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The Effect of the Ground Slots up on the Bandwidth Performance for UWB Antenna

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Abstract

This paper presents the ground plane slots effectiveness up on the bandwidth performance for the ultra-wideband (UWB) antenna. Our reference antenna is monopole feature microstrip feed style with a square radiator and a partial ground plane. Four different slots configurations (triangular, trapezoidal, rectangular and circular) have been inserted to the proper length of a partial ground plane on the feed line back side to alter the reference antenna bandwidth characteristics. The effect of the single and multiple slots cases up on the bandwidth characteristics is examined using CST-EM software package. The simulation results verify that the antenna bandwidth can be enhanced or has some reject bands based on the slots configurations and slots numbers.

Keywords: UWB antenna, Ground plane slots, Bandwidth enhancement, Reject band.

I. INTRODUCTION

Since FCC has adopted the low power widespread bandwidth of 3.1-10.6 GHz for ultra-wideband (UWB) services, many works during the past 15 years are concentrated on the design and modification of the antennas within this band taking into account low price, small size, wide impedance bandwidth, omnidirectional characteristics and easy fabrication. For that reason, the small size monopole microstrip antenna was a good candidate for this work moreover it could be used for many communication systems such as radar application, position and tracking systems, add-hoc systems and many others. Recently, microstrip antenna has been utilized for ultra-wideband technology by applying some modifications in antenna structure. The technique for expanding bandwidth of ultra-wide band antennas by using ground slot methods of various shapes and configurations like rectangular, partially circular triangular, and hexagonal under the back side of the feed line of the radiator are extensively considered for investigating impedance matching. Results of the simulation tests realized the influence of the slots on impedance bandwidth evaluation, radiation pattern features, gain performance, and radiation efficiency. A hexagonal slot on the ground surface accomplished the best fractional bandwidth improvement of 136.08 % for the magnitude of S_{11} < -10 dB among the other proposed slots configurations [1]. in [2] the authors investigated a Pacman-shaped antenna with a square ground cut under the top edge the feed line back to improve the performance of the impedance bandwidth. The proposed antenna offers a good impedance bandwidth feature between 2.9-15 GHz, and has approximately an omni-directional style radiation pattern. In [3], the authors introduced a unique small square slotted antenna with a variable band-stop characteristic for UWB purpose by modifying the proposed square antenna structure, the modification was made by inserting two G-shaped slots configurations in the ground and a T-shaped ring slot at square radiating patch. Both simulating and measuring evaluation showed that the proposed antenna can activate efficiently in the frequency range of 2.95 - 15.65 GHz with VSWR less than 2 and has rejection bands around 5.13GHz and 5.91 GHz. In [4] a circular patch antenna was investigated and modified by cutting the diagonal edges of the ground plane properly and inserting T-shaped slot. By this technique, the antenna obtained broader bandwidth of 3–12.62 GHz (123.32%) than the FCC typical bandwidth of 3.1–10.6GHz (109.45%). Many works with different ground cut was investigated to enhance the bandwidth properties receiving modification from 117% to 175%, such as M-shaped configuration presented in [5], other work used U-shaped structures [6,7], while inverted T-shaped used [8], a modified fork-shaped monopole antenna with two L shaped etched slot were investigated [9], moreover W-shaped, Π-shaped and a boat shaped slots configurations at the ground plane gives good results [10], beak-shaped structure [11], proper C-shaped slot gave a broad bandwidth with two band eliminations feature for WiMAX spectrum of 3.3-4.2 GHz and WLAN operating range of 5-5.96GHz [12], different squared shapes connected to each other's [13], and round grooves-shaped [14], To avoid electromagnetic interference between UWB and narrowband systems the monopole antenna was modified by inserting rectangular and arc-shopped slots on the ground, resulting in improved input reflection coefficient and the bandwidth [15].

This paper discusses the effect of the ground slots up on the bandwidth performance for a given ultra-wideband (UWB) antenna. investigated antenna is conventional UWB antenna of a monopole feature with a simple square radiator and partially ground plane and a microstrip transmission feed line style. Parametric study is done to evaluate the proper dimensions of the proposed antenna. Four different slots configurations (triangular, trapezoidal, rectangular and circular) have been inserted to the partial ground plane in the back side of upper edge of the feed line to evaluate the reference antenna

bandwidth characteristics. The effect of the single and multiple slots up on the bandwidth characteristics is investigated.

The remaining parts of this work are planned as: section 2 develops the proposed antenna design and structure. The simulation results with extensive discussions are presented in section 3. Finally, section 4 has the conclusion part.

II. ANTENNA DESIGN AND GEMETRICAL STRUCTURE

A conventional UWB antenna of a monopole like characteristic has been considered as a reference antenna. It is constructed from a copper square radiator mounted in the top side of PCB with a FR4-epoxy substrate with relative permittivity (ε) 4.4 and a dielectric tangent loss 0.024 and fed by a normal microstrip feed line of 50 Ω characteristic impedance. The bottom side of the PCB has a copper partial ground plane as displayed in Figure 1. The proper dimensions of the various antenna items are listed in table 1 [1].

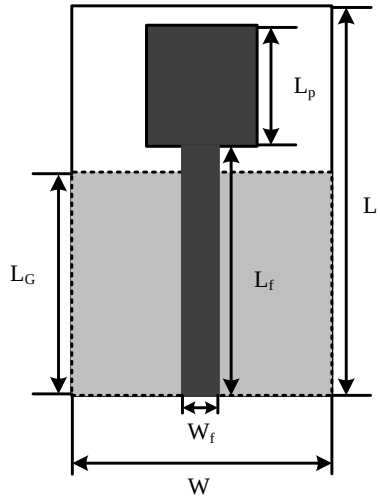


Figure 1: The reference UWB antenna geometrical structure.

Table 1: Proper dimensions of the reference UWB antenna elements.

Antenna's Item	Dimension [mm]
Substrate	W=23, L=35
Radiator	L_p=10
Transmission feed line	W_f=3, L_f=22
Partial ground plane	L_G=20

To examine the bandwidth performance of investigated antenna all over the UWB frequency range, single, double, and multiple slots configurations cases are cut on the ground plane on the back side of the feed line as illustrated in Figure 2. Slots cases of various configurations and numbers including: triangular, trapezoidal, rectangular and circular configurations, are used in this study. The proper slots dimensions are listed in Table 2.

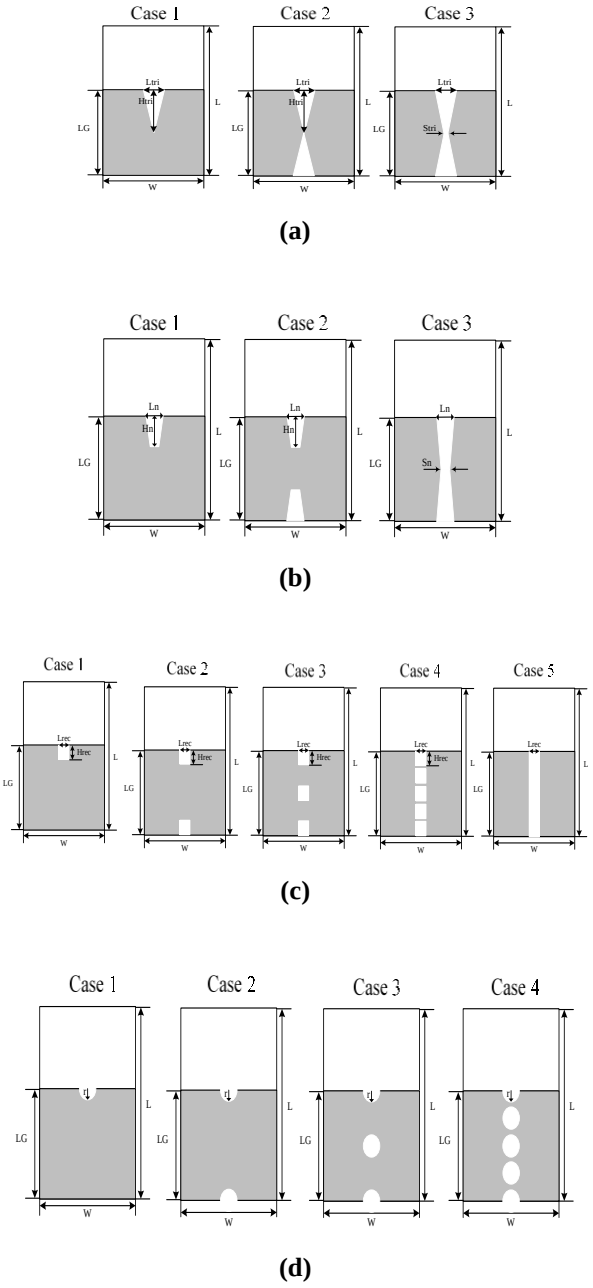
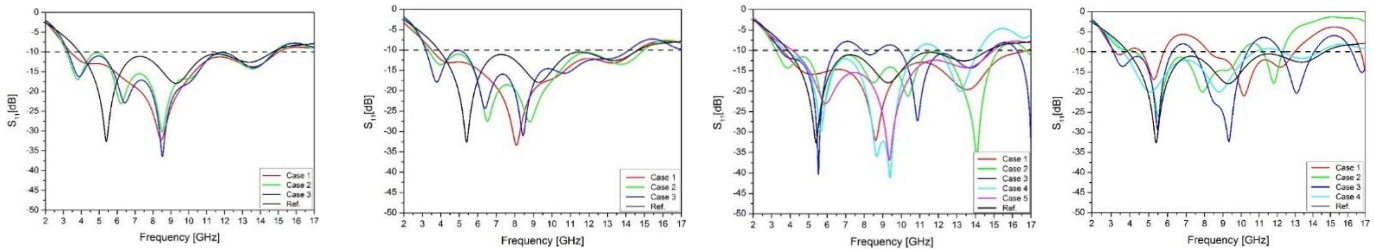


Figure 2. Cases of the slots configurations on the ground plane in the feed line back side.
(a) triangular slots, (b) trapezoidal slots, (c) rectangular slots, (d) circular slots

Table 2: The Dimensions of Different Slots Configurations.

Slot Configuration	Triangular	Trapezoidal	Rectangular	Circular
Dimensions	S_{tri} =1, L_{tri}=4,	L_n=4, H_n=6,	L_{rec}=3,	R=2
[mm]	H_{tri}=10	S_n=2	H_{rec}=3.2	

III. RESULTS AND DISCUSSIONS



(a) **(b)** **(c)** **(d)**

Figure 3. Investigated bandwidth characteristics for the proposed antennas with different slots configurations. (a) triangular slots cases, (b) trapezoidal slots cases, (c) circular slots case, (d) rectangular slots cases

To study the different antenna bandwidth performances, a simulation study using CST-EM software package has been carried out. The simulated S_{11} of the reference antenna (without slot case) and with different slots configurations and different numbers of slots are shown in Figure 3 and summarized in table 3. It can be realized that, the normal UWB antenna has a bandwidth of 4-14.9 GHz for S_{11} <-10 dB. However, applying different slots configurations and numbers, the antenna can have an improvement in bandwidth. In case of triangular and trapezoidal slots, there is an improvement in the bandwidth and there is no reject band characteristics. Although there is a bandwidth improvement in case of rectangular and circular slots, but most of the cases have at least one reject band performance as illustrated in Table 3. It is clear that, the bandwidth performance is affect by the type of slot configuration and number of slots.

Table 3: Bandwidth characteristics for the proposed antennas with different slots configurations cases.

	Slot Configuration	Band-width S_{11}< -10dB [GHz]	Band Reject S_{11}> -10dB [GHz]		Slot Configuration	Band-width S_{11}< -10dB [GHz]	Band Reject S_{11}> -10dB [GHz]
	Reference (without slot)	4-14.9	-	**Trapezoidal**	Case 1	3.5-14.2	-
Triangular	Case 1	3.5-15	-		Case 2	3.1-14.1	-
	Case 2	3.6-14.7	-		Case 3	3.1-14.9	-
	Case 3	3.1-14.9	-	**Rectangular**	Case 1	3.2-17	-
Circular	Case 1	4-14	10.5-12.4		Case 2	3.1-16.5	15.4-16.5
	Case 2	3-16.4	6.4-7.5, 10.5-12.4, 14.4-16.7		Case 3	3.5-16.2	6.4-7.5, 8.5-9.5, 14.5-16.2
	Case 3	3-16.4	3.5-4.6, 6-8, 13-16.4		Case 4	3.6-14	10.5-12.2
	Case 4	4-12	9.5-11.5		Case 5	4-14.9	-

IV. CONCLUSION

In this paper, the influence of the ground slots up on the bandwidth performance for ultra-wideband (UWB) antenna has been discussed. The reference monopole antenna is a square radiator with microstrip type feed transmission line and partially ground plane. Parametric investigation is employed to evaluate the proper dimensions of the proposed antenna. Four different slots configurations (triangular, trapezoidal, rectangular and circular) have been inserted to the partial ground plane on the back side of the feed line to alter the conventional antenna bandwidth characteristics. The effect of the single and multiple slots up on the bandwidth characteristics has been investigated. The final simulation results demonstrate that the bandwidth of the antenna can be enhanced or has some reject bands based on the slots configurations and the numbers of inserted slots.

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