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DESIGN OF DUAL BAND NOTCHED ULTRA WIDEBAND ANTENNA USING (U-W) SHAPED SLOTS

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ABSTRACT

The Ultra-Wideband (UWB) communications have become a hot topic for researchers. To mitigate the interference with the existing WiMAX (3.3 GHz – 3.6 GHz) and WLAN (5.15 GHz – 5.825 GHz) systems, a Dual Band-Notched antenna for Ultra-Wideband applications is proposed. The antenna consists of rectangular patch, a 50 Ω Microstrip line and partial grounding. By etching a nested inverted U-Shaped and W-Shaped slots in the radiating patch, band rejection filtering properties for WiMAX and WLAN were achieved. The simulation results were obtained using electromagnetic simulation software (CST Microwave Studio). Simulation results shows that the return loss for the frequency band from 2.87 GHz to 11.48 GHz is below -10dB, which is considered operational. The antenna also has band-notched functions in the range from 3.24 GHz to 3.65 GHz and from 5.01 GHz to 6.01 GHz. Thus the interference between WiMAX, WLAN and Ultra-Wideband can be avoided.

Keywords: UWB, WiMAX, WLAN, microstrip line, band-notched, U-shaped slot, W-shaped slot, CST.

INTRODUCTION

Ultra-Wideband Antennas have attracted the attention of multiple academic and industrial wireless communications developers in the past few years due to several advantages, including light weight, high frequency data rate, large channel capacity, small in size, low power consumption, and can be fabricated at low cost [1-4]. The U.S. Federal Communications Commission (FCC) authorized the use of Ultra-Wideband (UWB) communications in 2002. According to the FCC, the authorized use of UWB should be in the frequency range from 3.1 GHz to 10.6 GHz [5]. UWB is a distinctive technology that can be used in wireless communications, networking, radar, Medical imaging and indoor positioning [3], [5].

There is several narrowband wireless standards converge within some parts of the UWB spectrum that had been set by the FCC (From 3.1 GHz to 10.6 GHz). These narrow bands include Worldwide Interoperability for Microwave Access (WiMAX) service (3.3–3.6 GHz) and Wireless Local Area Network (WLAN) services IEEE802.11a (5.15 GHz – 5.35 GHz and 5.725 GHz – 5.825 GHz) [1][2]. It is Necessary to avoid the interference to make the equipment work properly [2],[6].

Various approaches have been observed in the literature in order to achieve single and dual band notches such as U-Shaped Slot [2], W-Shaped Slot [5], Diamond Shaped slot [3], and C-Shaped Slots [1]. Other types include arc shaped slot and quarter-wavelength open-ended slots. Also slot-type split ring resonator (SRR) was used to eliminate the unwanted bands. Some designs with dual band-notched characteristic were achieved by using two of half-wavelength parasitic elements in an open rectangular slot, or embedding dual C-shaped slots on the radiator, or inserting dual quarter-wavelength stubs.

This paper presents a simple rectangular patch antenna fed by a 50 Ω microstrip line. The antenna resonates in the Ultra Wideband from 2.88 GHz to 11.58 GHz. By adding an Inverted U-Shaped slot on the radiating patch, a band notch achieved from 3.24 GHz to 3.66 GHz. Another band notch were also achieved in by adding a W-Shaped Slot on the radiating patch and nested with the inverted U-Shaped Slot. The range of the second band notch is 5.015 GHz to 6.005 GHz. The antenna also features the use of partial grounding to achieve the desired operational band.

SINGLE BAND-NOTCHED UWB ANTENNA DESIGNS AND RESULTS

The antenna is designed on FR-4 epoxy glass substrate with dielectric constant $\mathcal{E}r = 4.4$ and a thickness h=1.6 mm. the dimensions of the substrate are 35mm x 30mm. The Thickness of the copper is 0.035 mm. The feed line is a 50 Ω microstrip line attached to the patch with a strip width of 2.9 mm. In order to achieve the desired bandwidth for UWB, partial grounding has been considered. The Ground Plane has dimensions of 11.2mm x 30mm.

UWB antenna with band-notch at WiMAX (3.3 GHz - 3.6 GHz)

Band notches are highly desirable in UWB systems to reduce the interference with WiMAX system. Figure-1 shows the geometry and dimensions of the UWB antenna with band notch characteristic at WiMAX (3.3 GHz – 3.6 GHz).

The band notch is created by etching an inverted U-Shaped slot in the rectangular radiating patch of the antenna. The dimensions of the radiating patch (patch width and patch length), the microstrip line and the slots (width and length) have been listed in Table-1 below. Figure-2 shows the geometry and dimensions of the partial grounding that has been used to achieve the desired bandwidth.

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Table-1. Inverted U-Shaped slot UWB antenna dimensions.

Symbol	Lp	Wp	Lm	SL1	SW1
Dimension (mm)	14	11.5	12.5	10	9

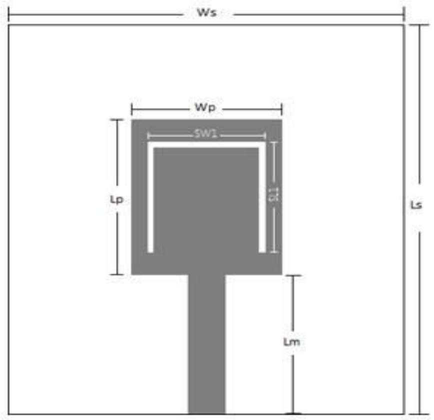

Figure-1. Inverted U-shaped slot UWB antenna.

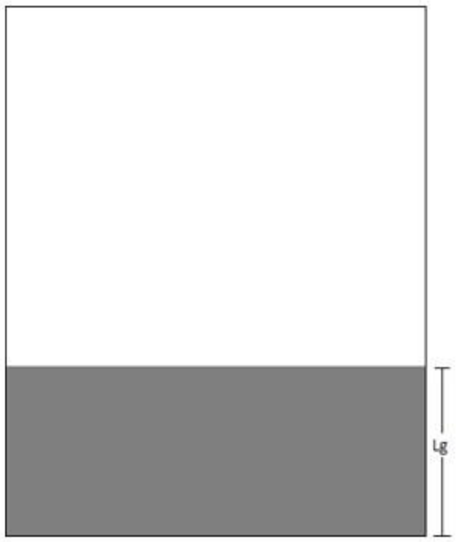

Figure-2. Antenna partial grounding.

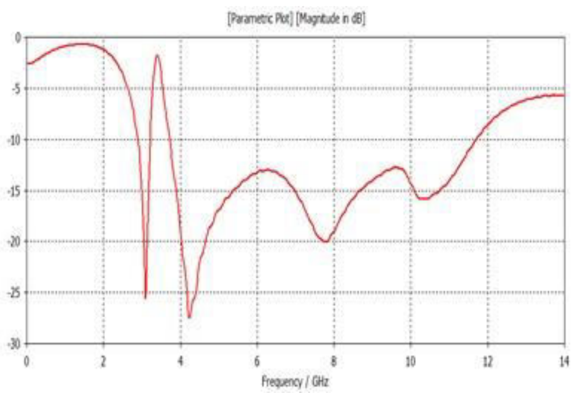

Figure-3. Return loss of the UWB antenna with band notch at WiMAX.

Figure-3 shows the CST simulation return loss (S1,1 parameter) of the antenna. It is observed that the band notch has been achieved between 3.214 GHz and 3.725 GHz at -10dB return loss. The antenna have a bandwidth ranging from 2.894 GHz to 11.691 GHz .The obtained results show that the desired filtering properties (3.3GHz to 3.6GHz band notch) have been achieved for this UWB antenna.

UWB Antenna with band-notch at WLAN (5.15 GHz – 5.825 GHz)

Beside WiMAX system, WLAN systems also operate in the UWB zone making it another unwanted noise in the system. As shown in Figure-4, the geometry of the substrate, the radiating patch, the microstrip line and the W-shaped slot have been presented. The antenna shown in Figure-4 has a band notch characteristic for WLAN (5.15 GHz - 5.825 GHz). As shown in the geometry the band notch has been achieved by etching a W-shaped Slot in the radiating patch. The ground have the same dimensions and geometry of the antenna presented in the previous section.

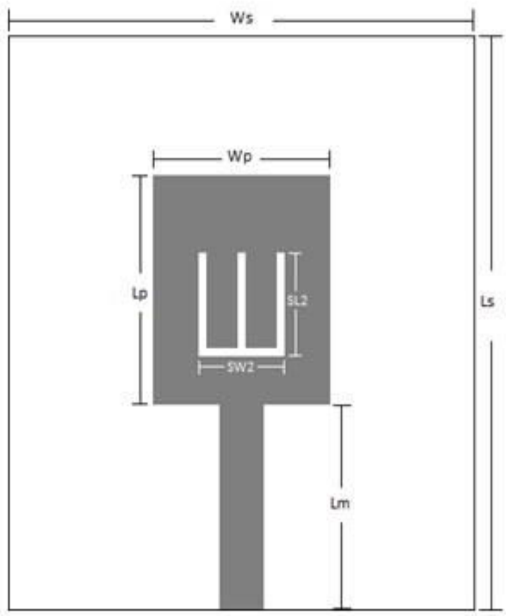

Figure-4. W-shaped slot UWB antenna.

Table-2 below lists the dimensions of the patch, the microstrip and the W-shaped slot of the UWB antenna. It is observed that the main dimensions (except slot dimension) remained unchanged from the design in the previous section.

Table-2. W-shaped slot UWB antenna dimensions.

Symbol	Lp	Wp	Lm	SL2	SW2
Dimension (mm)	14	11.5	12.5	6.3	5.5

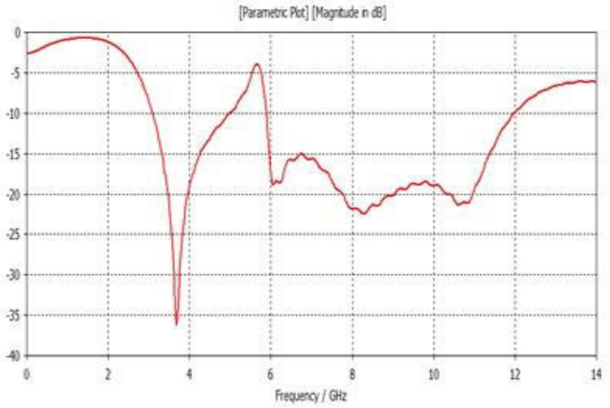

Figure-5. Return loss of the UWB antenna with band notch at WLAN.

Figure-5 presents the return loss (S1,1 parameter) results obtained from the simulations using CST. It is observed from the figure that a band notch between 4.985 GHz and 5.882 GHz has been achieved. The obtained bandwidth ranges between 3.096 GHz and 11.966 GHz. The desired band rejection properties (5.15 GHz to 5.825 GHz) have been achieved for this UWB antenna.

DUAL BAND-NOTCHED UWB ANTENNA DESIGN AND RESULTS

In order to achieve the dual band-notched antenna, the two single band-band notched antennas that have been presented in the previous section have been used. The band notches previously presented has been merged in one design using both types of slots (Inverted U-Shaped Slot and W-Shaped Slot). The main dimensions of the antenna are identical to the ones presented in Single Band-Notched antennas section. The substrate dimensions and characteristics remained unchanged as in the previous section.

Figure-6 shows the geometry and dimensions of the proposed dual band-notched UWB antenna. The figure clearly shows the nested inverted U and W shaped slots that has been used to achieve the dual notch properties.

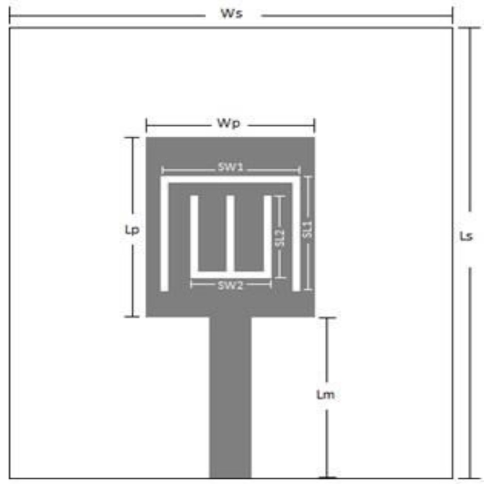

Figure-6. Dual band-notched UWB antenna.

Table-3. Dual band-notched UWB antenna dimensions.

Symbol	Dimension (mm)
Ls	35
Ws	30
Lp	14
Wp	11.5
Lg	11.2
Lm	12.5
SL1	9
SW1	9.5
SL2	6.5
SW2	5.5

Table-3 shows all the dimensions of the antenna presented in Figure-6. It is observed that the dimensions of the slots have been changed from the dimensions presented in the previous section for the single band notch antennas. The change in the dimensions included the length, the width, and the position of the slots in the patch. The change in the dimensions helped to achieve the desired dual band notches in the same structure. Despite all the changes, the dimensions of the radiating patch, the microstrip line and the ground plane remained unchanged.

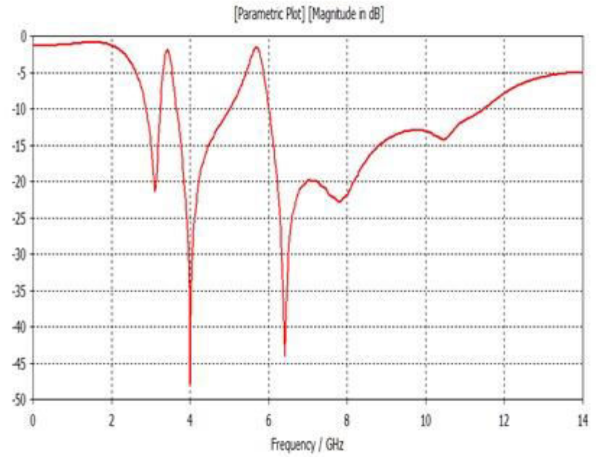

Figure-7. Return loss of the dual band-notched UWB antenna.

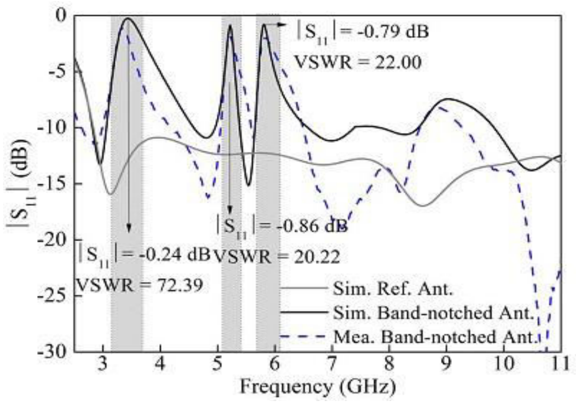

Figure-8. Return loss of multiple band-notched UWB antenna.

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The return loss (S1,1 parameter) obtained from the CST simulations is shown in Figure-7. The obtained result shows the antenna bandwidth ranging from 2.877 GHz to 11.474 GHz which totally covers the Ultra Wideband (3.1 GHz – 10.6 GHz). The figure also shows the Dual band notches achieved. The first band notch is from 3.242 GHz to 3.655 GHz which totally rejects WiMAX. The second band notch is from 5.013 GHz to 6.007 GHz which covers the WLAN. It is also observed from the figure that the antenna resonates efficiently at 4 main points, 3.1 GHz, 4 GHz, 6.4 GHz and 7.8 GHz.

In comparison to the return loss results obtained in earlier studies, we can see an improvement in our return loss (Figure-7) in terms of the margins of the notched frequencies, the bandwidth of the antenna, and frequency resonance. The return loss obtained earlier shows that band notched antenna is having a return loss above -10 dB at some point (e.g. 8.5 GHz – 10 GHz). Also the return loss at the best resonance is not exceeding -15 dB. It can also be observed that the rejecting band for the WiMAX (3.3 GHz – 3.6 GHz) is quite large in bandwidth (about 3.2 GHz – 4.6 GHz). In general, the obtained results in our antenna (Figure-7) shows better return loss compared to the mentioned points in Figure-8.

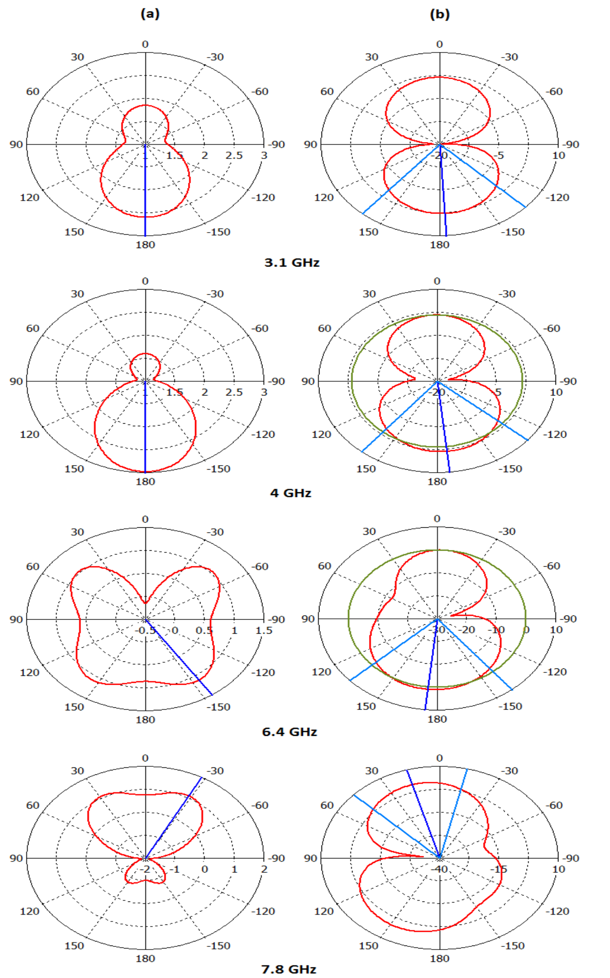

Figure-9. (a) XZ-plane of the radiation patterns **(b)** YZ-plane of the radiation patterns.

Figure-9 (a) and (b) shows the 2D polar representation of the XZ plane and YZ plane of the radiation patterns respectively. The figure shows the patterns for several resonances at 3.1 GHz, 4 GHz, 6.4 GHz and 7.8 GHz. It can be observed from the figure that along with the rise of the frequency of the proposed antenna, the radiation field in XZ and YZ planes suffers from distortion due to the effect of the higher harmonics of the low frequency field.

CONCLUSIONS

A Dual Band-Notched Ultra Wideband Antenna is presented. The proposed Antenna has small size and simple structure. In order to achieve the dual notches, the design went through two stages of single band-notched Ultra Wideband antennas. In these stages two types of slots have been used, inverted U-Shaped slot antenna for WiMAX notch and W-Shaped slot for WLAN notch. In the last stage of the design, we merged the two types of slots and modified their dimensions to achieve a UWB antenna with band notches for both WiMAX and WLAN in the same structure. The antenna proposed provides band rejection between 3.24 GHz to 3.65 GHz and between 5.01 GHz to 6.01 GHz, which can effectively avoid interference with WiMAX and WLAN systems. The antenna operates between 2.87 GHz and 11.48 GHz, which covers all the Ultra-Wideband Effectively. In comparison to the return loss figure presented in earlier studies, our antenna shows better return loss characteristics.

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