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Parametric Analysis And Design Of Rectangular Microstrip Patch Antenna for Ultra-wideband Application

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ABSTRACT

A compact monopole micro strip rectangular patch antenna having truncated ground plane(TGP) with notches is presented in this paper. Ultra-wide band (UWB) patch antenna is feed by micro strip line feed. Parametric analysis have been conducted by designing the pair of notches on both patch and ground plane, analysis by varying the distance between rectangular radiating patch and truncated ground plane, at last by obtaining micro strip feedline position. Optimum results are observed when gap between the radiating patch and TGP is 1mm and for centered feeding of microstrip feedline. The obtained reflection coefficient is less than -10dB for a frequency range of 3.1GHz to 12 GHz. The proposed antenna has been designed on a FR4 substrate with dielectric constant ϵr = 4.4, loss tangent (tan δ) = 0.02. The radiation pattern is directional in E-plane and nearly omnidirectional in H-plane. Efficiency decreases at the higher frequency edge due to the lossy substrate and it is upto 70%. The UWB antenna is simulated using CAD FEKO 6.2 suit electromagnetic simulator using MoM (Method of Moment).

Key words : Patch antenna, UWB, Radiating patch, truncated Ground plane

1. INTRODUCTION

The U.S. Communication Commission (FCC) authorized the unlicensed use of the ultrawideband (UWB: 3.1–10.6 GHz) in February 2002[2]. As the microstrip antennas are having various advantages as are low profile, conformable to planer & non planer surfaces, simple, low cost also easy to manufacture using modern printed circuit technology they are widely used in various applications. The radiating patch can be of square, rectangular, circular or any other configuration. But square, rectangular, circular & strip line shape are most common because of their radiation characteristics, especially low cross polarization [1]. For many years significant research activities and interests have been aroused in wideband applications for different communication applications [3]-[5]. Recently various academic and industrial field also shown their interest to explore various UWB antennas [6]-[7].

The main challenge in UWB antenna design is to achieve the wide impedance bandwidth while maintaining high radiation efficiency. A planar antenna is also desirable given that there are several additional constraints and challenges for the design of a UWB system antenna. In this article we present a rectangular compact planer monopole antenna having pair of notches on at patch lower corners & truncated ground plane with micro strip feed line.

At last parametric analysis is done on various parameters such as designing the pair of notches on both patch and ground plane, analysis by varying the distance between rectangular radiating patch and truncated ground plane, obtaining microstrip feedline position.

2. ANTENNA DESIGN

Fig. 1 shows the configuration of rectangular microstrip patch antenna with pair of notches at lower corner edges of rectangular patch and a truncated ground plane having pair of notches.

The proposed antenna, has the dimension of 25mm X 33mm (W_{sub} X L_{sub}), is constructed on FR4 substrate with thickness of 1.6 mm and relative dielectric constant of 4.4 having loss tangent (tan δ) of 0.02. The width W_f of the micro strip feed line is fixed at 3 mm. On the upper surface of the substrate, a rectangular patch with size of W_p X L_p is printed. The rectangular patch has a distance of to the ground plane printed on the back surface of the substrate. By cutting the two notches L_1 X W_1 and L_2 X W_2 of suitable dimensions at the monopole's two lower corners, it is observed that much enhanced impedance bandwidth can be achieved for the proposed antenna. This thing occurs because of two notches affects the electromagnetic coupling between patch and ground plane.

In addition to this, to obtain the more enhanced bandwidth the pair of notch is obtained on the ground plane of L_3 X W_3 and L_4 X W_4 , Also the distance between patch and ground plane and position of microstrip feedline is 1mm obtained by the way of simulation . This parameter is important to determine the sensitivity of impedance matching.

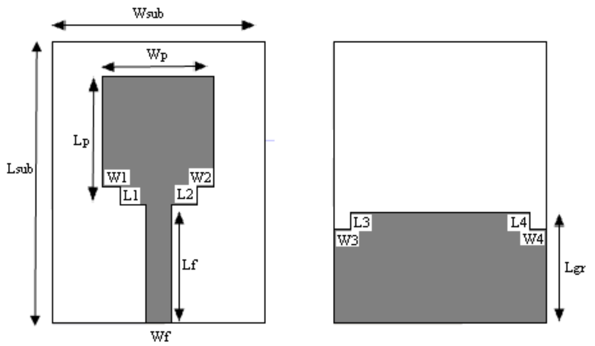


Fig. 1. Configuration of proposed antenna

The optimized dimensions of proposed antenna are as follows: W_{sub} =25mm, L_{sub}=33mm, W_p=13mm, L_p =15mm, W_f =3, L_1 =L_2 =L_3 =L_4 =2mm, W_1 =W_2 =W_3=W_4=2mm, L_f=14mm, L_{gr}=13mm. This is found that using these dimensions the antenna satisfies requirements of UWB antenna from 3.1GHz to 12Ghz.

3. RESULT & DISCUSSION

In this section, theoretical results of proposed compact planar antenna having notches at lower corner of patch and TGP are presented which is simulated and designed using CADFEKO simulation software version 6.2 [9].

To obtain the UWB frequency, Analysis of the antenna is done on various parameters firstly the plane rectangular microstrip antenna is designed and simulated. The simulated results are as shown in fig. 2, from results it is observed that patch the obtained reflection coefficient is below -10dB for frequency range of 3.25 GHz to 12GHz which is not the expected one. After the result analysis the notches of L_1 =L_2 =2mm and W_1 =W_2=2mm on the patch are designed and compared as shown in fig. 2 it is observed that antenna is radiating its frequency for 3.2GHz to 12GHz except band of 8.5GHz to 9.5GHz.

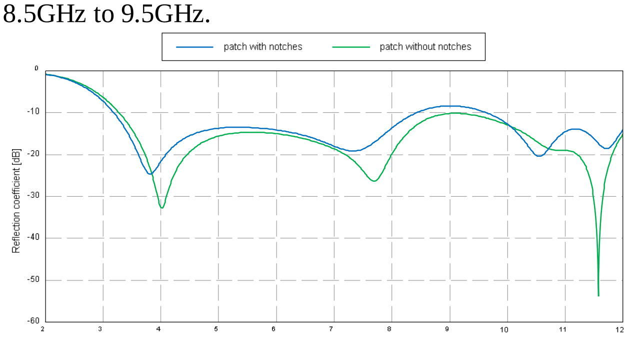


Fig.2(a)- Simulated reflection coefficient for Comparison of with & without notches on rectangular patch

As notched band is obtained for 8.5GHz to 9.5GHz the second parameter is defined to optimize the bandwidth i.e. designing of notches at the ground plane. Fig.3 shows the simulated results obtained after obtaining notches on the rectangular patch. Firstly the plane antenna without any notch on the ground plane is designed and simulated, Secondly the notch of 2mm X 2mm is designed at the center of ground plane and at lastly pair at the lower corner of the patch designed to obtain the proper enhanced bandwidth of the antenna and its size is fixed at the notches of size L_3=L_4=2mm and W_3=W_4= 2mm. The results for this parameter are obtained and analyzed as shown in fig. 3.

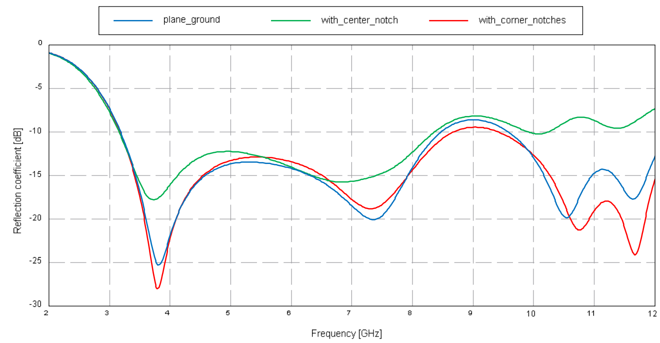


Fig.3-Simulated reflection coefficient for Comparison of (i)plane ground, (ii)with notch designed at the centre of ground plane & (iii)with corner notches on ground plane

The results shows that, by designing the planar ground the notched band frequency is reduced while for the notch designed at its center has rejected the higher edge frequencies but the antenna has shown its better performance for the pair of notches design at the corner of ground plane and VSWR < 2 for the same.

To have the better performance of the designed antenna, The distance between the rectangular patch having notches at its lower corner and truncated ground plane is varied and simulated. The fig.4 describes this parameter to analyze an antenna. From the simulated results it is observed that for distance of 0.75mm antenna has the better gain but the obtained frequency is from 3.3GHz to 12GHz. So, by the way of simulation for 1.5mm distance the rectangular patch and truncated ground plane an antenna starts rejecting the higher edge frequencies and gain of antenna is also reduced. While for 2mm distance, it has obtained small bandwidth of 4.8GHz as compared to the previous results. At last for the distance of 1mm it has exhibited the highest bandwidth and starts operating from 3.1 GHz to 12GHz.

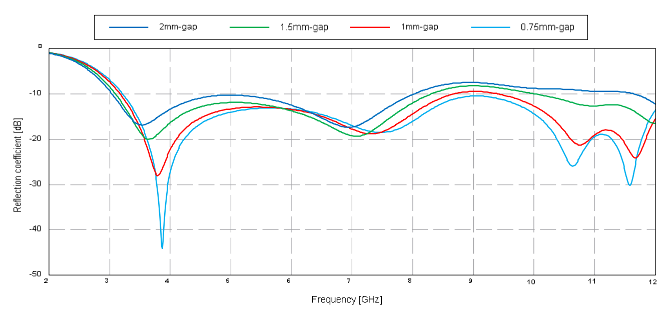


Fig.4(a)- Simulated reflection coefficient for the distance between rectangular patch and truncated ground plane at (i)0.75mm,(ii)1mm,(iii)1.5mm&(iv)2mm

To have the proper impedance matching the micro strip feedline is used having fixed feed width of W_f =3mm and helps to reduce the inductive nature of the antenna with increasing the characteristics impedance and antenna starts radiating the higher gain & efficiency.

In this design to obtain these parmeters microstrip feedline position is varied from its center to left hand side(LHS) by 2mm and right hand side(RHS) by 2mm at last simulated. Fig.5 shows simulated results for various feed positions. From simulated results it is observed that when the feed position was shifted towards LHS by 2mm the moderate gain was obtained and for RHS gain is being lowered at higher edges of frequencies. While for the centered feed position antenna has obtained higher gain also the better efficiency for this position and accomplished the frequency from 3.1GHz to 12GHz.

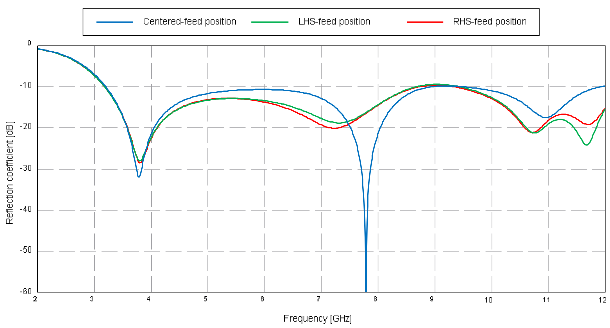
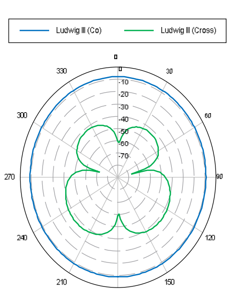
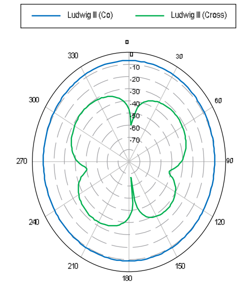


Fig.5(a)- Simulated reflection coefficient by variation of feed position at (i)Center, (ii)LHS, (iii)RHS

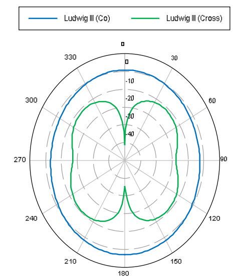
In fig.6. various radiation patterns obtained for E-plane and H-plane at 3.5GHz, 5.5GHz and 7.5GHz frequencies are shown. The Ludwig co-polarization and cross polarization is obtained for both E-plane and H-plane. In figure 6(a),(b) and (c) the radiation pattern for H-plane along the *x-z* axis at 3.5 GHz, 5.5GHz & 7.5GHz is shown. While in figure 6(c),(d) and (e) the radiation pattern for E-plane along the *y-z* axis at 3.5 GHz, 5.5GHz & 7.5GHz is shown. From simulated results it is observed that for E-plane as smaller is the cross polarization higher gain is obtained[1]. At 3.5GHz frequency the antenna operates at higher gain and efficiency about 90% is obtained, At frequency of 5.5GHz the gain of an antenna decreased moderately while at higher edge frequency of 7.5GHz cross polarization is increased which leads to decrease the gain of an antenna. Also it is observed that for H-plane typical eight shaped pattern is obtained at lower edge frequencies and As the frequency increases the number of lobes starts varying sometimes the number of lobes starts increasing[8].



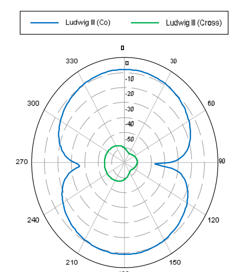
(a)H plane at 3.5GHz



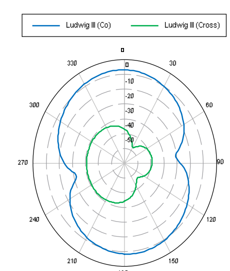
(b)H plane at 5.5GHz



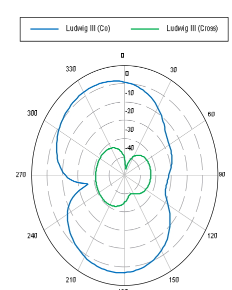
(c)H plane 7.5GHz



(d)E plane at 3.5 GHz



(e)E plane at 5.5GHz



(f)E plane at 7.5 GHz

Figure 6. Simulated Radiation patterns obtained along E-plane and H-plane at 3.5GHz, 5.5Ghz & 7.5GHz

4. CONCLUSION

The design and parametric analysis of compact planar rectangular microstrip patch antenna has been designed and simulated using CADFEKO 6.2 simulator version for ultrawideband application. By the way of different parametric analysis like designing the pair of notches on both patch and ground plane, analysis by varying the distance between rectangular patch and truncated ground plane, obtaining microstrip feedline position to have proper impedance matching to enhance the bandwidth. Antenna operates satisfactorily from 3.1 to 10.6GHz for VSWR<2. The radiation pattern is directional in E-plane and nearly omnidirectional in H-plane. Efficiency decreased at the higher frequency edge due to the lossy substrate about 70%. The results and discussion proves that the designed antenna is a good component for hand held microwave applications. In future the designed antenna can be reconfigured to avoid the interference of narrowband systems in UWB applications.

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