

A CPW Fed Octagonal Patched Antenna for UWB Applications

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Abstract

In this paper, we present a CPW fed octagonal patch antenna with hexagonal slot for ultra wideband (UWB) application. The proposed antenna is designed on FR4 substrate with dielectric constant 4.4 has dimension 29 X 31 mm² and it covers a frequency range of 3.1 - 10.6 GHz for (VSWR \leq 2). The fundamental parameters of the antenna such as return loss, VSWR, 2D radiation patterns, gain and bandwidth are obtained and all meets of the acceptable antenna standards. The simulation results of this antenna are analyzed by using Zealand IE3D version 15.10 which is based on Method of moments.

Keywords: Coplanar waveguide(CPW), Ultra wideBand(UWB), Return Loss , VSWR, Gain

Introduction

Since Federal Communication Commission (FCC) released a frequency band of 3.1-10.6 GHz for commercial UWB applications in 2002 [1]. This technology has gained attention in both industry and academia [2]. UWB systems have various merits such as lower power consumption and high data transmission rate. Planar antenna is one of the key elements in this system. Hence, design of UWB antenna has gained attraction in wireless field. Planar slot antennas [3]-[4] have become popular among recently proposed antennas due to small size, wide bandwidth and ease of integration with RF front ends. However, the time domain analysis of UWB antenna is not analyzed with mathematical expressions. Conventional Microstrip antenna has disadvantage of narrow impedance bandwidth. Many techniques such as E-shaped patch [5], defected ground plane structure (DGS) [6] have been proposed to increase the impedance bandwidth of the Microstrip antenna. However, they cannot provide large bandwidth. This can be rectified by using coplanar waveguide (CPW) feed with different radiating patches like elliptical [7], crescent patch [8] etc. for ultra-wide bandwidth. Ultra wideband antenna has various applications such as location tracking, radio frequency identification, in radars, sensor networks. UWB system faces several challenges. Since UWB antenna has pulse based transmission, phase should be constant over entire operating band to avoid pulse distortion in wireless communications. Secondly, the return loss of the antenna should be maintained below -10dB throughout operating band. Thirdly, the antenna should also be miniaturized so that fabrication is simple and it can be easily integrated with modern communication terminals [9]-[13]. The gain

of antenna is a function of frequency and radiation pattern. Hence, the antenna should receive signals in all directions. The characteristics such as VSWR, return loss, gain and radiation pattern are discussed in this article.

In this paper, a CPW-fed rectangular shaped antenna is presented for UWB applications. The antenna has better impedance matching and good radiation patterns over the UWB. The optimized geometry of the proposed CPW-fed antenna is rectangular shaped containing hexagonal slot. The effects of various geometrical parameters of the antenna on return loss and bandwidth are investigated by parametric study and they are presented in this paper. The radiation patterns of antenna in both E-plane and H-plane are simulated and presented. The 3D Current distribution and gain of antenna are also being discussed

Antenna Structure and Design

The geometry of antenna is shown in Fig.1. The antenna is printed on FR4 dielectric substrate with dielectric constant $\epsilon_r=4.4$, loss tangent $\tan\delta=0.002$ and thickness of 0.8mm. The antenna has compact size of 28 × 31 mm² and it is fed by CPW. The gap 'g' between center conductor and ground plane of CPW is 0.45mm. The CPW feed has 50ohm characteristic impedance and it is terminated by subminiature version A (SMA) connector. Since the patch and feed structure are constructed on the same plane, one metallic layer only is present. Hence, the antenna can be easily fabricated and it has low cost. The antenna has novel tuning stub in Hexagonal-like slot. The antenna is optimized with

Zealand IE3D electromagnetic solver. The total width 'W' and length 'L' [14] of planar antenna are given by the Eq.1.

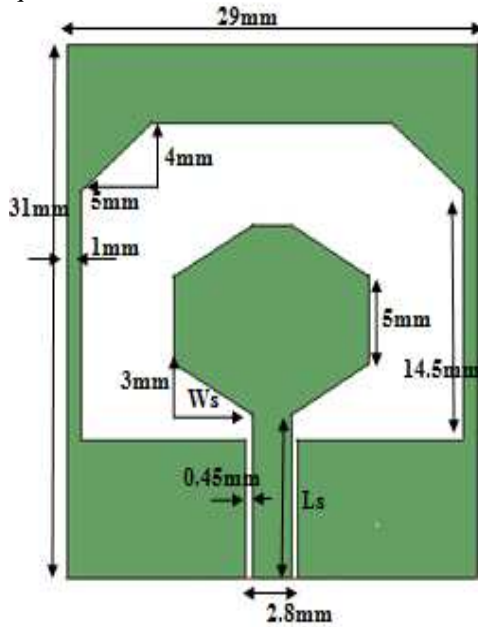


Figure1. Geometry of the proposed antenna

$$W = L = \frac{c}{2f_l \sqrt{\epsilon_{eff}}} \quad (1)$$

Where c is velocity of light in free space and f_l is the lowest operating frequency corresponding to free space wavelength λ_o .

$$\text{where } \lambda_o = \frac{c}{f_l} \quad (2)$$

and

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} \quad (3)$$

The theoretical values of W and L are obtained from Equation.1 for the lowest resonant frequency $f_l = 3.1$ GHz and dielectric constant $\epsilon_r = 4.4$. The optimized values of W and L are obtained using IE3D electromagnetic solver. These values are shown in fig. 1.

Simulation Results and Discussions

Figure.2 shows that, the simulated return loss characteristics of proposed CPW fed octagonal patched UWB antenna. From the figure it can be seen that, proposed antenna resonates between 3.1-10.6 GHz with good matching. From return loss characteristics it is found that, antenna shows return loss is below -10dB

for the operating band at 3.1-10.6GHz and peak return loss is around -43dB and it covers entire UWB range

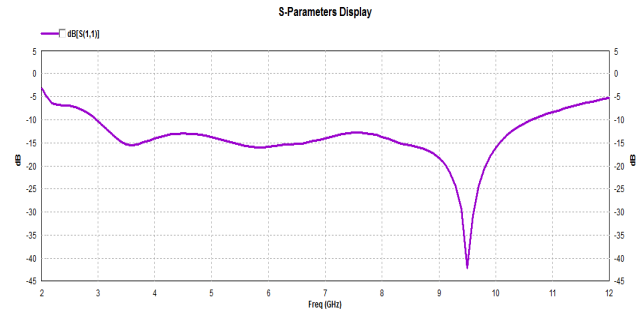


Figure 2 Return loss characteristics of proposed antenna

Parametric Analysis

In this section, the effects of different geometric parameters of antenna on return loss and bandwidth are investigated for the proposed antenna. This helps to design UWB antenna with wider bandwidth. The parametric study is performed and the performance of antenna is analyzed with IE3D electromagnetic solver. The analysis is done by varying one parameter at a time, keeping all other parameters constant.

Effect of Bottom Length W_s of Patch

Figure.3 shows that, the variation of resonance characteristics of proposed antenna with bottom length W_s . When it increases from 3.5 to 5.5mm, from the figure 3 it can be seen that, there is a shift in highest as well as the lowest resonating frequency. The impedance bandwidth also changes due to inductive and capacitive effects, which are produced by electromagnetic coupling between ground and patch. Since change in W_s affects impedance matching at resonant frequencies, So this parameter plays an important role in improving bandwidth. Hence, the simulated analysis shows that the antenna has better impedance matching at ultra-wide bandwidth for the optimum value $W_s = 5.5$ mm.

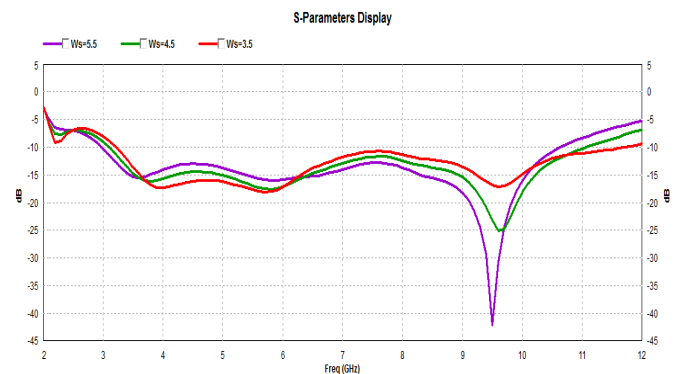


Figure.3 comparison of return loss characteristics of proposed antenna by various W_s

Effect of feed length L_s

The parameter L_s has great effect on performance of antenna as shown in Figure 4. This parameter is optimized such that there is proper coupling between feed lines to the patch. The antenna is simulated for various values of L_s starting from 8.5 to 10.5 mm.

From simulation results, it is observed that the impedance matching is poor at $L_s = 8.5$ mm. As L_s increases from 8.5 to 10.5 mm, the simulated lowest and highest resonating frequency shifted. The impedance bandwidth also changes. Hence, it is concluded that the L_s affects more on lowest, highest resonating frequencies and impedance bandwidth. The antenna has better impedance matching at the optimum value $L_s = 9.5$ mm.

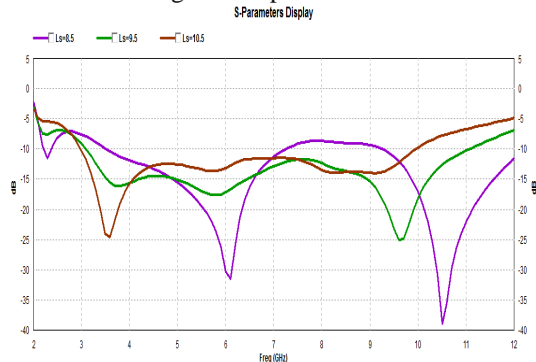


Figure.4 comparison of return loss characteristics of proposed antenna by various L_s

Figure 5 shows the simulated voltage standing wave ratio (VSWR) of the proposed antenna is less than 2 for entire frequency range of 3.1 to 10.6GHz. From figure it is clear that standing wave ratio is around 1 for entire operating band which satisfies 2:1 VSWR bandwidth.

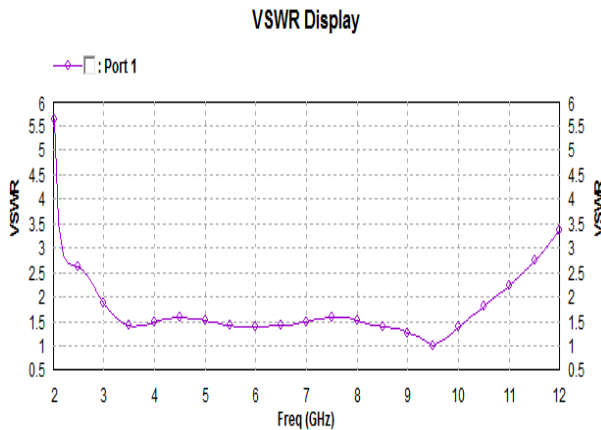


Figure.5 VSWR characteristics of proposed antenna

Figure 6 and 7 shows the simulated radiation patterns with Elevation and azimuthal plane at 9.5GHz frequency by using ZELAND IE3D software. The

antenna has bi-directional radiation patterns in E-plane at 9.5 GHz resonant frequency. In H-plane, the antenna has Omni-directional radiation patterns, which indicates that it can receive the signals in all directions. The patterns and other curves are obtained at the time of simulation. We observed good radiation patterns by taking 20 cells per wavelength.

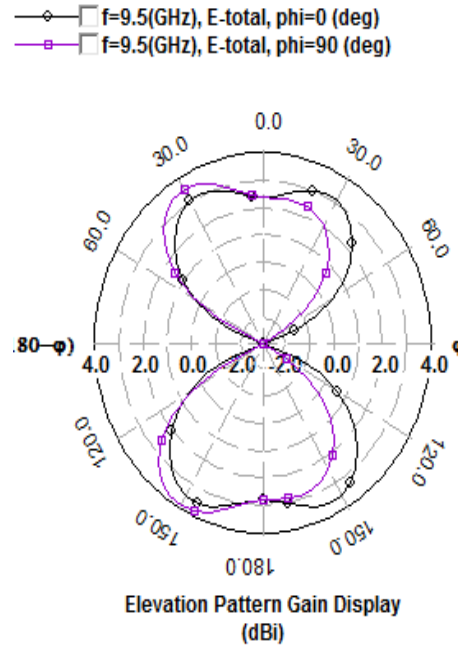


Figure.6 2D Radiation pattern in elevation

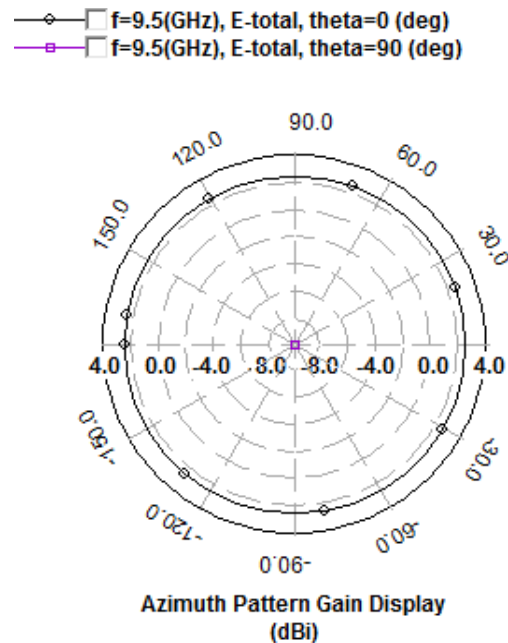


Figure.7 2D Radiation pattern in azimuthal

Figure.8 shows the current distribution at resonant frequency 9.5 GHz. At 9.5 GHz, the electric current distribution is mainly on the lower and upper edge of the ground plane, lower portion of patch, outer edge of patch and feed line. At the top of ground plane, the strong current distribution indicates that this part of the ground plane which is nearer to patch acts as a part of radiating structure. Hence, the distance L_s or distance between lower part of the radiating patch and ground plane and also feed gap 'g' strongly affect the return Loss of antenna.

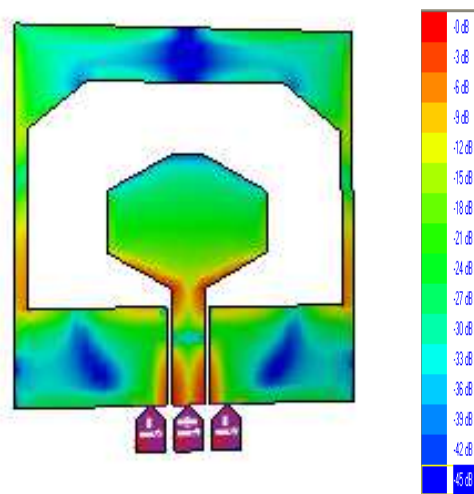


Figure. 8 3D current distribution of proposed antenna

Figure.9 shows total field gain of the antenna as a function of frequency. The antenna has consistent gain that varies between 3.0 and 4.8dBi in the operating band UWB (3.1-10.7 GHz) and has peak gain 4.8dBi at 7 GHz. These characteristics can make sure the ability of the proposed antenna to operate in UWB band effectively.

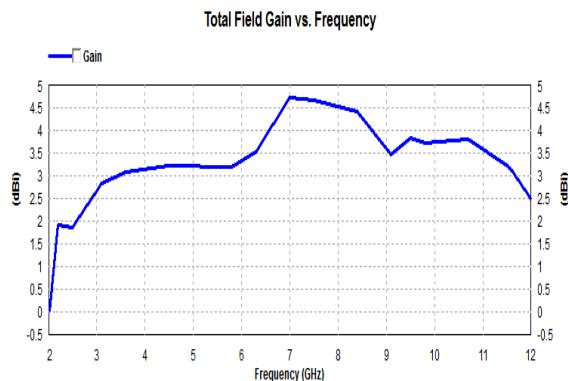


Figure.9 Gain characteristics of proposed antenna

Conclusion

In this paper, a CPW fed octagonal shaped antenna is proposed for UWB (3.1-10.7 GHz) application. The proposed antenna is size of $29 \times 31 \times 0.8$ mm³. The simulated results confirm that the antenna satisfies the -10 dB return loss requirement of UWB, which is specified by FCC from 3.1 to 10.6GHz. Various geometrical parameters of antenna are investigated to achieve the optimal design. The antenna has bidirectional radiation pattern in E-plane, omnidirectional radiation pattern in H-plane and the gain is almost constant. The Various characteristics such as small size, low manufacturing cost and sufficient bandwidth make antenna suitable for UWB applications.

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