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An Upper Cut Rectangular Shaped with F Slot Ultra-Wide Band (UWB) Antenna

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ABSTRACT

An upper cut rectangular shaped with F slot ultra wide band (UWB) antenna. The proposed antenna usages, an upper cut rectangular shaped radiator in place of conventional monopole patch antenna to achieve UWB frequency. The ground plane is also modified by cutting rectangular slots. Therefore, the ground plane works like a radiator that resonates at lower band of UWB. The antenna is practically fabricated and simulated. A measured result shows a good agreement with simulated results. The prototype with compact overall size of 36mm × 36mm × 1.6mm achieves wide bandwidth, constant gain and stable radiation patterns over an operating band width of 2-13 GHz.

Keywords: UWB microstrip patch antenna, return loss, radiation patterns.

1. INTRODUCTION

Ultra wide band (UWB) technology is an ideal candidate for short range, broadband indoor wireless communication, and many more applications [1-5]. According to the federal communication, 3.1-10.6 GHz band is used for commercial applications of UWB technology [6-9]. The F slot antennas have numerous advantages over monopole antennas, such as: they provide wide band width, bidirectional or unidirectional radiation patterns [10-15]. This has instigated the researchers over the world to dwell deep in design of monopole like slot UWB antennas.

Diverse shapes of monopole antennas such as a beveled rectangular patch and a circular printed monopole with steps and various shapes of slot and tapered slot with tuning patch have been reported for a compact UWB antenna.

In this article, an upper cut rectangular shape with F slot UWB antenna is proposed and designed. The antenna is mainly composed of a radiation performance from 2 to 13 GHz. The proposed antenna usages an upper cut rectangular shape radiator in place of the conventional monopole patch antenna to achieve UWB frequency. The ground plane is modified by cutting rectangular slot, thus, it also works like a radiator that resonates lower band of UWB. The proposed structure is illustrated in Figure 1. The antenna prototype with a

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compact overall size of 36mm × 36mm × 1.6mm achieves wide bandwidth, constant gain, and stable radiation patterns over an operating band.

2. ANTENNA DESIGN

Normally, the bandwidth of a conventional microstrip antenna is not very broad because it has only one resonance frequency but if there are two or more resonant part available with each one operating at its own resonance, the overlapping of these multiband or broadband performances. Thus, there is a need of modified conventional microstrip antenna to support the multi resonance. Unlike the conventional microstrip patch antenna using a solid ground plane on other side, in this design, the ground plane is defected by cutting two rectangular slots with the dimensions $L_{g1} \times W_{g1}$ and $L_{g2} \times W_{g2}$, respectively as shown in Figure 1. The overall size of antenna is 36 mm × 36 mm × 1.6 mm. The basis of the monopole like radiator is a rectangular patch which has the dimension of length L and width W and finally the structure is modified to form an upper cut rectangular shape.

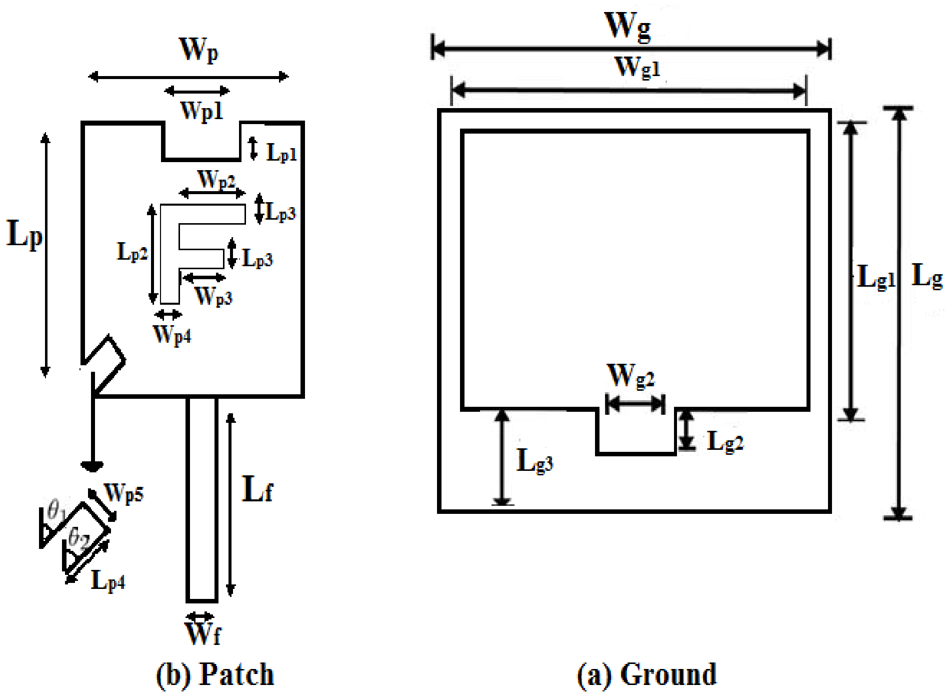

Figure 1 Schematic configuration of the proposed Upper Cut Rectangular Shaped with F Slot Ultra Wide Band (UWB) Antenna

A rectangular notch is introduced at the left lower corner of upper cut rectangular shape radiator to control the high frequency band of UWB. The width microstrip feed line is fixed at 1.5mm to achieve 50 Ω-characteristic impedance. The above design skills are

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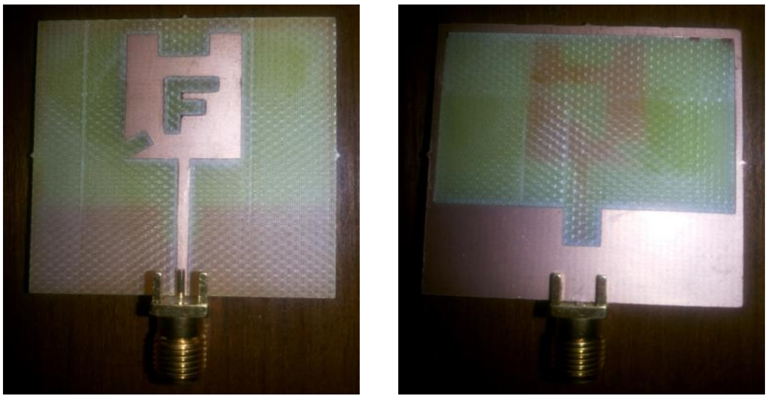
introduced to obtain UWB accompanied with good impedance matching over the entire operating band. The detail dimensions of the proposed UWB antenna are listed in Table.1. The UWB antenna was fabricated and printed on a commercially available 1.6 mm thick FR-4 substrate with permittivity of 4.4 and a loss agent of 0.024. A layout photograph is shown in Figure 2 and current densities at 2 GHz and 10.5 GHz of the antenna is depicted in Figure 3 The electromagnetic solver, Ansoft HFSS version 14.0, was used to investigate and optimize the proposed antenna configuration.

Table 1: Design Parameters of Proposed Upper Cut Rectangular Shaped with F Slot Ultra Wide Band (UWB) Antenna

Parameters	W_g	W_{g1}	W_{g2}	W_p	W_{p1}	W_{p2}	W_{p3}	W_{P4}	W_{p5}	W_f
Unit (mm)	36	34	4	14	6	4.5	1.5	3	2	1.5
Parameters	L_f	L_g	L_{g1}	L_{g2}	L_p	L_{p1}	L_{p2}	L_{p3}	L_{p4}	θ_1/θ_2
Unit (mm)	17.5	36	22.8	4.8	16.5	3	7	1.5	4	60°/61°(120°)



(a) Front View (b) Bottom View

Figure 2: Photograph of the proposed Upper Cut Rectangular Shaped with F Slot Ultra Wide Band (UWB) Antenna

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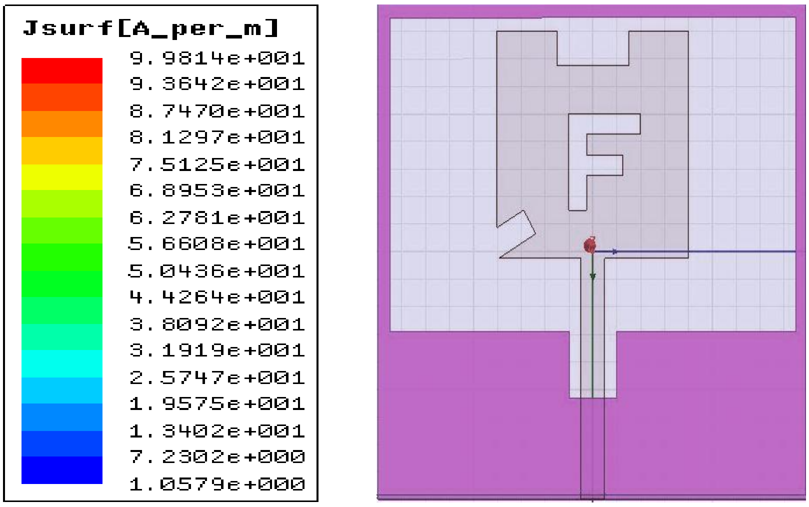
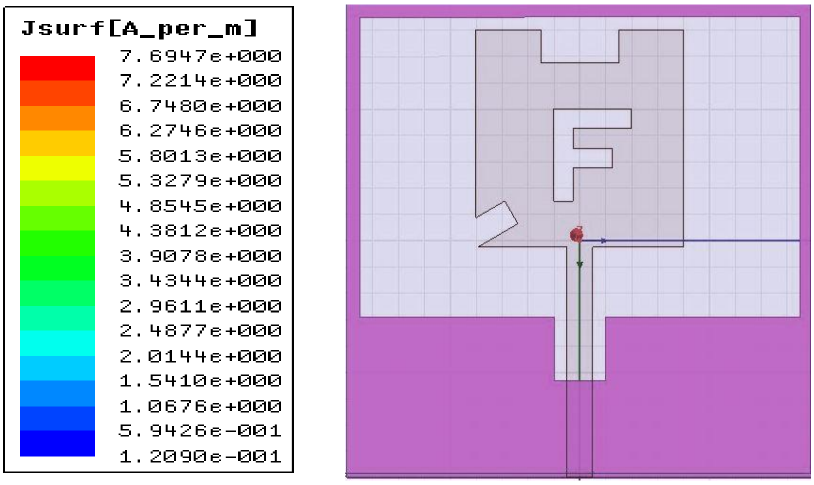


(a) Current density at 2GHz



(b) Current density at 10.5GHz

Figure 3: Current Densities of the proposed Upper Cut Rectangular Shaped with F Slot Ultra Wide Band (UWB) Antenna

Figure 4 trace (d) show the simulated return loss of the proposed antenna with the optimized parameters as listed in Table 1. Obviously, the simulation results show UWB width from 2 to 13GHz. Apparently, the above obtained band width cover the entire UWB spectrum from 3.1 to 10.6 GHz. Initially the conventional microstrip patch radiator was examined to achieve UWB bandwidth and then the structure was modified to F-shaped with rectangular notch at left lower corner radiator, the return loss for these structures which are denoted as curve (a), (b), (c) and (d) respectively are also analysis and presented in the Figure 4. Note that in these cases all the unmentioned dimensions are the same as listed in Table 1.

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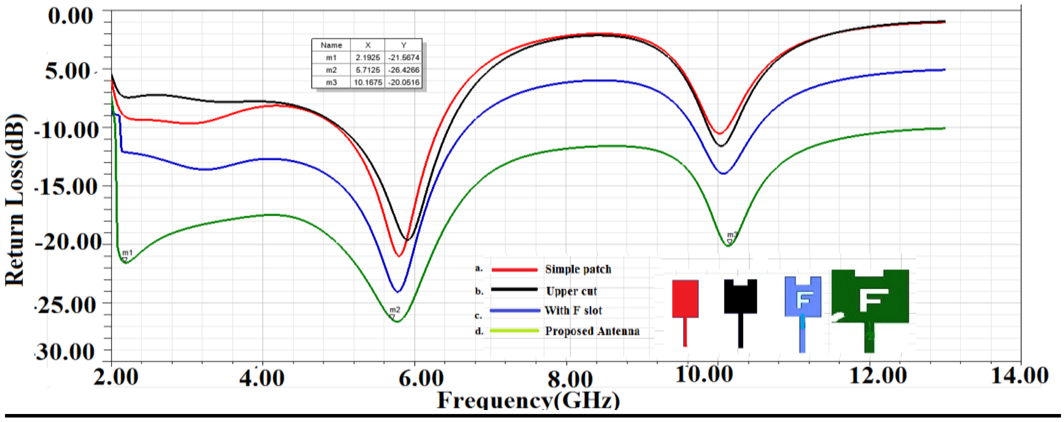

Figure 4: Simulated return loss against frequency for the proposed Upper Cut Rectangular Shaped with F Slot Ultra Wide Band (UWB) Antenna

For the conventional rectangular upper cut antenna [curve (a) and (b)], narrow bandwidth is achieved and two resonance modes appear in both curves. In curve (a), two resonant modes seem to form at about 5.76GHz and 10.05 GHz and in curve (b), two resonant modes at about 5.96GHz and 10.03GHz. As for the case of F slotted radiating antenna [curve (c)], the bandwidth increases from 2.11GHz to 6.70GHz and resonant modes at this curve are at 5.76GHz and 10.08GHz. Finally, the F slot, upper cut rectangular shape with notch radiating patch in the proposed design significantly gives the wide bandwidth and shows three resonant frequencies at 2.13GHz, 5.76 GHz and 10.14 GHz, respectively.

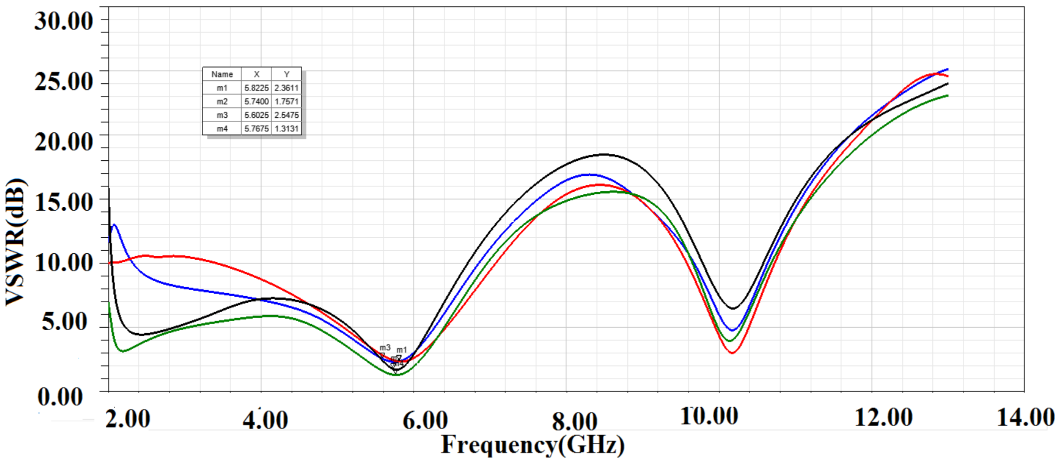

Figure 5: Simulated VSWR against frequency for the proposed Upper Cut Rectangular Shaped with F Slot Ultra Wide Band (UWB) Antenna

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Figure 5 depicts the simulated result for VSWR of the proposed antenna. For simple patch, VSWR at 5.71GHz is 1.72dB. For upper cut the VSWR at 5.85GHz is 1.88dB. For slot, the VSWR at 5.71GHz is 1.82dB and for proposed antenna, VSWR at 5.98GHz is 1.89dB.

2.1. Variation of Patch Parameters

Figure 6, shows the simulated result of the proposed antenna with patch width W_p, from 14 mm to 20 mm. It can be seen that the bandwidth for return loss decreases as W_p increases from 14 mm to 20 mm. From Figure 6, we seen that narrow band appears at W_p = 18 mm and W_p = 20 mm, and bandwidth increases when W_p = 16 mm but this band is not wide and W_p = 14 mm, wide band appears. Therefore, it is decided to take W_p = 14mm as the optimum, resulting in the bandwidth from 2 to 13 GHz.

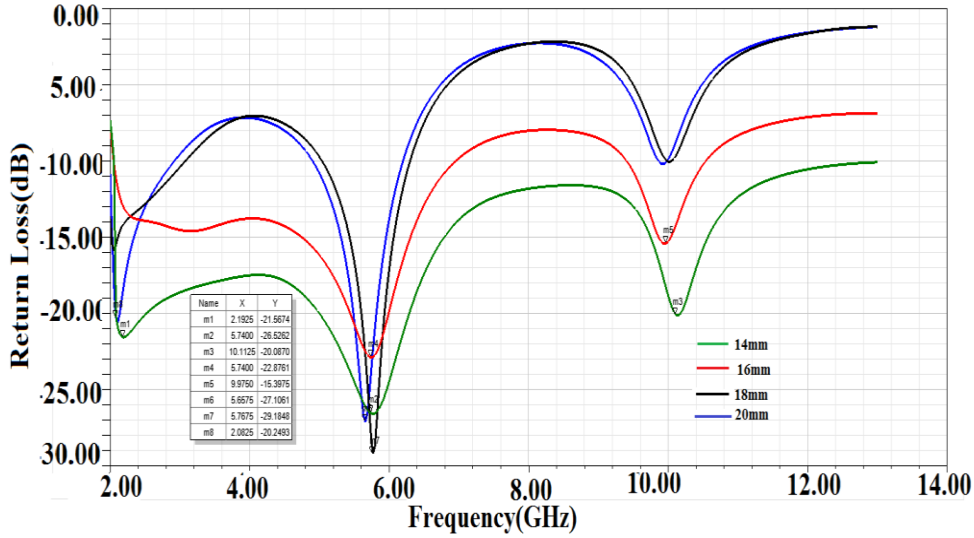

Figure 6: Simulated return loss against frequency for the upper cut with F slot UWB antenna with various with various *W*p: other parameters are the same as listed in Table 1.

2.2 Variation of feed parameters

Figure 7 shows the simulated result of the proposed antenna with feed width W_f , from 1 mm to 3 mm. It can be seen that the bandwidth for return loss decreases as width of feed increases. Figure 7, clearly shows that narrow band appears at W_f= 3mm and W_f= 2mm, and bandwidth is increases when W_f= 1mm but this band is not wide. When W_f= 1.5 mm as the optimum, resulting in the bandwidth from 2 to 13GHz.

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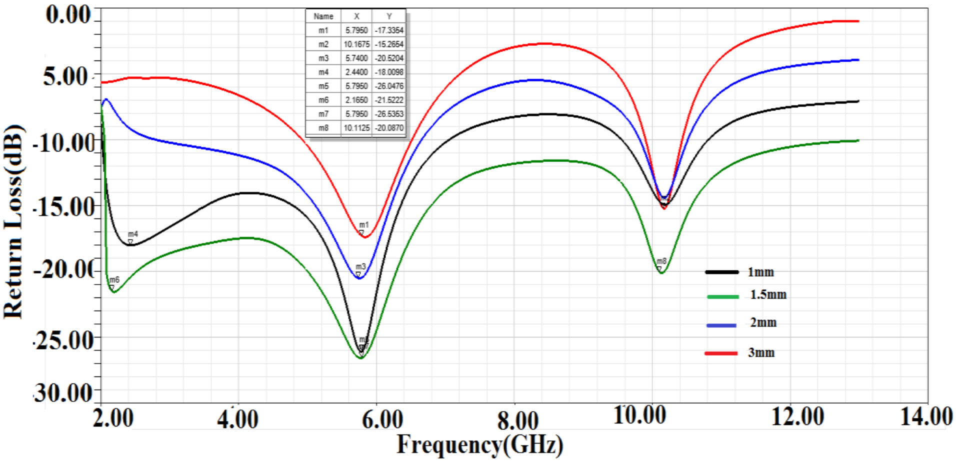

Figure 7: Simulated return loss against frequency for upper cut with F slot UWB antenna with various W_f: other parameters are the same as listed in Table 1.

2.3 Variation of Upper Cut Parameters

Figure 8 shows the simulated result of the proposed antenna with upper cut width W_{p1} from 5mm to 6.5 mm. From Figure 8, it is clearly seen that narrow band appears at W_{p1}= 5.5mm and return loss at this frequency is 15.88 dB. When width changes say W_{p1}= 5mm then return loss is 23.40 dB at resonant frequency 5.76GHz. But at W_{p1}= 6mm, the wide band appears and return loss is 26.53 at 5.79 GHz.

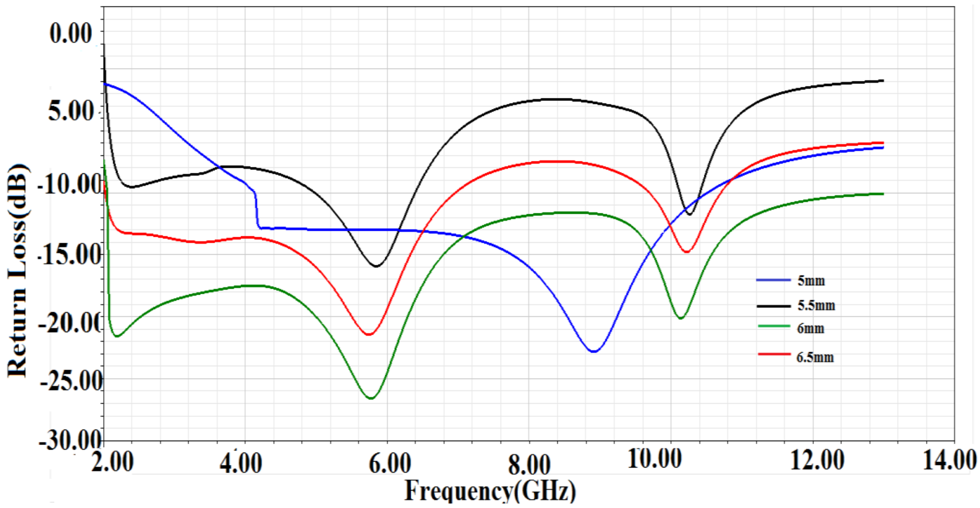

Figure 8: Simulated return loss against frequency for upper cut with F slot UWB antenna with various W_{p1}: other parameters are the same as listed in Table 1.

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2.4 Variations of Ground Parameters:

Figure 9 predicts, the simulated results of the proposed antenna showing the effect of slots in ground plane. As for the case of the ground plane (with only one slot) the worst matching condition appears over the entire band, while one resonant mode seems to form at about 4GHz. As for the case of the ground plane with only upper slot, the matching condition is still poor across the full band. However, two resonant modes appear across the band. Finally the ground plane with two slots significantly improves the impedance matching condition for the entire band.

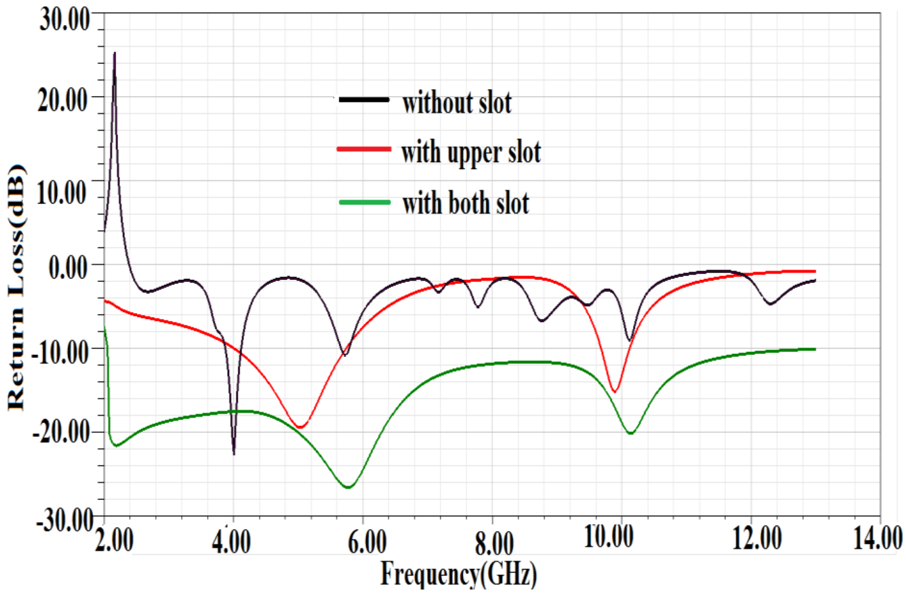

Figure 9: Simulated return loss against frequency for upper cut with F slot UWB antenna with ground variations: other parameters are the same as listed in Table 1**.**

3. EXPERIMENTAL RESULTS AND DISCUSSION

Figure 10 shows the measured and simulated return loss curves of the upper cut rectangular shaped with F slot UWB antenna. As shown in Figure 10, a good agreement between the simulated and measured results is observed. The small difference between the measured and simulated results is due to the effect of SMA connector soldering and fabrication tolerance. The designed antenna has a UWB performance of 2.45 to 12.50 GHz.

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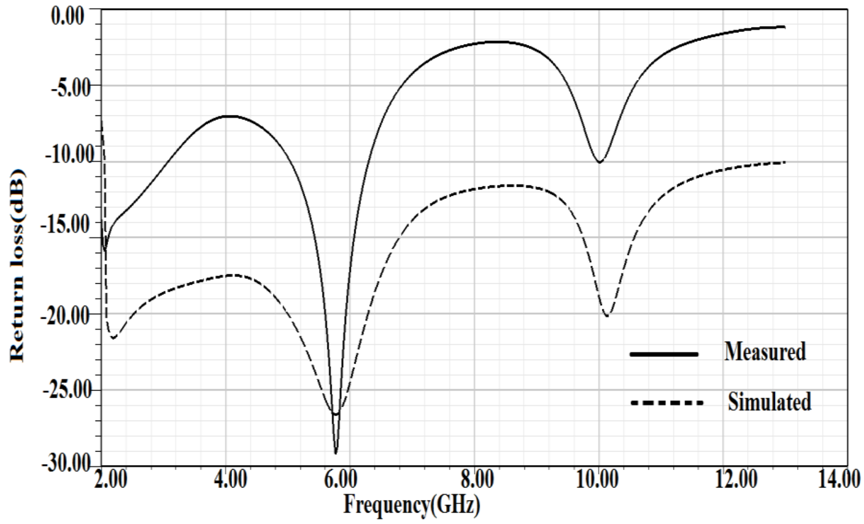
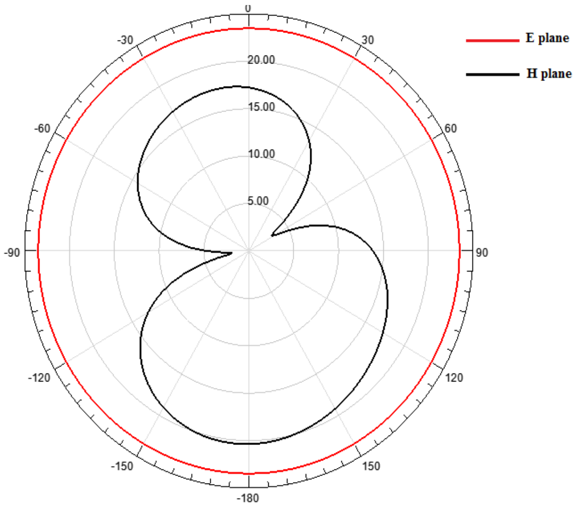


Figure 10: Measured and Simulated Return loss for the proposed upper cut rectangular shaped with F slot UWB antenna

4. RADIATION PATTERN

Figure 11, 12, 13: shows the different type of radiation patterns for several frequencies: 2.52 GHz, 4.72 GHz and 12.50 GHz. It is clearly seen that the radiation patterns are almost bidirectional.



E and H plane pattern: Radiation pattern at F = 2.52GHz

Figure 11:Radiation pattern of antenna at F = 2.52GHz, Theta = 0degree and phi = 0 degree

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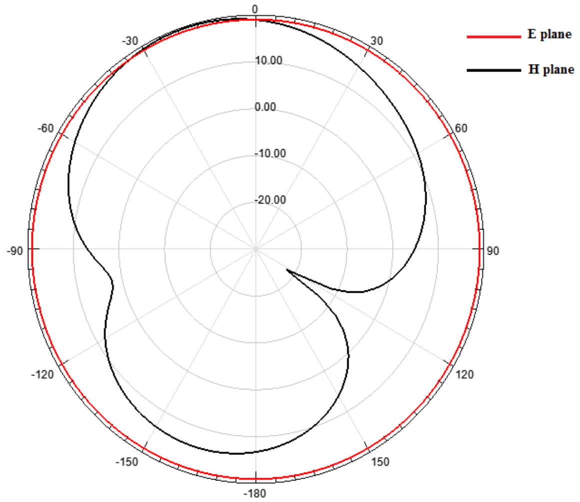
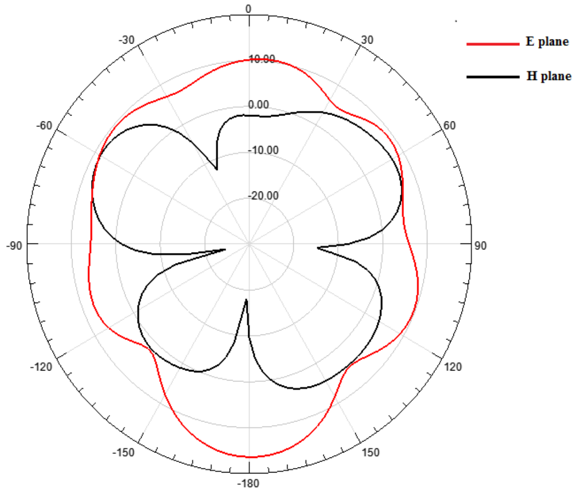


E and H plane pattern: Radiation pattern at F = 4.72GHz

Figure 12: Radiation pattern of antenna at f =4.72GHz,Theta = 0degree and phi = 0degree



E and H plane pattern: Radiation pattern at F = 12.50GHz

Figure 13: Radiation pattern of antenna at F = 4.72GHz, Theta = 90 degree and phi = 90degree.

6. CONCLUSION

An upper cut rectangular shaped with F -slot UWB antenna is proposed. The measured results of the fabricated antenna show stable radiation patterns over the entire UWB band. The return loss, constant gain and bidirectional radiation patterns, over the entire operating bandwidth of 2.38 to 12.40GHz (10.02 GHz) that make this antenna a good candidate for UWB applications and systems.

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