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Design and implementation of planar UWB antenna with dual band rejection characteristics

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Abstract

In this paper, we design and implement an Ultra-Wide Band (UWB, 3.1~10.6 GHz) antenna with 5G mobile communication (3.42~3.70 GHz) and Wireless Local Area Network (WLAN, 5.15~5.825 GHz) bands rejection characteristics. The proposed antenna consists of a planar radiation patch with two slots. The upper slot contributes to reject 5G mobile communication band and the lower slot contributes to reject WLAN band. The Voltage Standing Wave Ratio (VSWR) values of the proposed antenna show good performances in whole UWB band except for rejection bands based on VSWR 2.0. The proposed UWB antenna was simulated using High Frequency Struture Simulator (HFSS) by Ansoft. The simulated antenna showed dual rejection bands of 3.31~3.92 GHz and 5.04~5.90 GHz in UWB band, and measured antenna showed dual rejection bands of 3.35~3.97 GHz and 5.06~5.97 GHz. The largest VSWR values measured at each rejection band are 13.60 at 3.64 GHz and 10.25 at 5.52 GHz. The measured maximum gain is 5.31 dBi at 10.00 GHz. The lowest gains for the measured antenna at rejection bands are -8.73 dBi at 3.70 GHz and -4.36 dBi at 5.56 GHz.

Key words : UWB, band rejection, antenna, planar, dual band

Ⅰ. Introduction

Since the late 1980s, Ultra-Wide Band (UWB) technology has been rapidly developed, but it has been referred to in various terms. It was not until 1989 that UWB was named by the U.S. Department of Defense [1].

UWB technology, a short-range wireless communication technology, has been applied to high-security communications for military purposes in the United States. It was used only for military and government agencies, and not for commercial purposes. However, in February 2002, the Federal Communications Commission (FCC) allowed commercialization to implement wireless communications using 3.10~10.6 GHz frequency band [2].

However, UWB system is faced with serious interference issues with the existing World Interoperability for Microwave Access (WiMAX, 3.3~3.7 GHz), Wireless Local Area Network (WLAN, 5.15~5.825 GHz), X-band (7.25~8.395 GHz) and Korea's 5G mobile communication (3.42~3.70 GHz). Therefore, to avoid interference with existing wireless services, the band rejection feature should be considered in UWB systems [3-7].

There is a simple way to prevent undesired

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interference with these conventional system signals. A Step Impedance Resonator (SIR), a Split Ring Resonator (SRR), a Complementary Split Ring Resonator (CSRR) insertion method, a H-shape, a U-shape, a C-shape, and an I-shape slots insertion method, and a method of inserting parasitic elements of various shapes have been proposed [8-14].

In this paper, we design and implement an UWB antenna rejecting 5G mobile communication (3.4~3.7 GHz) and WLAN (5.15~5.825 GHz) bands by using planar radiation patch with slots. Compared to [6], we tried to meet the required rejection band characteristic without parasitic elements. As you can see at [6], without parasitic element that do not cover required specification of Voltage Standing Wave Ratio (VSWR) 2.0. The proposed antenna in this paper, the VSWR values shows good performances in whole UWB band except rejection bands based on VSWR 2.0. In addition, in order to enhance rejection bands characteristic, a deformation of slot shape was applied.

Ⅱ. Proposed Antenna

Fig. 1 shows the geometry of the proposed UWB antenna with 5G mobile communication and WLAN bands rejection characteristics. Table 1 shows the parameter values. The size of the proposed antenna is 25.0 mm(W) × 35.0 mm(L) × 1.6 mm(H). The characteristics of the proposed antenna were simulated using the High Frequency Structure Simulator (HFSS) by Ansoft.

Fig. 2 shows an implemented UWB antenna. The FR4 substrate with a dielectric constant of 4.4 and a thickness of 1.6 mm was used. And antenna is fed by 50Ω SMA connector on the strip line.

Fig. 3 shows the simulated results on VSWR values for the cases of with and without slots in the flat radiation patch. The upper n-shape slot contributes to reject 5G mobile communication band and the lower n-shape slot contributes to reject WLAN band.

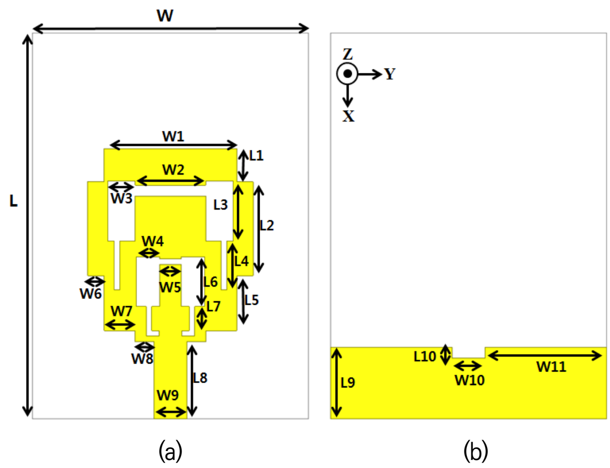


Fig. 1. Geometry of the proposed UWB antenna (a) Top view, (b) Bottom view.

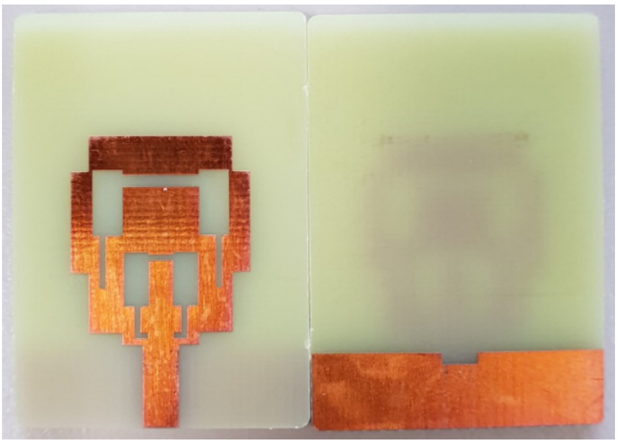


Fig. 2. Photograph of the implemented UWB antenna.

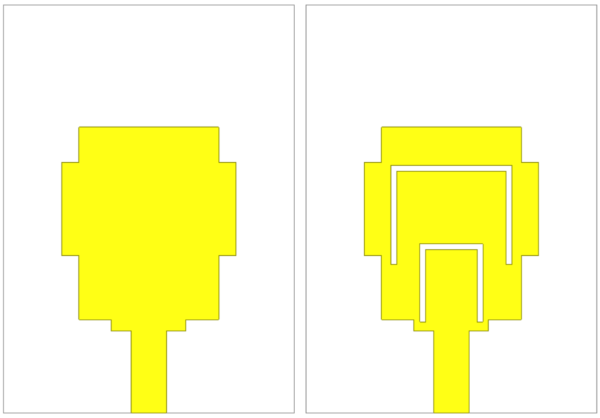
Fig. 4 shows the simulated results on VSWR values when the slot shape deformation applied to enhance the VSWR value of the rejection bands. As a result of deformation, VSWR values increased from 6.26 to 9.44 in the 5G mobile communication band and from 6.93 to 7.75 in the WLAN band. So, we can see that deformation of slot shape can effectively enhance VSWR performance for rejection bands.

Ⅲ. Simulation and Measurement

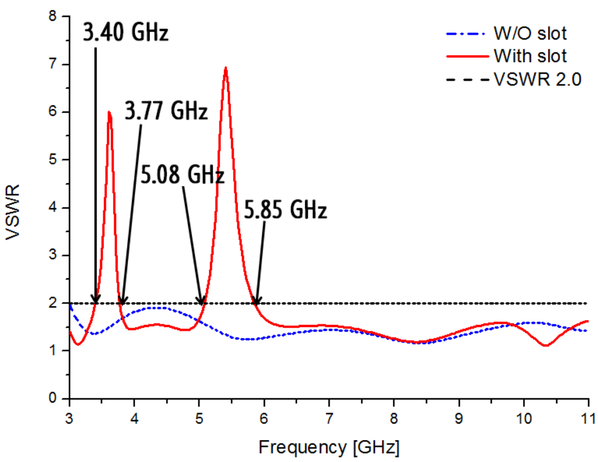
Fig. 5 shows the current distribution on the surface of the antenna at 3.5 GHz and 5.5 GHz, which are the center frequencies of the rejection

Table 1. Design parameters of the proposed UWB antenna.

Parameter	Length(mm)	Parameter	Length(mm)
W	25.00	L	35.00
W1	12.00	L1	3.00
W2	6.40	L2	8.50
W3	2.50	L3	5.50
W4	2.10	L4	4.40
W5	2.00	L5	5.00
W6	1.50	L6	4.50
W7	2.80	L7	2.70
W8	1.70	L8	7.00
W9	3.00	L9	6.50
W10	3.00	L10	1.00
W11	11.00		

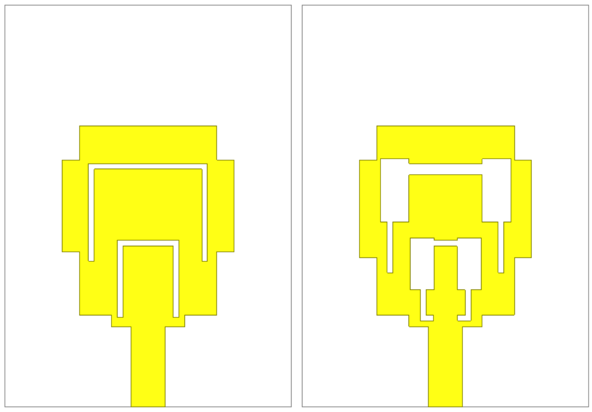


(a)

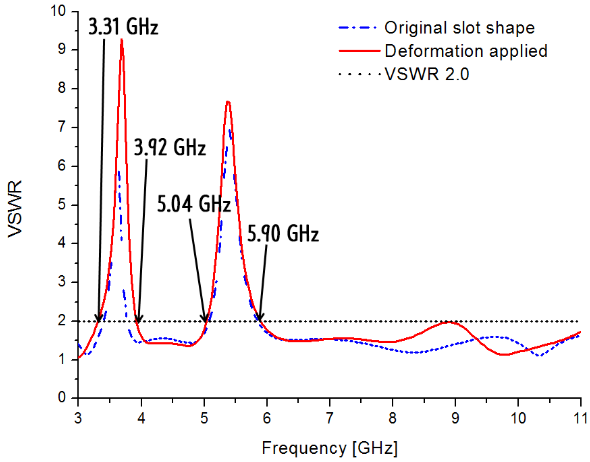


(b)

Fig. 3. Simulated results on VSWR for UWB antenna with and without slots (a) Simulated antenna, (b) Simulated results.



(a)

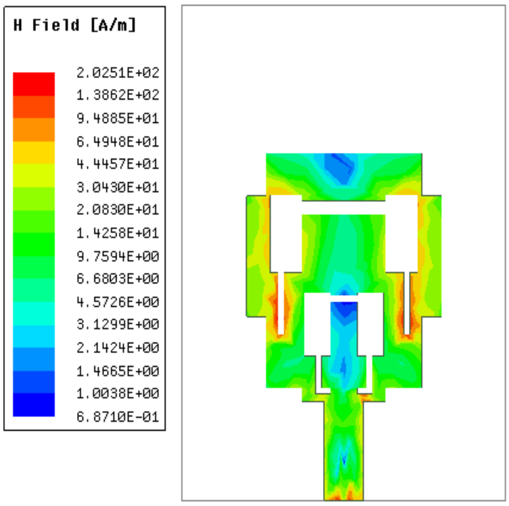


(b)

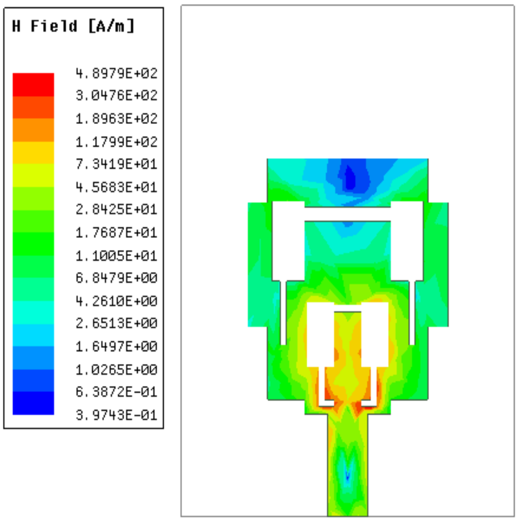
Fig. 4. Simulated results on VSWR for UWB antennas with original slot shape and deformation applied (a) Simulated antennas, (b) Simulated results.

band of the proposed antenna. Fig. 5 (a) shows that the upper n-shape slot rejects the 5G mobile communication band and Fig. 5 (b) shows that the lower n-shape slot rejects the WLAN band. As a result, it can be seen that slots take a roll for bands rejection efficiently by blocking the radiation within the UWB band.

Fig. 6 shows the simulated and measured results for VSWR characteristics of the antenna. The proposed antenna is designed to reject the 5G mobile communication and the WLAN bands, and the VSWR characteristics of the simulated antenna are shown to reject 3.31~3.92 GHz and 5.04~5.90 GHz bands based on VSWR 2.0 and measured antenna are shown to reject 3.35~3.97 GHz and 5.06~5.97 GHz bands based on same VSWR value. The largest VSWR values measured



(a)



(b)

Fig. 5. Simulated current distributions for the proposed antenna (a) At 3.5 GHz, (b) At 5.5 GHz.

at each rejection band are 13.60 at 3.64 GHz and 10.25 at 5.52 GHz. The simulated and measured VSWR values shows good performances in whole UWB band of 3.10~10.60 GHz except rejection bands.

Fig. 7 and Table 2 show the measured peak gain at each frequency. The maximum peak gain in UWB band was 5.31 dBi at 10.00 GHz. And minimum peak gains at each rejection band were -8.73 dBi at 3.70 GHz and -4.36 dBi at 5.56 GHz. As a result, it can be seen that the proposed antenna effectively rejects the corresponding band.

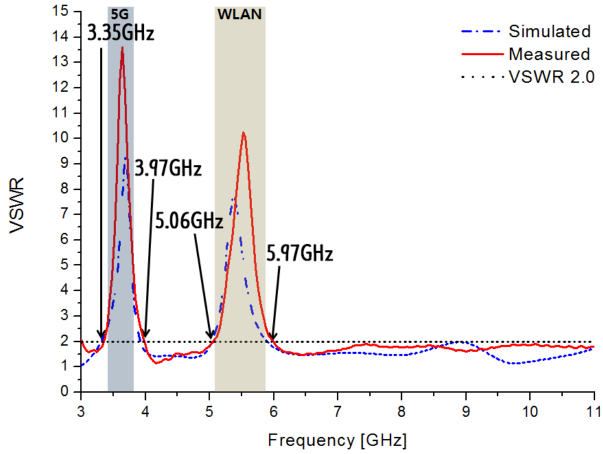


Fig. 6. Simulated and measured VSWR of the UWB antenna.

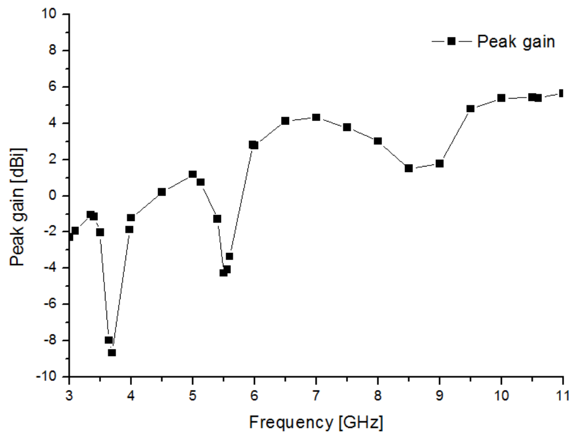


Fig. 7. Measured peak gain of the UWB antenna.

Table 2. Measured peak gain of the UWB antenna.

Frequency (GHz)	Peak gain (dBi)	Frequency (GHz)	Peak gain (dBi)
3.00	-2.12	5.60	-3.95
3.10	-1.54	5.97	2.76
3.35	-0.82	6.00	2.82
3.40	-1.24	6.50	4.10
3.50	-2.07	7.00	4.38
3.64	-7.77	7.50	3.84
3.70	-8.73	8.00	3.22
3.98	-1.22	8.50	1.69
4.00	-1.36	9.00	1.83
4.50	-0.01	9.50	4.90
5.00	1.21	10.00	5.31
5.13	1.03	10.50	5.21
5.40	-0.65	10.60	5.27
5.50	-3.73	11.00	5.37
5.56	-4.36		

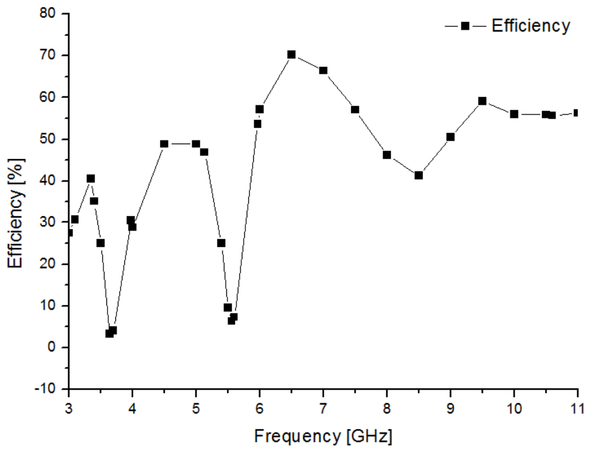


Fig. 8. Measured efficiency of the UWB antenna.

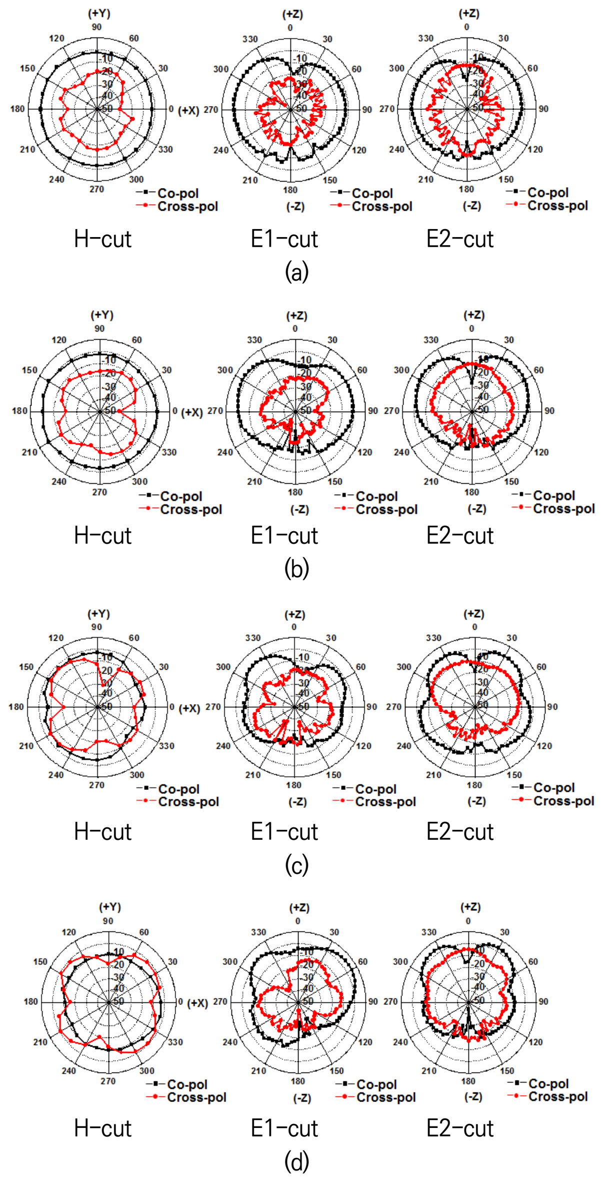


Fig. 9. Measured normalized co-polarization and cross-polarization radiation patterns (a) At 4.5 GHz, (b) At 6.5 GHz, (c) At 8.5 GHz, (d) At 10.0 GHz.

Fig. 8 shows the measured antenna efficiency at each frequency. It can be seen that the radiation efficiency is low in the rejection band and thus we can see the required goal is achieved suitably.

Fig. 9 shows the co-polarization and cross-polarization radiation patterns of UWB antenna. H-cut (Theta = 90°), E1-cut (Phi = 0°) and E2-cut (Phi = 90°) at 4.5 GHz, 6.5 GHz, 8.5 GHz and 10.0 GHz were measured. The measured co-polarization radiation patterns showed almost omni-directional characteristics in the horizontal plane.

The antenna size presented in [10] is 26×30 mm^2 and proposed UWB antenna show smaller element size. One important factor is number of rejection band, many papers show same performance in view point of number of rejection bands. The proposed antenna has dual rejection band of our currently of interest, 5G mobile communication and WLAN bands.

Ⅳ. Conclusion

We designed and implemented an UWB antenna with 5G mobile communication and WLAN bands rejection characteristics. The band rejection characteristics of UWB antennas were implemented using two n-shape slots in the planar radiation patch, and the two slots were seen to reject the 5G mobile communication and WLAN band, and the VSWR value of each rejection band was enhanced by deformation appiled slots.

The measured results of the implemented antenna showed band rejection at 3.35~3.97 GHz and 5.06~5.97 GHz based on VSWR 2.0 and the maximum VSWR values at each rejection band were 13.60 at 3.64 GHz and 10.25 at 5.52 GHz. The maximum peak gain is 5.31 dBi at 10.00 GHz. The minimum peak gains of the measured antenna were -8.73 dBi at 3.70 GHz and -4.36 dBi at 5.56 GHz which confirms band rejection characteristics.

The proposed antenna has shown to effectively reject interferences from 5G mobile communication and WLAN. Therefore, it is expected to be applicable to UWB service suitably.

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