DESIGN OF ULTRAWIDEBAND PRINTED ARRAY ANTENNA WITH MULTIPLE NOTCH BAND CHARACTERISTICS

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***Abstract*—*The printed rectangular patch antenna with T-shaped slot and corner truncation with a defective ground structure yields Ultra Wideband response from 3 GHz to over 12 GHz. Placing a stub in the T-slot gives rise to a notch band or rejection band, By further truncating the stub, a dual notch band is achieved. Then the performance of the antenna is analysed by making a 1×4 planar array and quad notch bands are achieved. Various antenna parameters like returns loss, Gain, Directivity and Radiation pattern and found them to be satisfactory for the Ultra Wide Band Applications.*

Keywords—Notchband; Stub; Truncationgap; Array

1. INTRODUCTION

Ultra Wideband (UWB) Antenna design has gained prominence over the recent years with the Federal Communication Commission allocating an unlicensed 7.5GHz band for commercial communication applications [1]. The band ranges from 3.1-10.6 GHz. Usually, the UWB devices operate at very low power [2]. There are many narrowband wireless systems which also operate within the UWB range, but with high operating power. These pose the problem of interference to the UWB antenna.

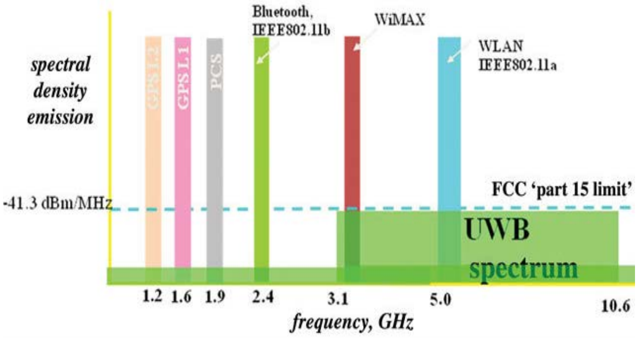


Fig.1:Coexistence of various wireless systems with UWB band

The UWB from 3.1 to 10.6 GHz, assigned by the FCC for unlicensed use, overlaps with the WLAN frequency band from 5.15 to 5.85 GHz; thus, the UWB system and WLAN systems could interfere with each other. One of the possible solutions to this problem is to design the UWB antenna with band notched characteristic [9]–[11]. In [12]–[16], MIMO antennas with notched characteristics were studied to suppress interference from the WLAN systems. The UWB MIMO antenna in [12] was designed on a flexible film. Two heptagonal monopole elements were orthogonally and symmetrically placed on the substrate for good isolation between the two input ports. A slot was cut on each of the antenna elements to create a notch in the WLAN band. However, the two monopole elements did not have a common ground plane, making the MIMO antenna difficult to use in practice. The MIMO antenna in [13]employed two-folded monopole elements, each coupled with a parasitic inverted-L element, to achieve UWB operation. Two meander lines, a connection line and a short parasitic line, were used to enhance isolation between the two input ports. The band notched characteristic was created using an open stub on the radiator. The antenna structure was a little complicated and required high fabrication accuracy. In [15] and [16], slot antennas were designed for UWB MIMO applications with a strip to ensure high isolation. The slots were etched on the feeding structure to create a band notch. However, this kind of structure had a relatively large size. In [14], a dual band notch was designed for an UWB MIMO antenna using parasitic strips and slots on the radiator.

In this paper, rectangular patch with a stub in the T-shaped slot is presented to achieve band rejection. The stub position, width and length play a major role in achieving the notch band [4]. Some applications require multiple notch bands within the UWB range to avoid interference from various high power wireless systems [5]. For this purpose, a truncation is introduced in the stub, i.e. the stub is cut. The design and performance of the 1×4 planar antenna array are presented in the further sections in which we have quad notch bands.

2. ANTENNA DESIGN

The proposed UWB antenna with dual notch band is shown in figure 2. Rogers RO4003 is used as substrate, which has a relative permittivity of 3.55. The rectangular patch is tapered at the bottom. A slit is placed on the partial ground plane with exactly the same width as the feed line to achieve good matching and the tapered partial ground is one of the good technique for achieving the Ultra Wideband. To increase the current path length the regular rectangular patch antenna has been truncated on the feed side. The T-shaped slot aids in increasing the compactness also this is also because of the increase in the current path length. A stub inserted in the T-shaped slot acts as a band stop filter [6][7] to create a rejection band within the Ultra Wideband. Without truncation of stub, single notch band is attained. The position of the stub and the width of the stub play a major role in attaining the rejection band. And to attain dual notch bands the stub is divided into two parts by truncating it at the center and this gives a dual notch band response. The level of truncation in the stub plays a major role in attaining the dual notch band. In spite of many techniques like introducing multiple slots in the patch and in the ground plane, using electromagnetic band gap structures, using frequency selective surfaces, using split ring resonators for achieving the Ultra Wideband in the micro strip printed antennas here we used only a single slot and a tapered partial ground to achieve the Ultra Wideband and a stub with a truncation in the middle to achieve a dual rejection band which is more effective and simple to construct.

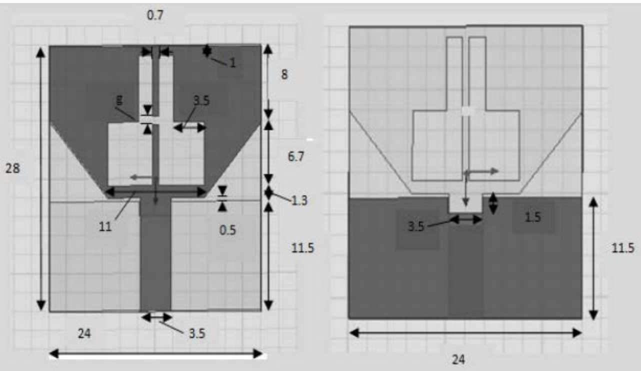


Fig. 2: Proposed design: Top view and bottom view

3. SOFTWARE USED

For simulation of the above designs, High Frequency Structure Simulator (HFSS) version 13.0 is used. The return loss curves provide the resonant and notch bands, higher return loss value at the notch band is the measure of strength of rejection higher the return loss value implies high rejection at that frequency. Apart from these, other parameters like radiation pattern, directivity and gain can be observed for evaluating the performance of the antenna.

4. RESULTS AND DISCUSSION

At first the single element of the Ultrawideband Printed Array Antenna with Multiple Notch Band Characteristics has been simulated and the antenna parameters like return loss, Gain and Directivity are measured. Then to check the performance of the proposed antenna for the high gain applications the simulations were carried out on the 1×4 planar antenna array and the antenna parameters like return loss, Gain and Directivity are measured.

The antenna simulated in HFSS is as follows. Figure 3(a) is the structure of the patch with T-slot and edge truncations with a stub truncated in the middle and 3(b) is the partial tapered ground plane.

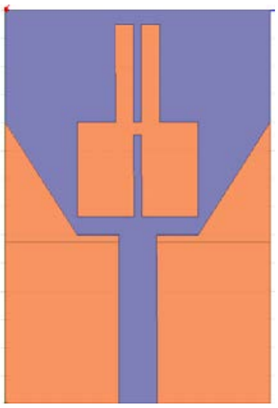


Fig: 3(a). Patch simulated in HFSS

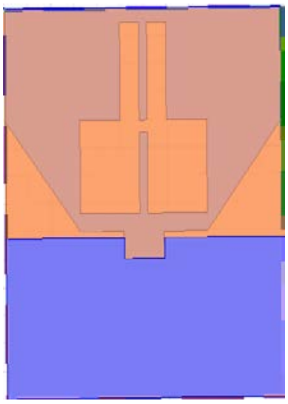


Fig: 3(b). Ground plane simulated in HFSS

The return loss curve obtained for the antenna shown in figure (3) is shown below. The first notch band ranges from 4.27-5.72 GHz and the second notch band ranges form 6.43-7.22 GHz.

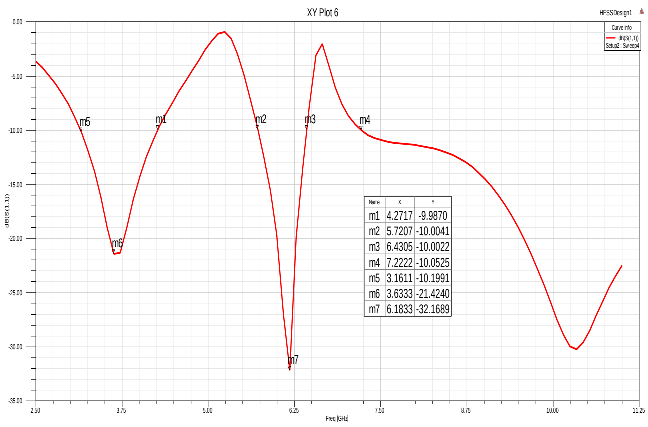


Fig4: Return loss curve with dual notch band

The Gain and Directivity obtained for the antenna at two intermediate frequencies of 3.63 GHz and 6.18 GHz are shown in figure 5 below. Achieved a gain and directivity of 4.78 dB and 4.22 dB at 3.63 GHz and a gain and directivity of 4.18 dB and 4.24 dB at 6.18 GHz respectively.

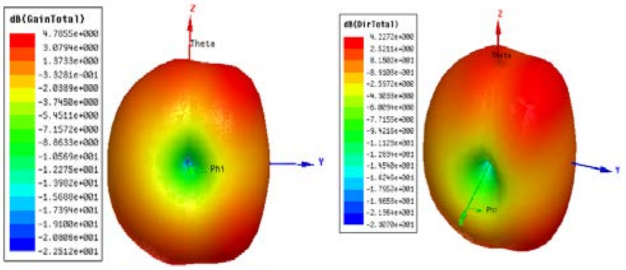


Fig.5(a): Gain and Directivity at 3.63 GHz

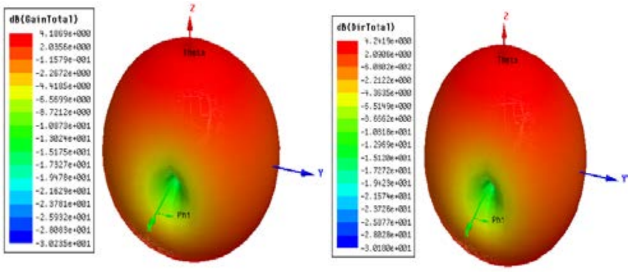
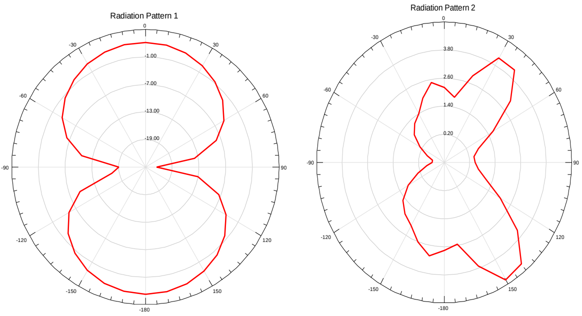


Fig.5(b): Gain and Directivity at 6.18 GHz

The E-plane and H-plane obtained for the antenna shown in figure (3) at two intermediate frequencies of 3.63 GHz and 6.18 GHz are as shown below. It can be observed that at both the intermediate frequencies Omni directional radiation pattern is observed which is very needed for the Ultra Wideband applications.

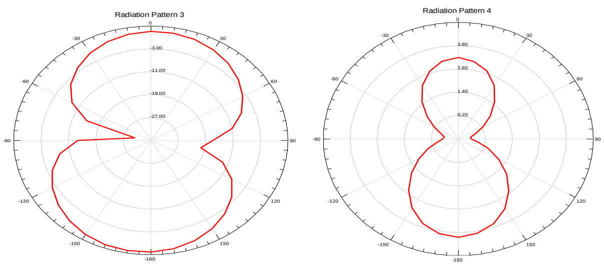
At 3.63 GHz:



E-Plane H-Plane

Fig.6(a): E-planer and H-plane patterns at 3.63 GHz

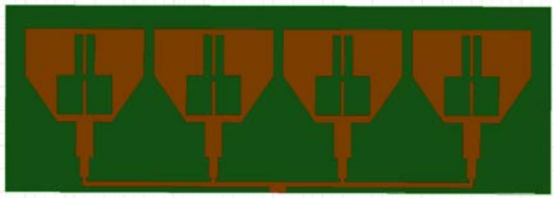
At 6.18 GHz:



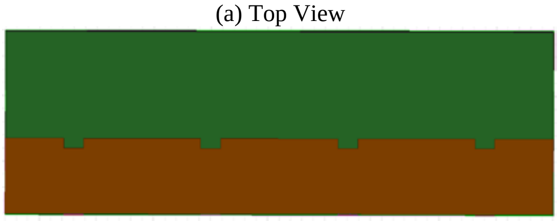
E-Plane H-Plane

Fig.6 (b): E-planer and H-plane patterns at 6.18 GHz

When there is a application which require a high gain and directivity with a narrow beam width we need to have an array, figure 7 below shows the1×4 planar antenna array.



(a) Top View



(b) Bottom View

Fig.7:1×4 planar antenna array

The return loss curve obtained for the antenna array shown in figure (7) is shown below. The first notch band ranges from 5.12-5.56 GHz, the second notch band ranges form 5.99-6.40 GHz, the third notch band ranges from 6.84-8.67 GHz and the fourth notch band varies from 9.26-9.80 GHz.

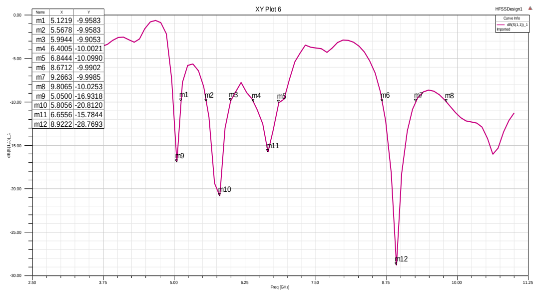


Fig. 8. Return loss curve with dual notch band

The Gain and Directivity obtained for the antenna at two intermediate frequencies of 5.80 GHz and 8.92 GHz are shown in figure (9) below. Achieved a gain and directivity of 9.50dB and 9.56dB at 5.80 GHz and a gain and directivity of 9.52dB and 9.41dB at 8.92 GHz respectively. From the results obtained we can clearly say that the gain and directivity of the array antenna is much more higher compared to the single antenna element and is best suited for the array applications. Observed a beam width reduction at both the frequencies.

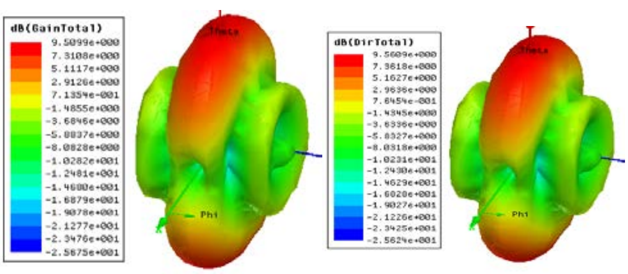


Fig.9(a):Gain and Directivity at 5.80 GHz

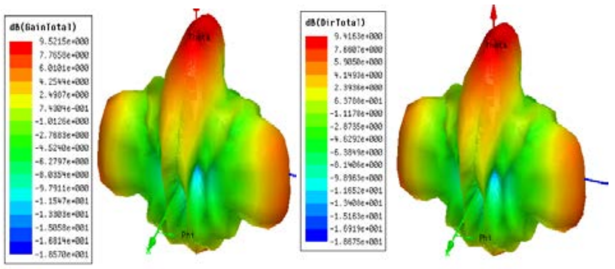


Fig.9(b):Gain and Directivity at 8.92 GHz

The E-plane and H-plane obtained for the antenna shown in figure (3) at two intermediate frequencies of 5.80 GHz and 8.92 GHz are as shown below. It can be observed that at both the intermediate frequencies omni directional radiation pattern is observed which is very needed for the Ultra Wideband applications.

At 5.80 GHz:

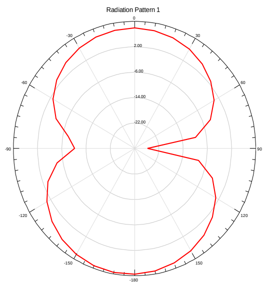


Fig.10(a): E-plane and H-plane patterns at 5.80 GHz

At 8.92 GHz:

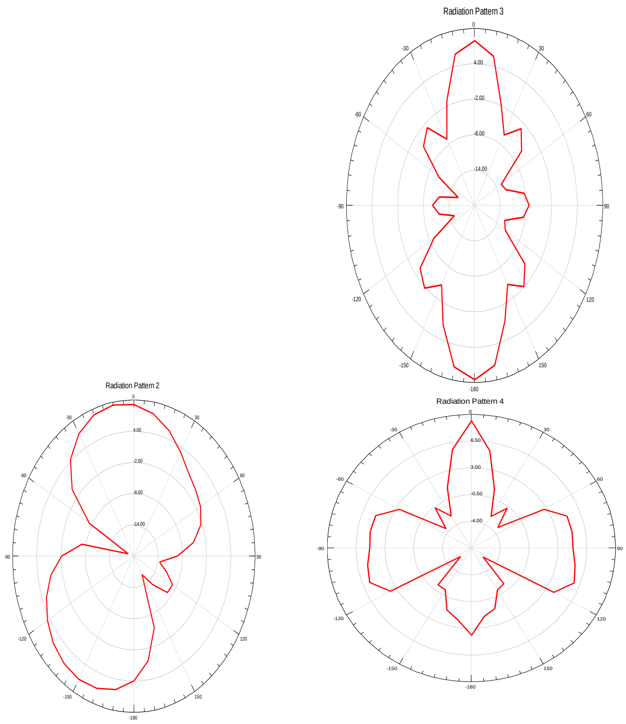


Fig.10(b): E-plane and H-plane patterns at 8.92 GHz

5. Conclusion

The occurrence of two notch bands within the Ultra Wideband is observed for the designed patch antenna with truncated stub. And quad notch bands are observed in the antenna array. Depending upon the application we can select a single antenna or an antenna array. Thus, this antenna helps to eliminate the interference caused due to other high power wireless systems.

6. ACKNOWLEDGMENT

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