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DESIGN AND FABRICATION OF ULTRA WIDE-BAND ANTENNA WITH BAND NOTCHING PROPERTY

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Abstract: *In this paper, a microstrip feed line antenna with defected ground plane for ultra-wide band (UWB) application is presented. Insertion of defected ground plane just beneath the radiating patch, results in UWB characteristics. A big challenge in the design of a UWB antenna is to avoid the interference from narrow band systems like WLAN operating in the environment so that UWB technology can be operated in parallel with other existing systems. To solve this problem the UWB antennas one should have band notching properties for the minimization of the interference from other active environment. DGS affects the current distribution and hence antenna performance parameters, therefore in order to achieve band notching at WLAN frequency, a patch antenna with defected ground structure just beneath the radiating patch is designed using HFSS 13. In this proposed thesis we have designed "U", "W" and "B" shaped slots whose length and width are varied with reference to DGS to achieve the desired UWB band notch characteristics. Return loss of -25 dB is achieved and smooth VSWR below 2 is achieved throughout the band from 3.1 to 10.6 GHz except for band notch region. Gain of 1 dB to 5 dB over is reported for complete Ultra Wide Band except for WLAN region which is notched. Antenna is fabricated with Roger 4003 material having dielectric constant 3.55 thickness1.524. The thesis contain the simulated results of designed antenna which has overall size of $2x2cm^2$ and can be used in UWB technology as antenna achieve good result.*

1. INTRODUCTION

On February 14, 2002 Federal Communication Commission (FCC) authorized the unlicensed use of spectrum from 3.1 to 10.6 GHz popularly known as UWB technology and opens it for commercial applications for short range indoor and outdoor wireless communication [1].The UWB antenna is an important component of UWB communication system and has drawn growing attention [2-4].The practical UWB antenna should have good impedance bandwidth(BW) matching, stable gain, omni-directional radiation pattern, linear phase and compact size. In the literature, many methods have been reported to increase the impedance bandwidth of the antenna. Some methods are variation in patch geometry such as rectangular, circular, octagonal [5-7] from simple to complex; feed structure such as double feed, trident feed, meandering feed [8-10] and ground structure such as tapered CPW ground, notched ground, saw tooth ground[11-13]etc.

UWB in principle do not interfere with other spectrum applications like WLAN, WiMax because of low signal transmission level. There is a probability that UWB user in WLAN, WiMax environment may be affected with high signal transmission level of WLAN/WiMax [14]. Use of filters to notch the particular bands has been reported to avoid the signal interference. However, the use of filters increases the complexity and insertion loss along with weight and size of UWB system [15]. Therefore, there is immense need to design and implement an antenna which transmits the UWB signal at desired performance standards and without receiving the WLAN/WiMax system in the environment. DGS is one of the best and popular method to notch a particular band without degrading the antenna performance. DGS increases the current path (electrical length) of the microstrip line which results in the increase in series inductance [16-17]. This series inductance and parallel capacitance is equivalent to LC resonator which provides an attenuation pole at a resonant frequency. Therefore, the band rejection at a specific frequency can be realized by etching a DGS under the antenna structure. A lot of work has been reported by researcher to notch the interfering band using DGS technique.

WLAN and DSRC band notched characteristics has been achieved by etching a partial annular slot on radiating patch [15]. The band notching for WiMax and C-band satellite communication using DGS has been reported in [18].T-shaped slots on the trapezoidal radiating patches for band notching has been reported in [19]. Three bands have been notched at the cost of larger areas by etching U- shaped DGS and arc-shaped slots to radiating patch [20]. Dual band has been notched on circular monopole antenna with arc-shaped parasitic strips on one side and slotted aperture on other side in [21] and by etching rectangular slot and T-shaped stubs on the chamfered ground plane in [22]. Quad band-notched antenna has been reported in [23] by etching 4 U-shaped slots in radiating patch and multiple band has been notched by adding multiple slits in[24].

Here, in this paper, DGS underneath the patch has been proposed to realize a UWB antenna with band notching from 5 to 7 GHz to overcome the problem of unwanted interference from existing WLAN environment. Simulated results for this proposed antenna are discussed in this paper.

2. ANTENNA STRUCTURE AND DESIGN

The proposed antenna was designed on Roger 4003 substrate with dielectric constant and thickness of 3.55 and 1.42 mm respectively. The size of UWB antenna is reduced to 20x20 mm^2.
The truncated ground structure is made beneath the radiating patch to improve the return loss characteristics and to cover the frequency band of range 3.1 to 10.6GHz.

2.1 Optimization in designed antenna

To investigate the impact on the proposed antenna by different parts i.e. the microstrip feed, U,W,B slots in patch and DGS shape; a systematic optimization approach using parametric analysis has been described below.

Antenna with U,W Slot in Patch

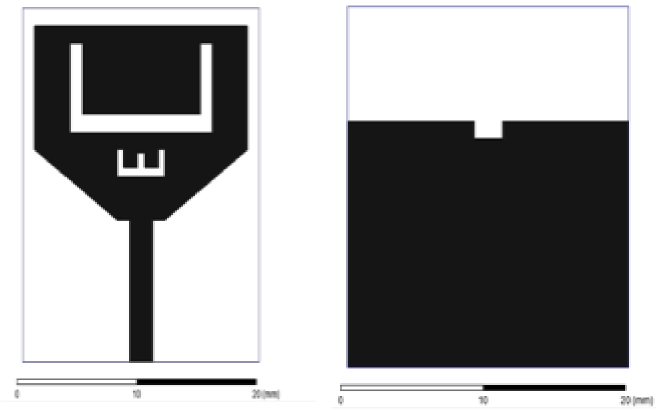


Fig-1 A) TOP VIEW B) BOTTOM VIEW

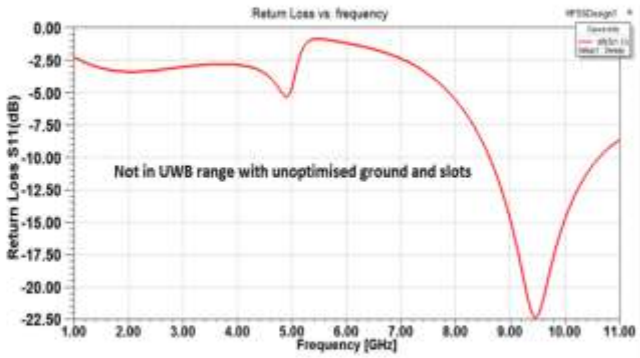


Fig1-(c) Variation of return loss with frequency for U,W Slot in patch.

Figure 1 shows the top and bottom view of the un- optimized antenna. In this case antenna has return loss of -22 dB and antenna is not in UWB range as shown in Figure 2(a). This antenna does not show the UWB characteristics and band notched is not in desired WLAN range. To achieve UWB characteristics and band notching in WLAN band optimization is carried out. Figure 2(a) the un-optimized antenna with W & B slot in patch with their result.

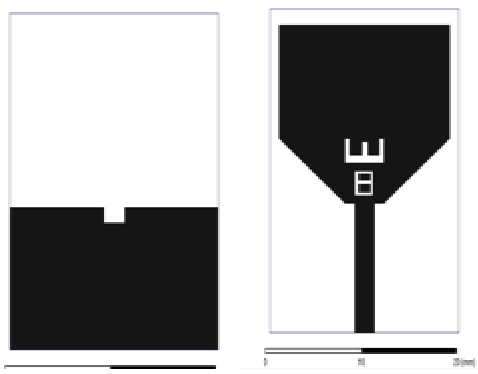


Fig 2 a) Bottom View b) Top View

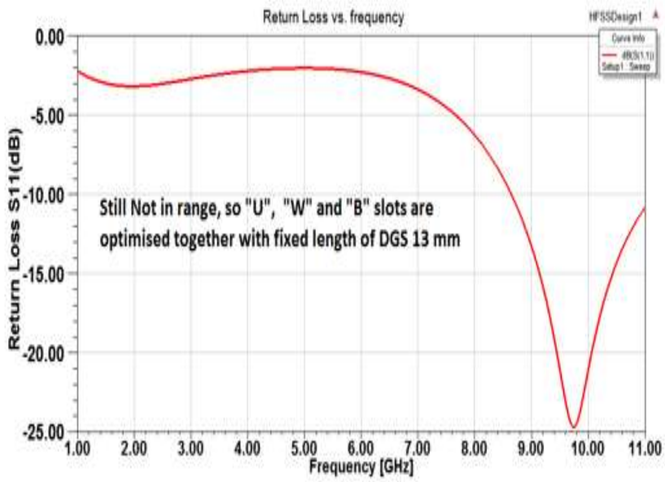


Fig 2-c) Return Loss Vs Frequency of W,B patch Antenna

Still, the antenna not in UWB range.
Further, U,W & B slots are design in patch to achieve result in UWB range with band notch. Figure 3 shows the antenna with UWB slot in patch with DGS ground. This time result is achieved in UWB range and band notch from 5-7 GHz.

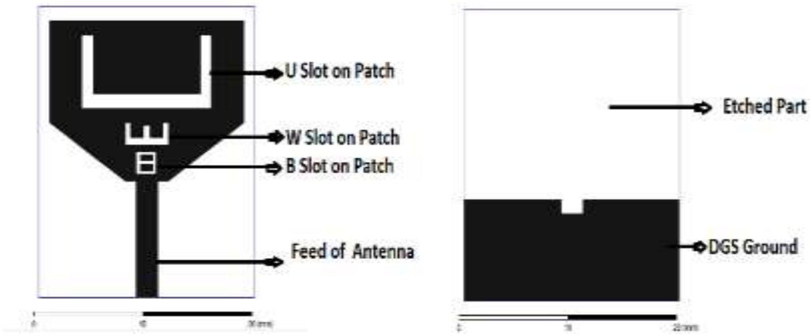


Fig.-3 Optimized UWB Antenna with U,W & B slot

2.2 Current distribution

The current distributions on patch and ground (with and without distribution) are shown in Figure 4, where the currents are mainly concentrated on the edges of patch and DGS.

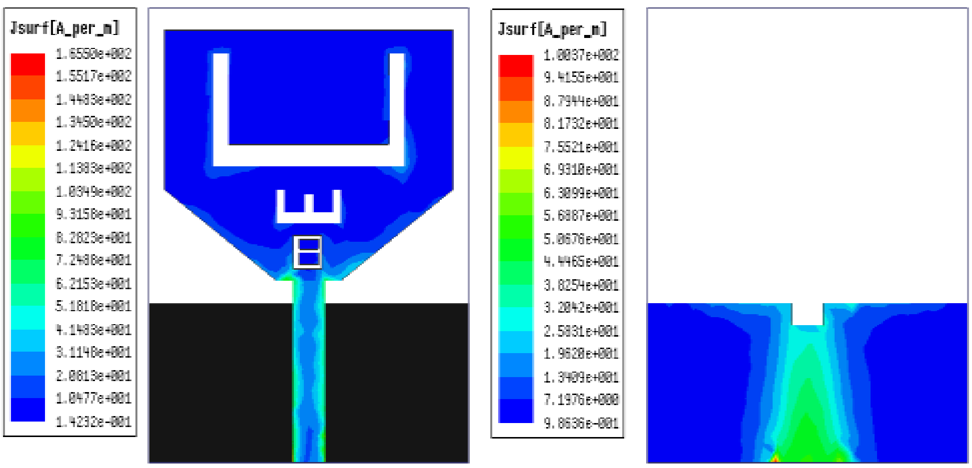


Fig-4 Current distribution on a) patch (b) Ground

DGS in the ground plane increases the current path which in turn increases the electrical length of the microstrip line resulting in increase of the series inductance. Due to DGS section increases and reactance of parallel capacitance decreases. The parallel capacitance with series inductance resonates at a frequency equivalent to LC resonator and provides an attenuation pole. So, due to this UWB characteristics can be easily achieved using DSG.

2.3 Equivalent model of designed UWB antenna

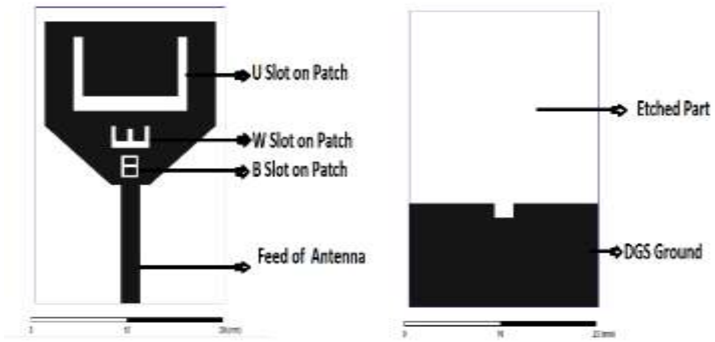


Fig-5 Optimized UWB Antenna

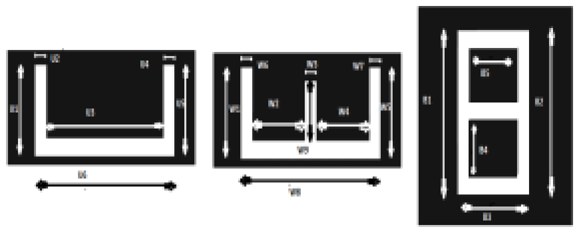


Fig-6 Dimensions of UWB Slots

Table 1 shows the dimensions of proposed UWB antenna.

Dimensions of Proposed UWB Antenna				
Dimensions for patch			Dimensions for Ground	
U Slot	W Slot	B Slot	L1=7mm	W1=20mm
U1=5	W1=1.5 W7=0.5	B1=1.5	L2=20mm	W2=2mm
U2=1	W2=1 W8=4	B2=1.5	L3=1mm	
U3=10	W3=0.5 W9=3	B3=1.8		
U4=1	W4=1	B4=0.4		
U5=5	W5=1.5	B5=1.2		
U6=12	W6=0.5	Feed=8mm		

Table-1 Dimension of Proposed UWB antenna

Effect of different DGS length is shown in figure 7.

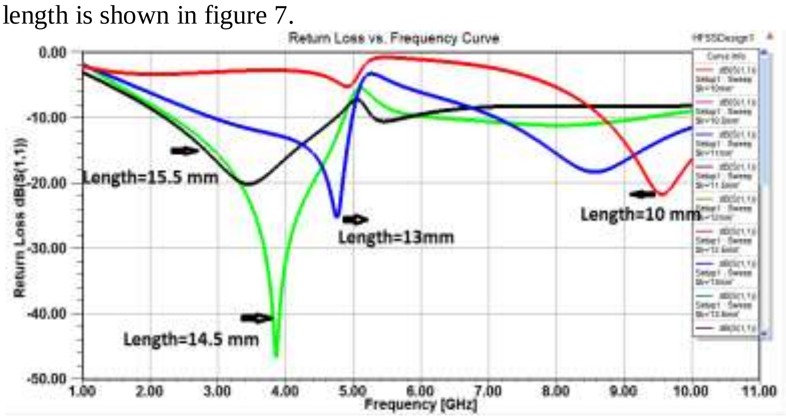


Fig-7 Effect of Different DGS Length on UWB characteristics

In this paper, the desired result is achieved by varying the length of DGS plane. This shown in figure7.Effect of different length is also shown in table 2.

Parametric Analysis on dimensions of DGS			
Length	Band notch range	Freq. Range	UWB range
10mm	Not in range	Not in range	Not
12mm	3.6-6.1 GHz	3.08-11.89 GHz	In uwb range
13mm	5-7 GHz	3.07-10.6 GHz	In UWB ,WLAN notch range
14.5mm	5-6.7 GHz	3.07-9 GHz	Notch not in range
15.5	4.3-6 GHz	3.1-5 GHz	UWB not in range

3. RESULT ANDDISCUSSION

The various antenna parameters such as return loss, VSWR, gain, radiation pattern, and 3D - polar plot have been simulated.The detailed optimized results of all parametric analysis at different lengths are given in table 2. Figure 6 shows the geometry and dimensions of as designed UWB antenna.

In the literature, return loss of -18dB by varying patch geometry has been reported [19, 20]. The return loss of -14 dB with band notching from 4.98 to 5.57 GHz using slotted DGS [21], by embedding open circuit stub and U- shaped patch in [22] band notch from 5.3 to 5.9 GHz has been reported. It is observed that the present design results good antenna parameters with band notch for WLAN environment. The improvement in the wide band characteristics have been noticed by introducing defected ground structure as shown in Figure 8. In this case antenna is made to return loss of -25 dB has been obtained except for the band notch for WLAN environment.

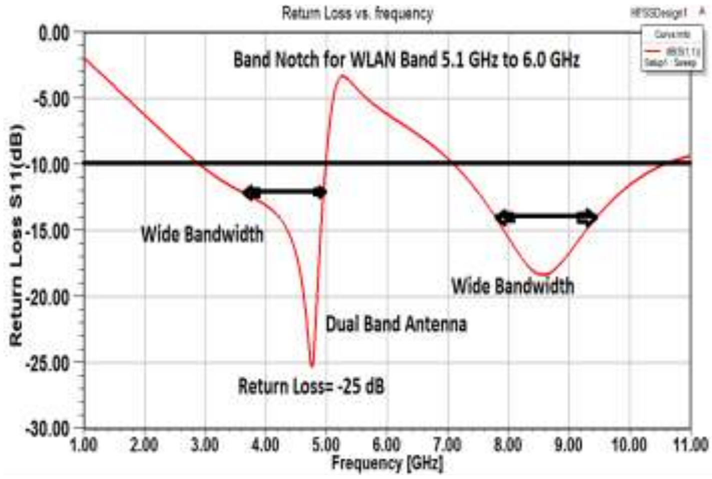


Figure 8. Plot of return loss against frequency, showing band notch.

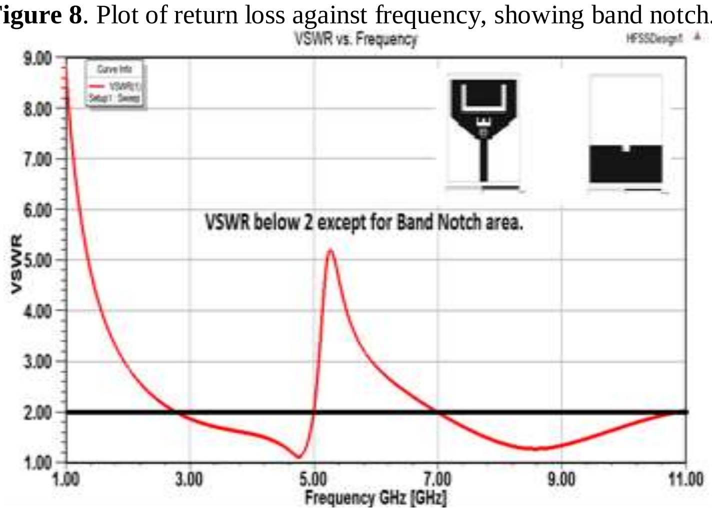


Fig-9 VSWR vs Frequency of Proposed Antenna

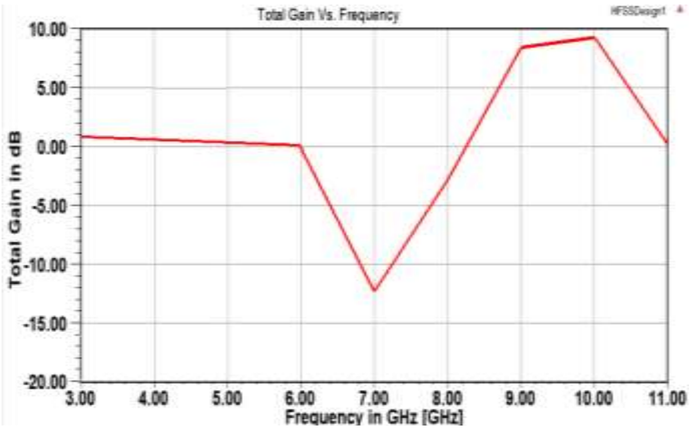
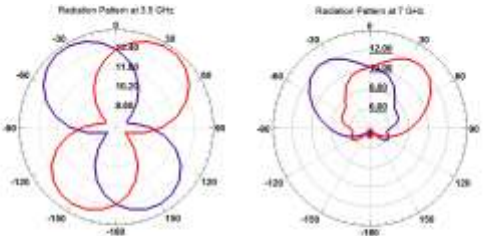


Fig-10 Gain of Proposed Antenna

VSWR is less than 2 in range from 3.1 to 10.6 GHz as shown in figure 9.which indicates an excellent matching between the antenna and feed network except for band notch from 5 to 7 GHz.

a) At3.2GHz b) At 5 GHz



c) At7 GHz d) At 10GHz

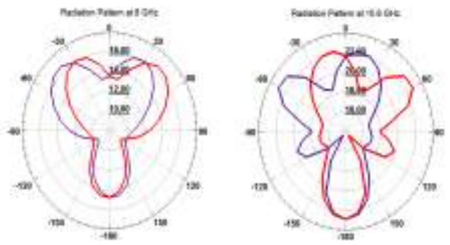
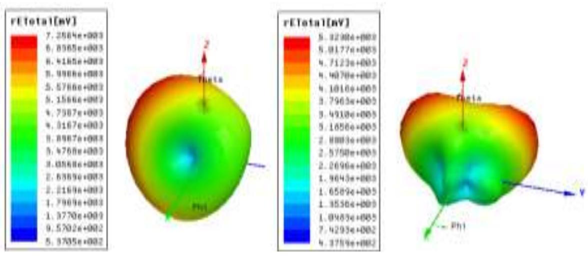
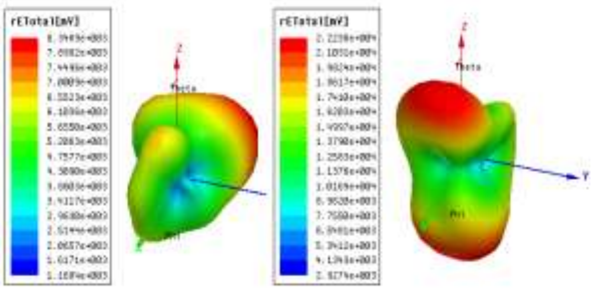


Fig-10 Comparison of radiation patterns



a) 3.2GHz b) 5GHz



a) 7GHz b) 10GHz

Figure 11. 3D Polar plot of UWB antenna at (a) 3.2 GHz (b) 5.0 GHz (c) 7 GHz and (d) 10 GHz.

Conclusion from radiation pattern and polar plot shown in table 3.

Conclusion from radiation pattern & polar plot		
S,no	Freq(GHz)	Efficiency
1	3.5	15.40 db
2	5-7	10.00 db
3	8.5	14.00 db
4	10.6	22.00 db

Comparison of radiation efficiency vs. frequency table 3 is also plotted to conclude that radiation efficiency is maximum at resonant frequency of antenna i.e. 3.1 to 10.6 GHz.

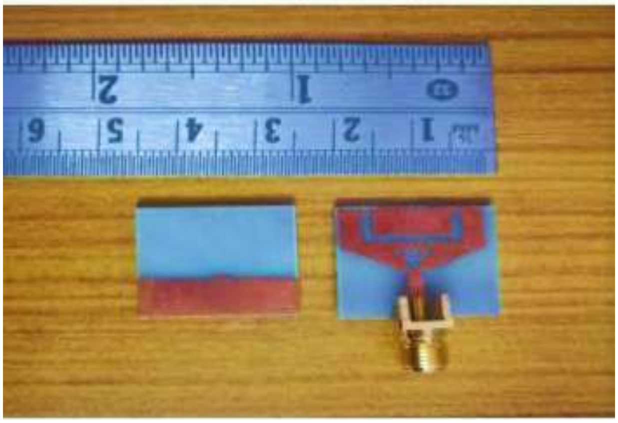


Figure 12 shows the practical design of UWB antenna connected with SMA connectors.

4. CONCLUSION

Today researcher's interest in the area of UWB technology has been increased due to many advantages such as high data rate, highly secure and immune towards multipath communication. In this paper, a microstrip feed antenna with defected ground plane for UWB application is presented. UWB characteristic has been observed by making slot in the patch.

Result, also shows band notching property from 5 to 7 GHz therefore, the proposed antenna overcomes the signal interference problem with existing WLAN. An equivalent circuit is modeled [22-23] to verify the band notching and return loss of antenna. The simulation of radiation characteristics of the designed antenna are in good agreement with each other, and therefore can be suitably used for UWB application in WLAN environments.

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