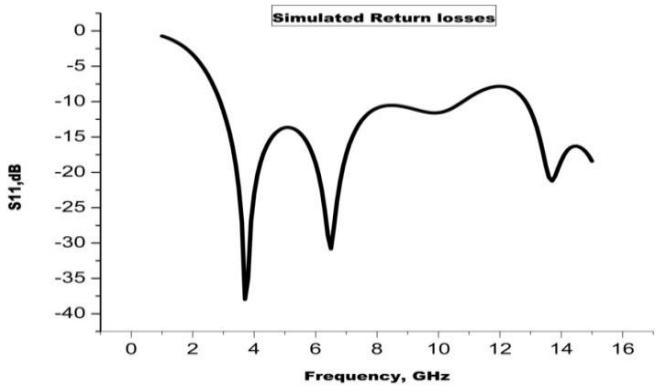
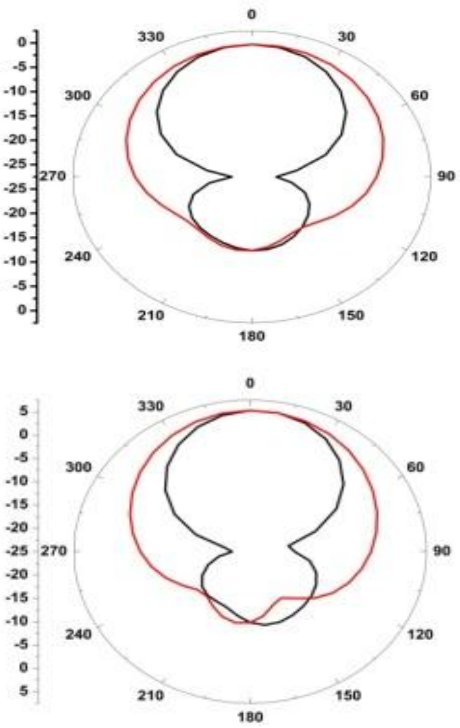


Fig 5 Simulated Return losses Vs Frequency of atenna1



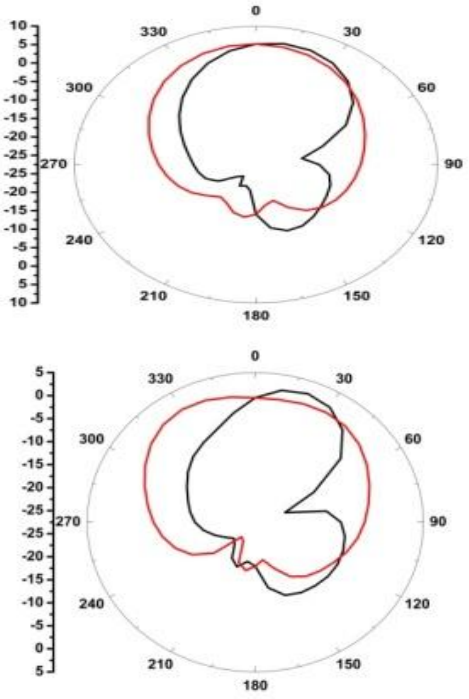


Fig 6 Simulated Radiation patterns at 3,5,7,9 GHz

To avoid interference band dispensation characteristics are proposed by making slots in feed line as well as in patch. The structure of antenna 2 is shown in Fig 7.

Dimensions and position of the slots are calculated using parametric analysis and the dimensions are mentioned in Table 2

Antenna 2: Dual Band notched UWB antenna

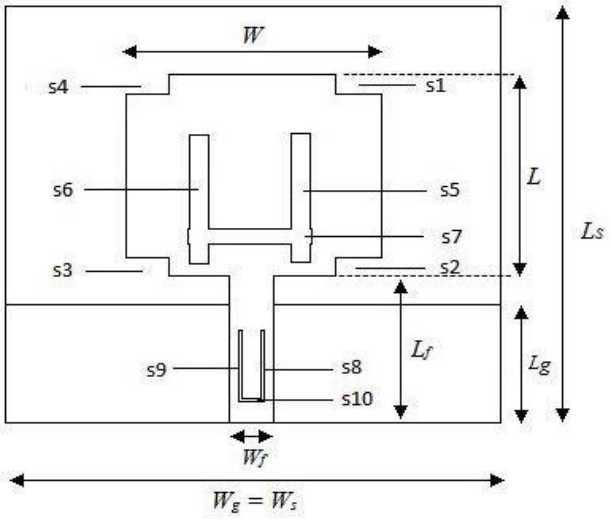


Fig 7.Structure of Antenna 2

Antenna 2 is fabricated and the fabricated antenna front and back view is shown in Fig 8

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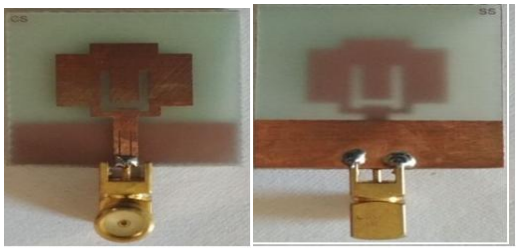

Fig 8. Top and bottom view of fabricated Antenna2.

The slot dimensions are calculated using the formula mentioned in literature [10]

Total length of the slots are calculated using the formula

$$f_{notch} = \frac{c}{2*Lslot*\sqrt{\varepsilon eff}} \quad (1)$$

Where f_{notch} is the notching band frequency.

L_{slot} is the total length of the slot

The dimensions of the slots are shown in Table 2.

By parametric analysis each side length of the slot is calculated and the detail dimensions are calculated and are mentioned in Table 3.

Table 3: Slot dimensions of Antenna2

Slot name(H slot)	Dimensions in mm	Slot Name (U slot)	Dimensions in mm
Dimensions of slot s5	7.77 x1(mm)	Dimensions of slot s8	5 x 0.23(mm)
Dimensions of slot s6	7.77x 1 (mm)	Dimensions of slot s9	5 x 0.23(mm)
Dimensions of slot s7	5.7 x1(mm)	Dimensions of slot s10	0.23 x1.45(mm)
Band notching	5.1-5.8 GHz	Band notching	7.2-8.3 GHz
Application	WLAN	Application	X-band satellite down link

The slot position and its dimensions play a crucial role in achieving wide band.

To avoid interference with the existing X band downlink satellite band U slot is made on the feed line .The dimensions of U slot is given in Table 3 which gives the band notching from 7.1-8.3GHz

H-slot is made on the patch to achieve rejection band from 5.1 – 5.8 GHz frequencies Both U and H slots gives the desired dual band rejection characteristics. The dimensions of U and H slots plays important role in achieving the dual band notched characteristics.

The simulated antenna is fabricated with optimum dimensions and different antenna parameters like VSWR, Return losses are measured using Anritsu MS2028C Vector Network Analyzer. The simulated and measured results are compared and reported in Fig 9-10

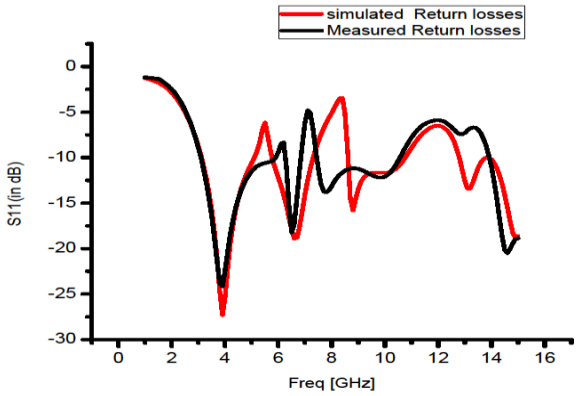

Fig.9 Simulated Vs Measured Return losses VS frequency for Antenna 2

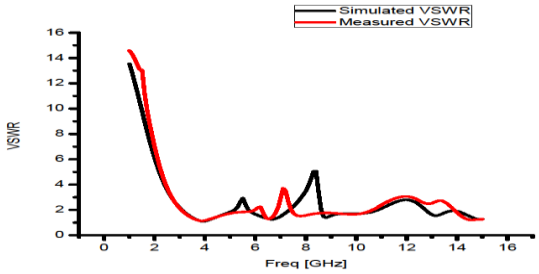

Fig 10.Simulated Vs Measured VSWRVS frequency for Antenna 2

E plane and H plane radiation patterns are measured by simulation at different pass band frequencies namely at 3,5,7,9 are shown in Figs11.

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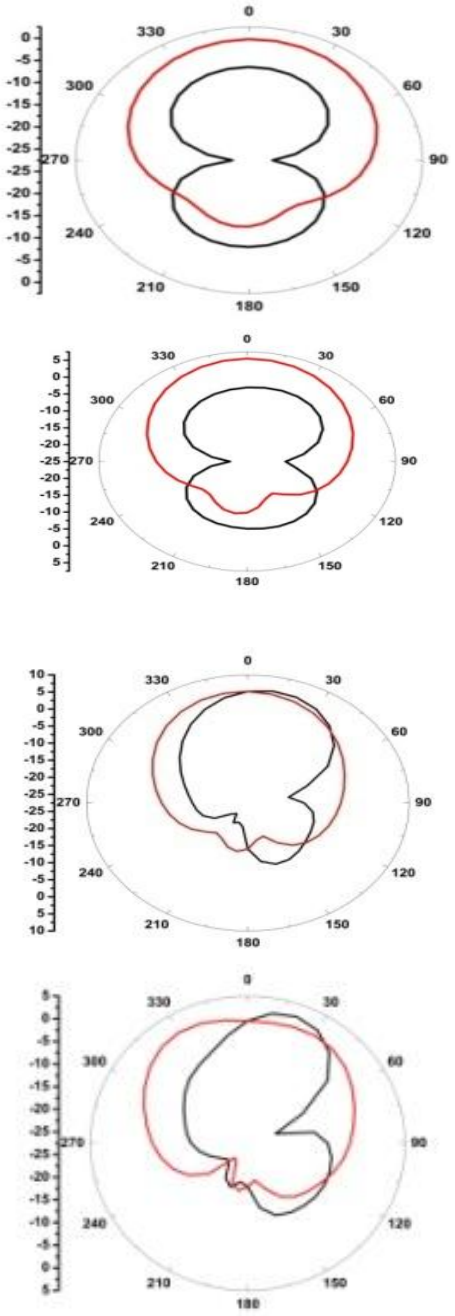

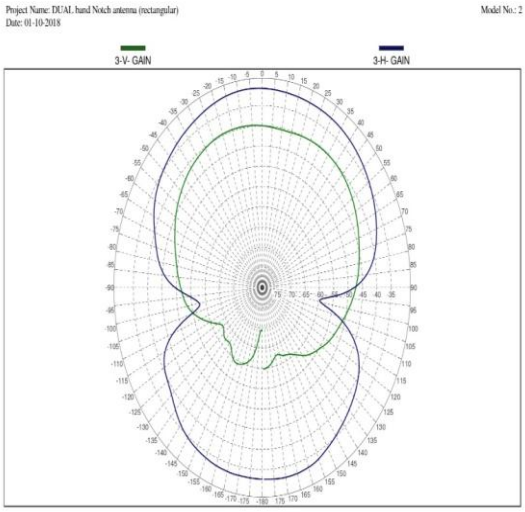

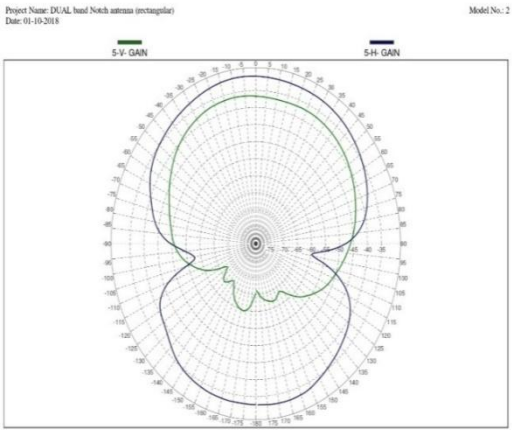

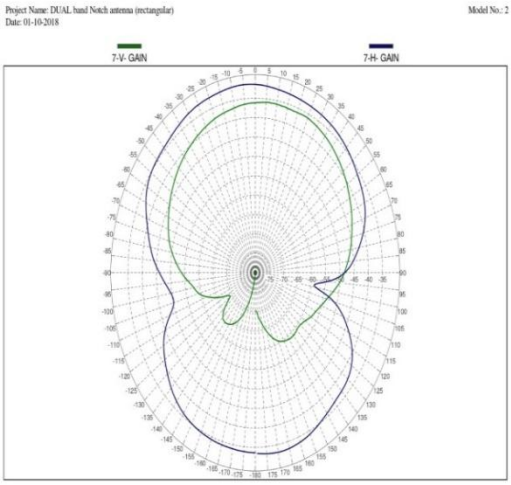

Fig 11 Simulated radiation pattern of antenna 2 at 3,5,7,9 GHz

Radiation patterns are measured in anechoic chamber are shown in Fig 12.The simulated and measured results are in line.

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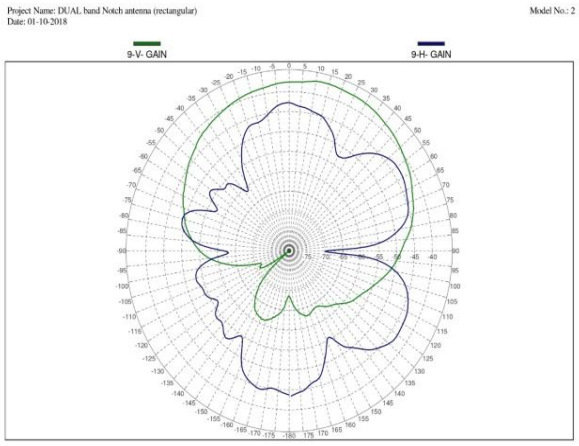

Fig 12.Measured Radiation pattern

III Results and Discussion

Both the antennas are working in the UWB range from 2-11GHz. Antenna 1 is giving bandwidth from 2-11GHz and the VSWR is <2 for the entire frequency band. The radiation patterns of both the antennas at different pass band frequencies are observed by simulation and it is observed that both the antennas are giving good Omni directional radiation pattern in pass band.

Table 4: Comparison of Gains for a dual band notch antenna.

Frequency in GHz	Gain (dB)	
	Simulated	Measured
3	-1.00	-1.31
5	5.35	1.8
7	4.65	-2.81
9	-0.27	5.68

IV .CONCLUSIONS

Dual band notch antenna with compact dimensions is presented. Different antenna performance parameters are measured. Simulated results are in line with the measured results. The presented antenna is compact in size compared to the antennas mentioned in literature [4,10,19,6,9,1].Dual band notched antenna is giving good peak gain compared to other antennas [10,7,16].The antenna is giving good radiation characteristics for entire frequency band . It is giving maximum peak gain of 5.35dB at 5GHz during simulation and while testing maximum gain of 5.68dB at 9GHz but after 9GHz the gain becoming negative and it is also observed that at notching bands the gain is becomes negative. The proposed antenna can be useful for the UWB applications

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