Design of Ultra-Wideband antenna with single notch characteristics

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***Abstract*—This paper presents an ultra-wideband microstrip antenna having dimensions 18x24mm^2 with single band notch characteristics. The designed antenna operates from 3.45GHz to 10.4GHz. The inverted U-shaped slot is created on the patch to achieve the notch (5.10-5.85GHz) which eliminates WLAN signal to avoid interference with the UWB system. The proposed antenna is designed using FR4 epoxy as a substrate with dielectric constant 4.4, the thickness of 0.8mm. This antenna has been designed and simulated with ANSYS HFSS 15. It is suitable for Short Range Devices (SRD) used for wireless indoor application, automotive and railway vehicles, onboard aircraft, and tank level probing radar.**

***Keywords*—Ultra-wideband, U-shaped slot, Single notch.**

I. INTRODUCTION

Ultra-Wideband antenna plays a vital role in short-range communication applications. Allocation of bandwidth ranging from 3.1 to 10.6 GHz done by the Federal Communication Commission (FCC) In February 2002 to be used for short-range communication purposes[1]. In wireless communication, UWB antennas are widely used at short range communications because they can transmit a large amount of data with very low power. Ultra-Wideband frequency range also includes many narrowband spectrums. So, there is a possibility of interactions of narrow bands with Ultra-Wideband (UWB) spectrum.

These narrowband also includes the wireless local area network (WLAN) services (5.15GHz-5.85GHz). These may also create interaction with the UWB system. To avoid those interactions extra band stop filter needs to be used, these will increase the complexity of the system. So, to avoid the complexity of the antenna, it can be designed with notch characteristics.

Different shapes are used as an inverted V slot is used on the rectangular patch to create band notch characteristics [2]. Open stub resonator is integrated into the structure to provide the band-rejection characteristics [3]. In [4] and [5] they have achieved only the UWB spectrum range without any notch characteristics. In [6] inverted U-shaped slot is created on the feed line to achieve the band-notched characteristics at 5.5 GHz. However, the above designs including [7] has larger size of the antenna or return loss (s11) > -40dB or return loss (s11) > -30dB. This paper presents a design of UWB microstrip antenna with inverted U-shaped slot on the radiating patch for single notch characteristics. The proposed antenna covers the range of UWB and also it is capable of rejecting frequencies like WLAN band. This approach has acceptable band notch performance without increasing size and complexity of antenna with return loss -56.59dB at 8.75GHz and -35.5dB at 4.15GHz.

II. DESIGN SPECIFICATION

The following steps are used to design the antenna. UWB antenna with single notch characteristics is designed using a modified rectangular patch with U-shaped slot. FR4 epoxy material having a permeability of 4.4 is used as a substrate. The substrate has a thickness of 0.8mm. A microstrip line feed of dimension 10mm x 1.5mm is provided. The design flow diagram is given below (Fig. 1).

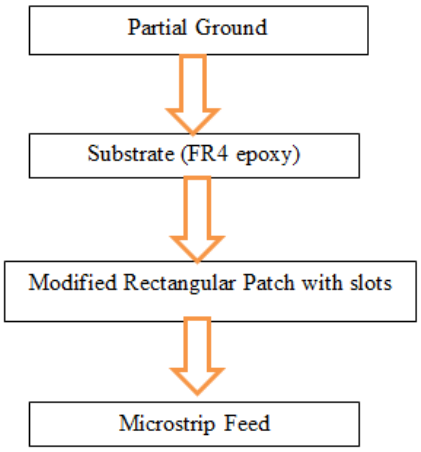

Fig.1 Design Flow Diagram

Calculating the length and width of the patch by using the formula given below.

Resonant Frequency = 5GHz

Substrate material: FR4 epoxy

$\varepsilon_r = 4.4$

Height of the substrate:

h = 0.8 mm

Width of the Patch:

$$W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon r+1}}$$

W = 18.25 mm

Effective Dielectric Constant:

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\frac{\varepsilon r-1}{2}}{\sqrt{\left(1+\frac{10h}{W}\right)}}$$

$$\varepsilon reff = 4.12$$

Effective Length:

$$Leff = \frac{c}{2f\sqrt{\varepsilon reff}}$$

Leff = 14.78 mm

$$\Delta L = \frac{h}{\sqrt{\varepsilon reff}}$$

$$\Delta L = 0.39\ mm$$

Length of the Patch:

L = Leff - ΔL

L = 14 mm

This antenna consists of four stages which are illustrated as follows (Fig 2). The figure shows the patch structure in all four stages.

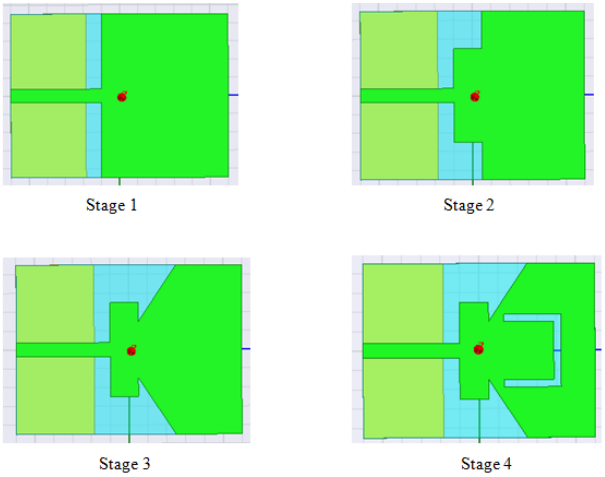

Fig.2 Different stages of antenna

Stage 1: In this stage the patch is created on the substrate with the calculated length and width using the formula. And the partial ground is used to enhance the Band width.

Stage 2 and 3: These two steps are also used to increase the bandwidth.

Stage 4: The last stage is to create the inverted U-shaped slot to notch the frequency band from 5.15GHz to 5.85GHz.

The geometry and design parameters of the proposed antenna are shown in figure 3 and table 1.

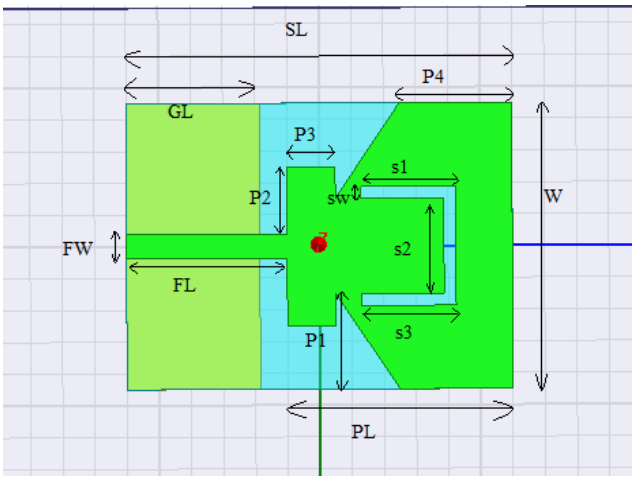

Fig.3 Geometry of Proposed antenna

Substrate material	FR4 epoxy
Thickness	0.8mm
W	18mm
Patch Length, PL	14mm
Substrate Length, SL	24mm
Ground Length, GL	8.3mm
Feed Length, FL	10mm
Feed Width, FW	1.5mm
s1	5.9mm
s2	6mm
s3	5.9mm
Sw	0.75mm
P1	6mm
P2	4.25mm
P3	3mm
P4	7mm

Table 1 Design Parameters

III. Simulation Results And Discussion

The UWB with single notch characteristics antenna is designed using ANSYS HFSS. The proposed antenna has a small size of 18×24mm^2 and operates over the frequency band between 3.45-10.4 GHz and the antenna resonates in the frequencies 4.15GHz & 8.75GHZ with return loss -35.5dB & -56.5dB. The design flow for the presented antenna contains partial ground, substrate, modified Patch with slots and microstrip feed.

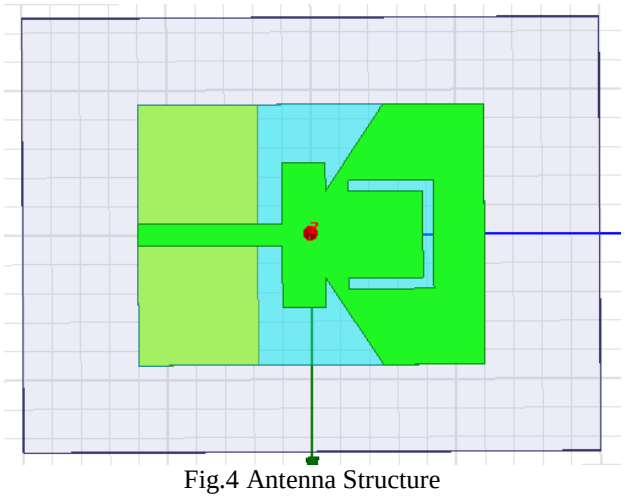

Fig.4 Antenna Structure

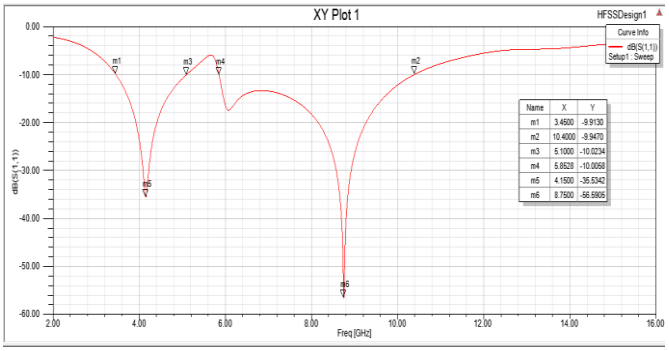

Fig.5 Return Loss Plot

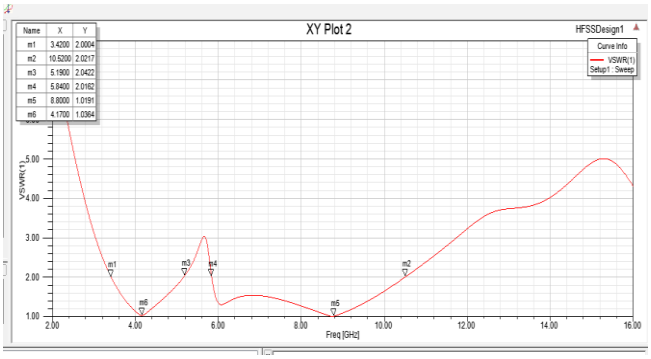

Fig.6 VSWR Plot

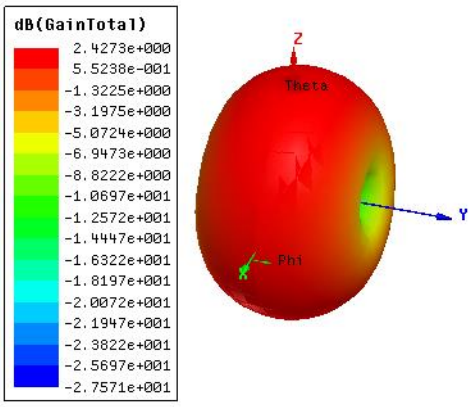

Fig.7 Gain (3DPolar Plot)

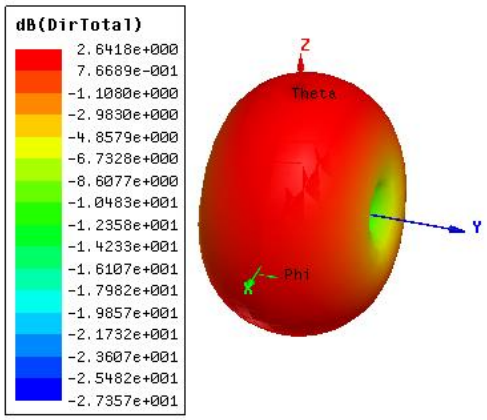

Fig.8 Directivity (3D Polar Plot)

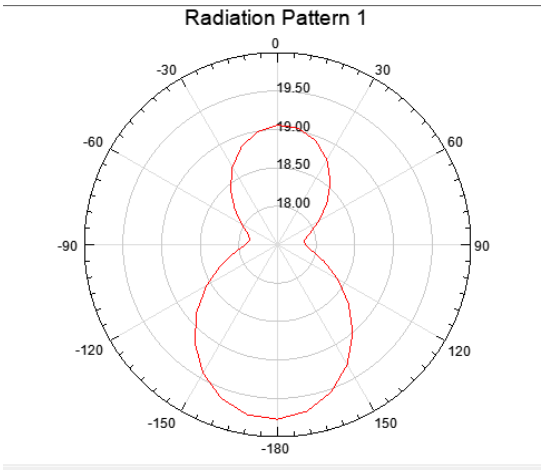

Fig.9 Radiation Pattern (2D)

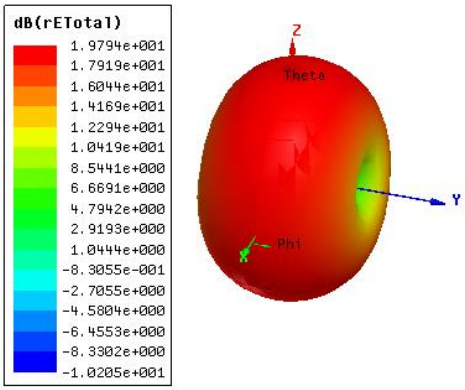

Fig.10 Radiation Pattern (3D)

The return loss, VSWR, gain and directivity of the fourth stage antenna are shown in figures from 5 to 10. Efficiency of an antenna is defined as the ratio of gain and directivity.

$$\text{Efficiency} = \frac{\text{Gain}}{\text{Directivity}} = 2.4273 / 2.6418 = 91.88\%$$

The table 2 shows that comparison of size, notch frequency band and return loss of prosed work with some reference papers.

Parameters	**Proposed work**	**Ref[3]**	**Ref[2]**	**Ref[6]**
Size	18mm x 24mm	30mm x 40mm	18mm x 24mm	32mm x 26mm
Notch fequency band	5.15GHz – 5.85GHz	5GHz – 7GHz	5.3GHz – 5.7GHz	5GHz – 6GHz
Return loss	-56.59dB at 8.75GHz and -35.5dB at 4.15GHz	-25dB at 3GHz and -35dB at 9GHz	-38dB at 4.3GHz and greater then -20dB in next band (6GHz - 12GHz)	-30dB at 3GHz and -25dB at 9GHz

Table 2

IV. Conclusion

This paper presents a kind of ultra-wideband microstrip antenna with single-band notch by creating an inverted U-shaped slot in a radiating patch. One rejection band is achieved of 5.10GHz~5.85GHz with the voltage standing wave ratio (VSWR) more than 2. This approach has acceptable band notch performance without increasing size and complexity of an antenna with return loss is -56.59dB at 8.75GHz and -35.5dB at 4.15GHz. Simulation results show that the proposed antenna will be using for single-band notched applications.

V. Future Scope

For Short Range Devices UWB antenna with small size is required. Ultra-Wideband cause interference with coexisting systems like WLAN (Wireless local area network) having an operating range of 8.15GHz - 8.85GHz. UWB antenna with single band notch can be an objective for future work. It is suitable for Short Range Devices (SRD) used for wireless indoor application, automotive and railway vehicles, onboard aircraft, and tank level probing radar [8].

References

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