

# A Planar Microstrip Patch Antenna Design for UWB Applications with Band Notched Characteristics

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**Abstract**— A rectangular planar Ultra-wide band antenna with dual band notched characteristics is proposed using two rectangular slots and one T-shaped slot on radiating patch. The proposed structure uses one T-shaped slot between two identical rectangular slots with stepped corners on the radiating microstrip patch antenna. Microstrip fed line is utilized along with partial ground plane in this design. This antenna operates in frequency ranging from 2.99 to 11.76 GHz with dual band notching ranging from 3.33 to 3.84 GHz and 5.21 to 7.28 GHz respectively. The VSWR is below 2 for entire said frequency range except for the two band rejections. The bandwidth of the proposed structure is nearly 6.187 GHz. This antenna may be utilized for applications in upper S band, C band, X band, ITU uplink satellite communication band (8.1-8.4 GHz) while rejecting 5.2/5.8 GHz WLAN, 3.5/5.5 GHz WiMAX, RFID (6.6 to 7.1 GHz) and whole U-NII (Unlicensed National Information Infrastructure) (5.15 to 5.825 GHz) band. The parametric study of different parameters is discussed in detail for better results.

**Keywords**— Rectangular ultra-wide band antenna, partial ground plane, stepped corners, dual band notch characteristic, T-shaped and rectangular slots.

## I. INTRODUCTION

The last two decades have witnessed the usage of Ultra-Wide Band (UWB) antennas in various applications like radar, sensors, military, RFID, Imaging, etc. But, there usage in the ultra-wide band applications has increased drastically after the approval of license free usage of ultra-wide band by FCC (Federal Communications Commission) [2-8]. It was on 14<sup>th</sup> February, 2002 when US-FCC has approved the license free usage of ultra-wide band ranging from 3.1 GHz to 10.6 GHz for low power and short range applications [1]. This was the eye-catching approval for researchers and academicians. Then after many ultra-wide band antenna designs were proposed using various band enhancement techniques like partial ground plane, defected ground structure (DGS), shorting pin, shorting wall, stacking, slotting, stubs, stepping, beveling, etc [2-16]. Many of the proposed designs do not fulfill the basic requirements of an ultra-wide band antenna. An UWB antenna must operate over entire ultra-wide band from 3.1 GHz to 10.6 GHz as per the FCC. Secondly, it should have either unidirectional or bidirectional radiation pattern as per the requirement of applications [5, 12, 15-16]. Many researchers want that an UWB antenna must have a constant gain over entire operating bandwidth, which is the ideal condition. Some researchers found that if an UWB antenna is used for numerous applications then there would be interference from the overlapping or nearby band(s) [8, 11, 13-14]. So the researchers have decided to reject those interfering bands by the help of creating destructive interference at those selective frequencies which was termed as band-notched characteristics. Some researchers focused on one band notching where as some designed UWB antenna with multiple band-notched.

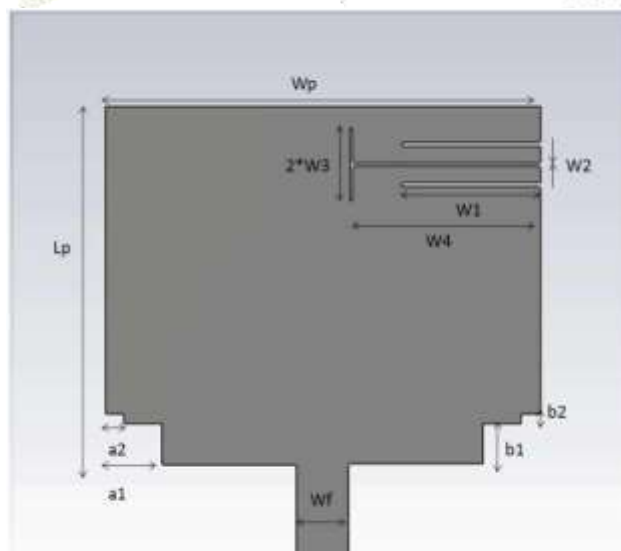


Figure 1. Top View of the proposed antenna.

The top and bottom side of the antenna is shown in figure 1 and 2 given above. In this paper, an UWB antenna design with dual band notched characteristic is presented using one T-shaped and two identical rectangular slots on radiating patch. The proposed structure uses one T-shaped slot between two identical rectangular slots with two level stepped corners on the radiating microstrip patch antenna. In addition to above, a microstrip fed also utilized along with partial ground plane for better results. Computer Simulation Technology Microwave Studio (CST-MWS) is used to design this antenna. Bandwidth of the antenna increases as the ground plane is removed partially along with the stepped corners [3, 8-12].

**II. DESIGN**

The proposed antenna is designed and simulated using FR-4 (Flame Retardant material) substrate of 1.6 mm height with a permittivity of 4.3 and loss tangent ( $\tan \delta$ ) of 0.025. In the proposed design one T- shaped slot is used between two identical rectangular slots along with partial ground plane. Partial ground plane and two level stepped corners are utilized for bandwidth enhancement. In the design process it was observed that the two level stepped corners and partial ground plane adds to the bandwidth where as the said band notching structures helps in rejecting some frequency bands, which is discussed in the result section. The optimized parameters of the proposed antenna are as follows:  $W_s = 32.42$  mm,  $L_s = 27.0$  mm,  $W_p = 22.80$  mm,  $L_p = 17.8$  mm,  $W_f = 2.75$  mm,  $W_g = 32.42$  mm,  $L_g = 3.55$  mm,  $a_1 = 3.0$  mm,  $a_2 = 1.0$  mm,  $b_1 = 2.0$  mm,  $b_2 = 0.5$  mm,  $W_1 = 7.2$  mm,  $W_2 = 0.8$  mm,  $W_3 = 1.8$  mm,  $W_4 = 10.0$  mm,  $h = 1.6$  mm and  $m_t = 0.035$  mm.

**III. RESULTS AND DISCUSSIONS**

The proposed antenna is designed and simulated using a software tool CST-MWS in three stages. In the first stage, the microstrip patch antenna is designed using standard equations and then in order to increase the bandwidth (to meet the UWB requirements) ground plane is truncated partially along with two level stepped corners on the radiating patch antenna. After this stage the structure is operating as an ultra-wide band antenna. In the second stage, two identical rectangular slots are inserted on the top right side of the patch to reject upper frequency band (5.21 to 7.28 GHz). The band rejection was needed to reduce the interference from the nearby frequency bands as an UWB antenna can operate on any frequency between 3.1 GHz to 10.6 GHz. In the last stage, one T-shaped slot is inserted between the two rectangular slots and one additional band rejection is observed by virtue on destructive interference from the two types of slots.

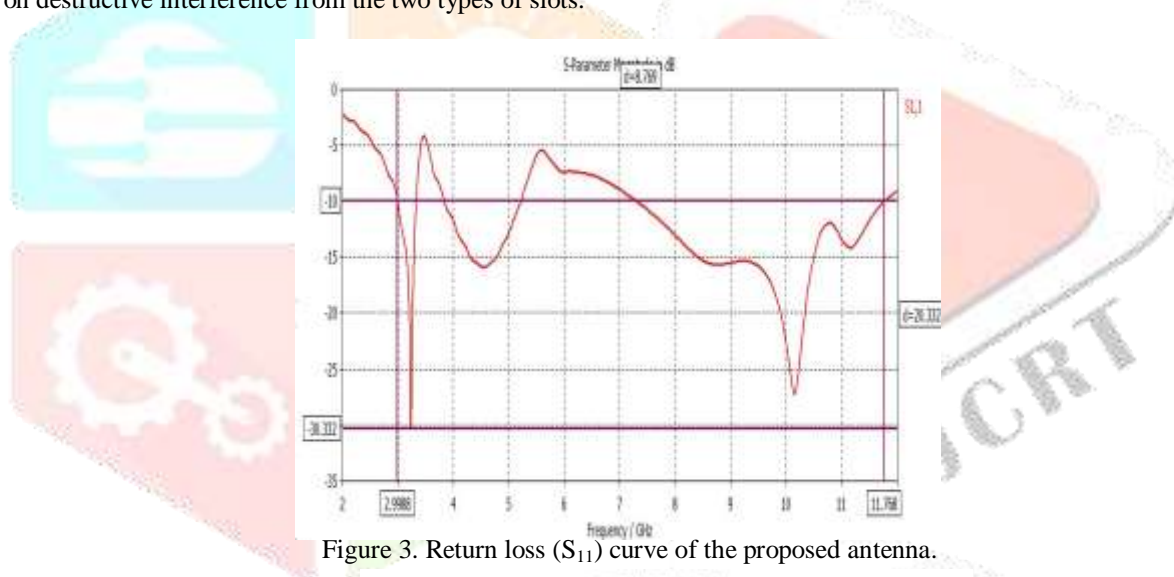


Figure 3. Return loss ( $S_{11}$ ) curve of the proposed antenna.

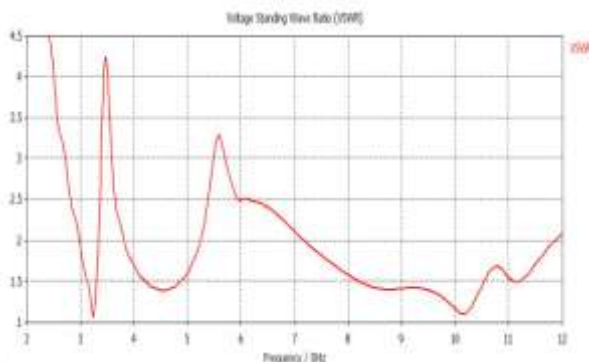


Figure 4. VSWR curve of the proposed antenna.

The return loss curve of the proposed design is shown in the figure 3 given above. The peak return loss value of -30.332 dB is achieved at 3.24 GHz. The bandwidth of the proposed design is about 6.187 GHz excluding the band rejection frequency bands. Voltage Standing Wave ratio (VSWR) curve of the proposed design is shown in the figure 4 given below. It can be easily observed that the value of the VSWR is less than 2 for entire ultra-wide band range except for the band rejections.

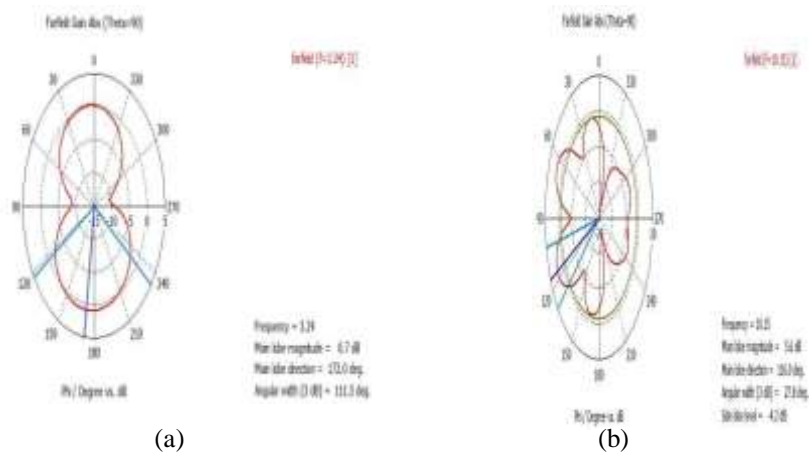


Figure 5. Radiation Plot at (a) 3.24 GHz  
(b).10.15 GHz

The radiation plots of the proposed design at frequency 3.24 and 10.15 GHz is shown above in the figure 5 and 6 respectively. The gain at 3.24 GHz is 1.63 dB where as it is 5.55 dB at 10.15 GHz. The radiation pattern at 3.24 GHz is bidirectional where as it is radiating nearly in all the directions for the second case.

#### IV. CONCLUSIONS

In this paper a rectangular planar Ultra-wide band antenna with dual band notched characteristics is proposed using two rectangular slots and one T-shaped slot on radiating patch. The proposed structure uses one T-shaped slot between two identical rectangular slots with stepped corners on the radiating microstrip patch antenna. This antenna operates in frequency ranging from 2.99 to 11.76 GHz with dual band notching ranging from 3.33 to 3.84 GHz and 5.21 to 7.28 GHz respectively. The bandwidth of the proposed structure is nearly 6.187 GHz excluding the two band rejections. This antenna may be utilized for applications in upper S band, C band, X band, ITU uplink satellite communication band (8.1-8.4 GHz) while rejecting 5.2/5.8 GHz WLAN, 3.5/5.5 GHz WiMAX, RFID (6.6 to 7.1 GHz) and whole U-NII (Unlicensed National Information Infrastructure) (5.15 to 5.825 GHz) band.

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