

# Design Microstrip Patch Antenna for Ultra Wideband Applications

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**ABSTRACT:** This paper describe the bandwidth improvement of compact wideband microstrip patch antennas using ground slot and designed with microstrip feed line. The multi-slots of different microstrip antennas shapes such as triangular and rectangular placed on the ground plane under the feed line of the radiator. The antennas are good impedance matching with microstrip line feed. The effects of the slots on the performance of antennas, in terms of impedance bandwidth, radiation pattern, gain and efficiency are studied. Results of simulation shows that the ground slot with proper dimensions placed under the feed line can improve the impedance matching. Hence increase the bandwidth without affecting the performance of antenna. Further, it is also observed that a stable omnidirectional radiation patterns the bandwidth and achieves moderate gain and efficiency across the wide band applications. Planar microstrip multi-slot UWB antennas are designed to satisfy the requirements of the UWB systems and minimize the interferences from WLAN applications. The UWB antenna consists of simple rectangular patch antenna with 50  $\Omega$  microstrip feed line. Investigations have been carried to cut steps in the four corners of the rectangular patch and to add slots in the ground plane. The covered BW at RL 10 dB is 3.42–11.7 GHz with good impedance matching. Slots are inserted in the patch and in the feed line to create rejection bands at WLAN and X-band frequency ranges respectively.

**KEYWORDS:** Ultra wideband, radiation pattern, gain, return loss, VSWR etc.

## I. INTRODUCTION

The study of patch antennas has made great progress in recent years and compared with conventional antennas patch antennas has several advantages and better prospects. Patch antennas are light in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover, the microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed line flexibility and beam scanning omnidirectional patterning. Basically microstrip element consists of an area of metallization support above the ground plane, named as microstrip patch. The supporting element is called substrate material which is placed between the patch and the ground plane. The microstrip antenna can be fabricated with low cost lithographic technique or by monolithic integrated circuit technique [1-10]. Using monolithic integrated circuit technique we can fabricate phase shifters, amplifiers and other necessary devices, all on the same substrate by automated process. In majority of the cases the performance characteristics of the antenna depends on the substrate material and its physical parameters [11-25]. A simpler and effective method by cutting a slot on the ground plane under the feed line has been proposed and studied. In these studies, rectangular slots were most often used. Other shapes such as triangular, trapezoidal and T-Shape have been also studied. In these studies, different shapes of radiators were used, so it is difficult to say which slot shape is the best choice for UWB antennas. In this paper, attempts are made to and out the best slot shape for the UWB antenna. This paper describes effects of using different slot shapes on the performance of an UWB antenna, in terms of impedance bandwidth, radiation pattern, gain and efficiency. In this paper a compact microstrip-fed monopole antenna with a square radiator and a partial-ground plane is used for simulation. Modelling, simulation and analysis of a compact size Ultra Wide Band (UWB) micro-strip patch antenna with improved antenna characteristics and increased bandwidth is studied using High Frequency Structural Simulator (HFSS) using version 13.0.

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## II. RELATED WORK

The rapid growth in wireless communication systems created huge demands for wide band antenna to satisfy high gain and large bandwidth covering all frequency ranges for these systems. In FCC approved the UWB technology in the frequency range of 3.1-10.6GHz with maximum radiated power-43.3dB/m/MHz and data rate between 110 to 200 Mbps with in 10m distance [7]. The advantages of the UWB technology are high data rate, less interference, secure. Low cost and low complexity. It is used in different applications such as radar, imaging in medicine and military communication. UWB patch antennas could be designed with different geometries; i.e triangular, circular disk, strip loop square [9, 10, 12, 17]. Several methods are used to enhance its bandwidth by using parasitic structures and other different arrangements [3, 9, 18]. Recently, researchers focus on designing UWB antenna with band rejection characteristics to eliminate any interference from narrowband wireless applications. This is achieved by adding slots with different shapes in the patch, feed and ground plane [1, 2, 4,5, 6, 12]. This paper describe the bandwidth improvement of compact wideband microstrip antennas using ground slot and designed with microstrip feed line. The slots of different shapes such as triangular and rectangular placed on the ground plane under the feed line of the radiator. The antennas are good impedance matching with microstrip line feed. The effects of the slots on the performance of antennas, in terms of impedance bandwidth, radiation pattern, gain and efficiency are studied. Results of simulation shows that the ground slot with proper dimensions placed under the feed line can improve the impedance matching. Hence increase the bandwidth without affecting the performance of antenna. Further, it is also observed stable omnidirectional radiation pattern across the whole bandwidth and achieves moderate gain and efficiency across the wide band applications. To improve the antenna BW and matching, round steps are added to the lower and upper corners of the patch besides adding the ground slot. Cutting steps at the bottom of the radiator increases the distance between the patch and the ground plane, which tunes the capacitive coupling between them [16] cutting steps in the upper corners of the patch tunes the inductive part of the antenna that neutralizes the capacitive coupling between the ground and the patch to get pure resistive input impedance [9] while the ground slot neutralizes the capacitive effects through the inductive nature of the patch to get nearly pure resistive input impedance [14]. The simulated RL results show better impedance matching and wider BW when adding one lower round step rather than two, a small enhancement in the impedance matching when adding one upper round step compared to that without upper steps over the whole frequency range, while adding ground slots improve the impedance matching at the higher frequency band more than the lower band. The simulated RL which is equal to  $-S_{11}$  (scattering parameter), shown in Fig.3, for the proposed antenna shown in Fig. 1, shows that with RL P 10 dB the antenna has BW 3.42–11.7 GHz with minimum RL of 17 dB.

## III. DESIGN AND SIMULATION OF MICROSTRIP ANTENNAS

The geometry of the microstrip-fed wideband monopole antenna without slot is shown in Fig. 1, which is used as a reference antenna in our study. The antenna is designed on a FR4 substrate with a thickness ( $h$ ) = 1.6 mm, a dielectric constant ( $\epsilon_r$ ) = 4.2 and a loss tangent ( $Tan\delta$ ) = 0.02. The square radiator printed on one side of the substrate has a length of  $L_p$  and is fed by a microstrip line with a length of  $L_f$  and a width of  $W_f$ . A partial-ground plane with the dimension  $L_g$  and  $W$  is printed on the other side of the substrate. The overall antenna occupies an area of  $L$  and  $W$ . The performance of the antenna is optimized, in terms of maximizing the bandwidth (for  $S_{11} < 10$  dB) and stabilizing the radiation pattern (omnidirectional), using the EM simulation tool HFSS. To improve the impedance matching of the antenna throughout the wideband, a small slot is cut on the upper edge of the ground plane under the feed line as shown in Fig. 2. Slots of different shapes including: (a) triangular, (b) rectangular. Design of a microstrip patch antenna with ground slot and plotting the S-parameter, VSWR and radiation pattern with a frequency band of about 3.1-10.5 GHz. Changing the values of substrate, patch and also changing the sweep frequency to obtain a desired bandwidth of minimum 40-50%. Designing of a patch antenna using different feed techniques, multi-substrate patch, parasitic patch, basic microstrip patch antenna, coaxial feed to get a desired bandwidth of about 40-50%. The method of using a ground slot for bandwidth improvement of a compact wideband planar monopole antenna has been studied. The antenna has a compact size of 35mm and 23mm and the small ground slot is placed under the feed line on the ground plane. triangular, rectangular have been used for studies by simulation. Results have shown that the slots can improve

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impedance matching of the antenna with little effect on the radiation characteristics. Among these slots investigated, the hexagonal slot provides the largest impedance bandwidth of 3.1-16.3 GHz for  $S_{11} < 10$  dB, with an average gain of about 2.8 dBi and an average efficiency of about 88%. The application of microstrip patches antennas for integrated phased array system, GPS (satellite navigational system), mobile satellite communications, the direct broadcast satellite (DBS) system and remote sensing applications. From the transmission line model of rectangular patch antennas, It is clear that the three essential parameters for the design of rectangular microstrip patch antennas are the frequency of operation ( $f_0$ ) = 1.9 GHz, dielectric constant of the substrate ( $\epsilon_r$ ) = 11.9 and height of the substrate ( $h$ ) = 1.5mm. We obtained  $W = 31.1$ mm,  $L = 22.8$  mm,  $\epsilon_{eff} = 10.787$ ,  $L_{eff} = 24$ mm. The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery.

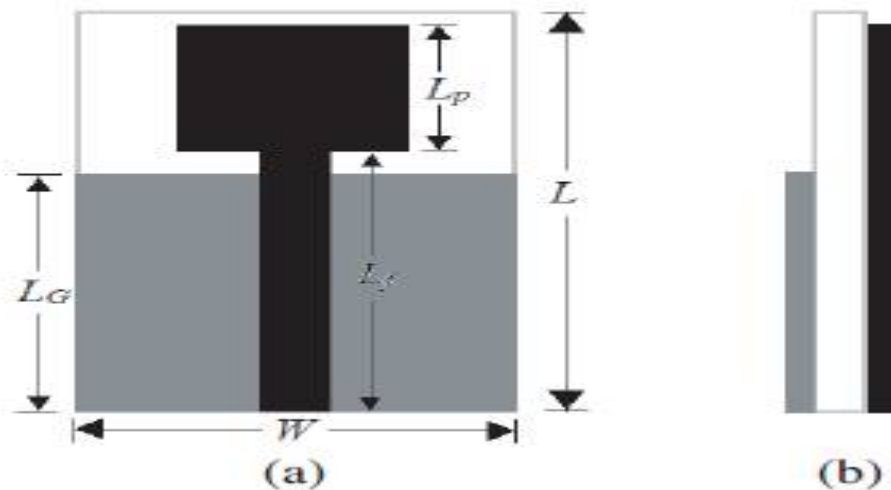


Fig 1: Geometry of UWB antenna without slot: (a) front view, (b) side view

## IV. SIMULATED RESULTS

The geometry of the microstrip-fed UWB monopole antenna without slot is shown in Fig. 1. The antenna is designed on a FR4 substrate with a thickness of 1.6 mm, a dielectric constant of 4.2 and a loss tangent of 0.02. The square radiator printed on one side of the substrate has a length of  $L_p$  and is fed by a microstrip line with a length of  $L_f$  and a width of  $W_f$ . A partial-ground plane with the dimension  $LG$  and  $W$  is printed on the antenna is optimized, in terms of maximizing the bandwidth (for  $S_{11} < -10$  dB) and stabilizing the radiation pattern (omnidirectional radiation pattern), using the EM simulation tool CST. The optimized dimensions are:  $L_p = 10$  mm,  $L_f = 22$  mm,  $W_f = 3$  mm,  $LG = 20$  mm,  $W = 23$ mm and  $L = 35$  mm. To improve the impedance matching of the antenna throughout the UWB, a small slot is cut on the upper edge of the ground plane under the feed line as shown in Fig. 2. Slots of different shapes including: (a) triangular, (b) rectangular shapes are used in our investigations. The rectangular and triangular slots of patch antennas are shown in Fig.2. The simulated  $S_{11}$  of antenna without slot and multi slot is shown in Fig.3. The simulated S-parameter, return loss, VSWR and radiation pattern plots are shown in Figs 4 to 6.

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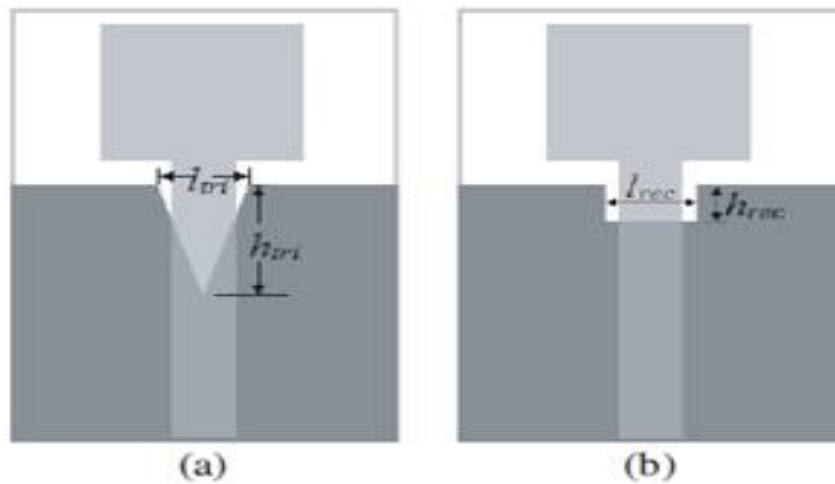


Fig.2 Patch antennas with different slot shapes: (a) triangular slot, (b) rectangular slot

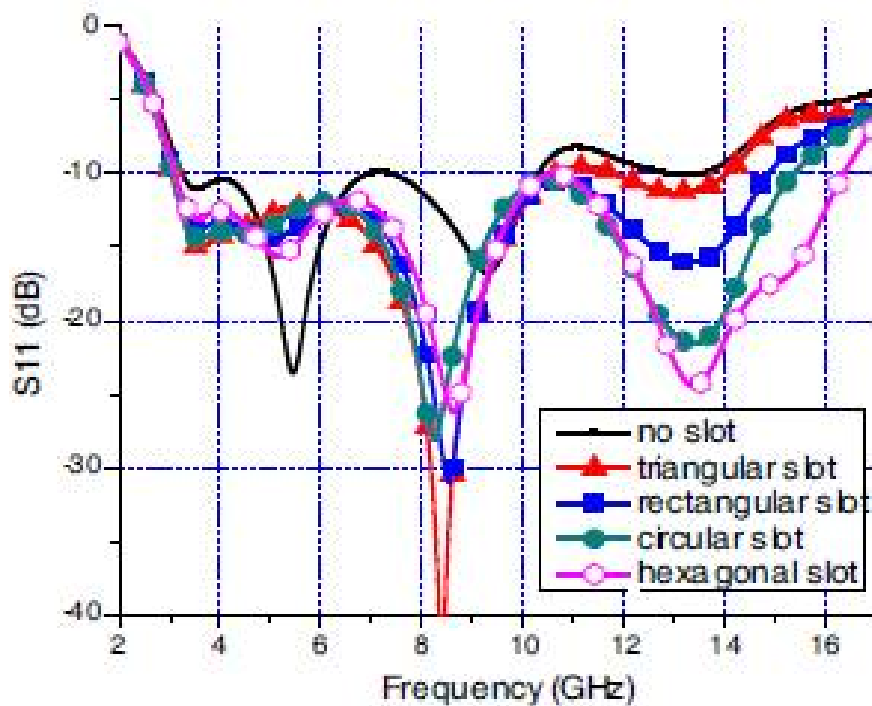


Fig.3 Simulated  $S_{11}$  of antennas without slot and with different shapes of slots.

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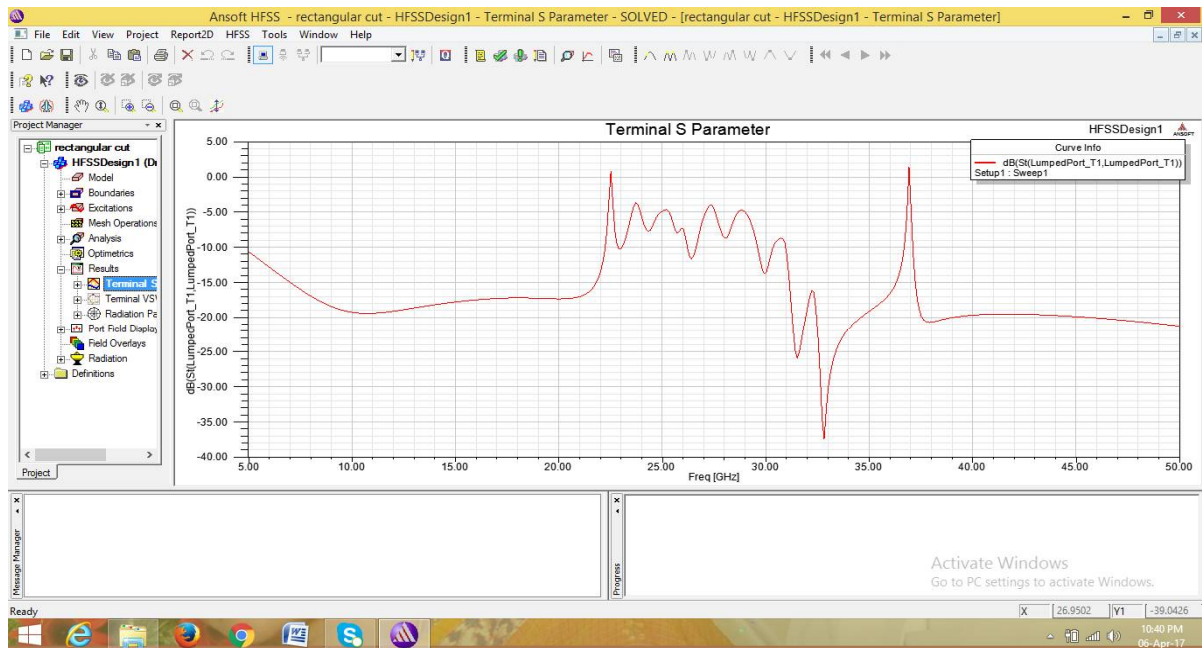


Fig.4 Simulated S-parameter of rectangular microstrip patch slot antenna

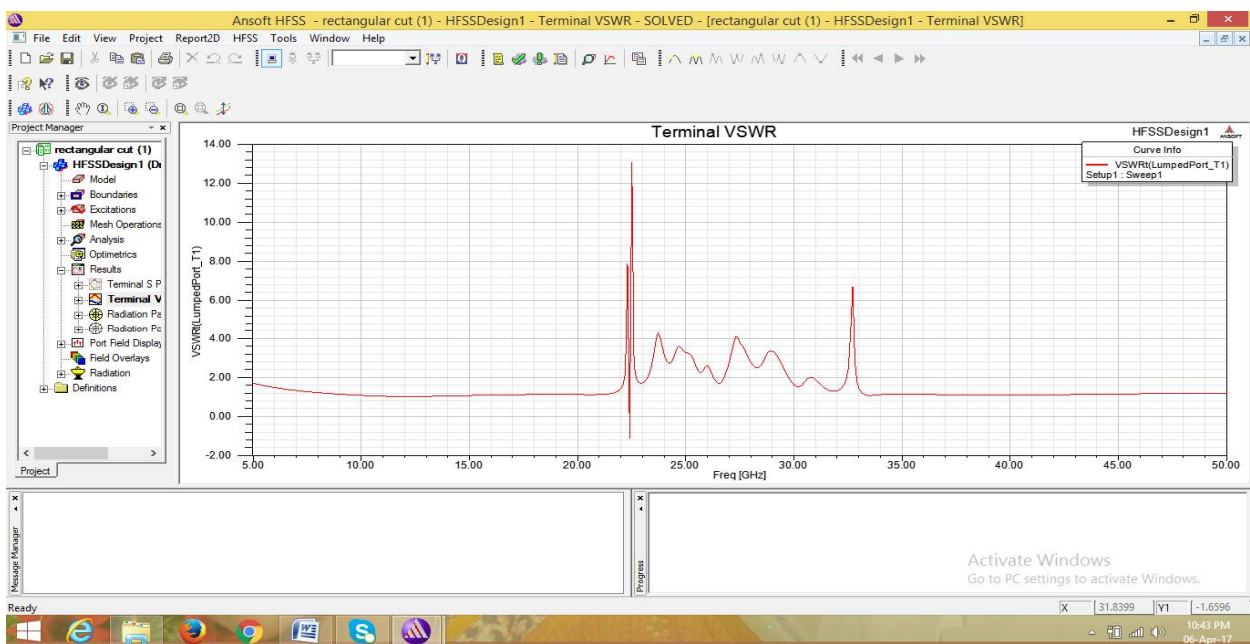


Fig. 5 Simulated VSWR plot of rectangular microstrip patch slot antenna



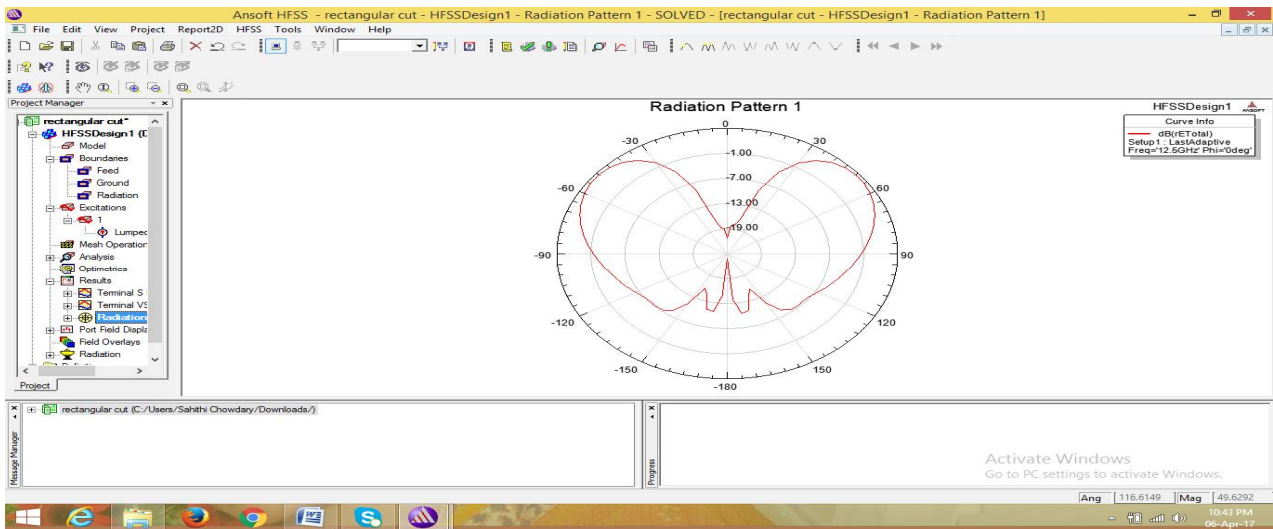


Fig.6 Simulated radiation pattern of rectangular microstrip patch slot

## V. CONCLUSION

This paper describes the bandwidth improvement of compact wideband microstrip antennas using ground slot. The microstrip patch antennas are designed with microstrip line feed. The slots of different shapes such as triangular and rectangular placed on the ground plane under the feed line of the radiator. The antennas are good impedance matching with microstrip line feed. The effects of the slots on the performance of antennas, in terms of impedance bandwidth, radiation pattern, gain and efficiency are studied. Results of simulation shows that the ground slot with proper dimensions placed under the feed line can improve the impedance matching. Hence increase the bandwidth without affecting the performance of antenna. Further, it is also observed stable omnidirectional radiation pattern across the whole bandwidth and achieves moderate gain and efficiency across the wide band applications. The antenna has a compact size of 35mm × 23mm and the small ground slot is placed under the feed line on the ground plane. Triangular, rectangular have been used for studies by simulation. Results have shown that the slots can improve impedance matching of the antenna with little effect on the radiation characteristics. The major parameters (such as Return-loss, radiation patterns and gain) that affect design and applications were studied and their implications understood. The constructed slotted waveguide antenna operated at the desired frequency and power levels. Several patch antennas were simulated (using HFSS) and the desired level of optimization was obtained. It was concluded that the hardware and software results we obtained matched the theoretically predicted results. Planar compact multi-slot UWB antennas are designed to satisfy the requirements of the UWB systems and minimize the interferences from WLAN applications. The UWB antenna consists of simple rectangular patch antenna with 50  $\Omega$  microstrip feed line. Investigations have been carried to cut steps in the four corners of the rectangular patch and to add slots in the ground plane. The covered BW at RL 10 dB is 3.42–11.7 GHz with good impedance matching. Slots are inserted in the patch and in the feed line to create rejection bands at WLAN and X-band frequency ranges respectively.

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