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CPW-fed Hexagonal Shaped Slot Antenna for UWB Applications

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Abstract

A coplanar waveguide fed hexagonal slot antenna for ultra wideband applications is proposed. The antenna consists of a hexagonal slot on rectangular patch designed on FR4 substrate with relative permittivity of 4.4. The antenna dimensions are 39mm X 24mm X 1.5mm.The antenna is successfully implemented using Ansoft HFSS13 and simulation results show that the antenna offers excellent performance for UWB application ranging from 3.1GHz to 10.6GHz with VSWR <2 and Return Loss(S_{11}) <-10 dB. The analysis of the proposed antenna for different physical parameter values has also been done by varying them. This antenna configuration would be quiet useful for UWB indoor application.

Keywords: CPW Feed, UWB antenna, slot antenna.

1. Introduction

Increasing demand of broad bandwidth, high speed data rate and reduced fading from multipath interferences makes ultra wide band (UWB) technology one of the most promising solutions for present and future wireless communication. To address these issues, FCC (Federal Communications Commission) rules, has allowed unlicensed use of a specific band from 3.1 GHz to 10.6 GHz with limited transmitted power, wide bandwidth availability and excellent immunity to multi path interference as a step towards relaxing the spectrum usage regulations [1]. Apart from the number of advantages such as large bandwidth, large channel capacity, coexistence with current narrowband radio service; low transmit power, resistance to jamming, low SNRs etc there are still some challenges in design of UWB antenna such as impedance matching, type of feed and excitation, compact size, and limitation of short range transmission. There are various antenna configurations such as planar monopoles, slot antennas and dipoles that are earlier suggested for use in wireless applications [2-5]. Among them, planar slot antennas are more promising because of their simple structure, easy to fabricate and wide impedance bandwidth characteristics. Apart from traditional feeding mechanisms such as microstrip line feed, coaxial feed or aperture coupled feed, the CPW (Coplanar waveguide) fed antennas are more advantageous due to salient features like less radiation loss, less dispersion, easy integration with monolithic microwave integrated circuits (MMIC), simple configuration and the ability to effectively control their characteristic impedance [2]. The coplanar waveguide was proposed by C.P. Wen in 1969. It is an alternative to Microstrip and Stripline that place both, the signal and ground currents on the same layer. The conductors formed a center strip separated by a narrow gap from two ground planes on either side. The dimensions of the center strip, the gap, the thickness and permittivity of the dielectric substrate determined the effective dielectric constant, characteristic impedance and the attenuation of the line [5]. Etching the slot and the feed line on the same side of the substrate eliminates the alignment problem needed in other wideband feeding techniques such as aperture coupled and proximity feed. UWB communication demands ultra wide bandwidth which basic patch antennas cannot support. So where cost, size, performances are constraints planar slot antennas are more beneficial compared to microstrip patch antenna.

In this paper, CPW-fed UWB hexagonal shaped slot antenna with geometry is presented. The antenna has simple design due to less number of design parameters compared with the existing wideband antennas in the literature. Details of the antenna design are discussed and simulation results of the proposed antenna are presented and analyzed.

2. Antenna Geometry

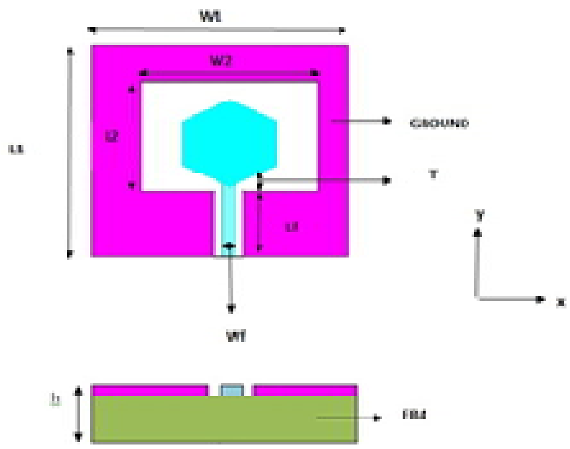

Fig. 1: Proposed antenna design.

The geometry and parameters of the hexagonal slot antenna with a rectangular stub are shown in Fig. 1, where W1 and L1 are the width and length of the ground, W2 and L2 are the width and length of the rectangular slot and W_h And L_h are the width and length of hexagonal stub and T is the distance between the stub and the CPW feed line. Wf and Lf are the width and length of the feed line. The antenna is supported by a FR4 epoxy dielectric substrate of a height equal to1.5mm and a relative dielectric constant of 4.4. The CPW is designed for a 50Ω characteristic impedance with feed line width and length equal to 3.6mm and 10 mm, respectively. In order to provide design criteria for this antenna, the effects of different geometrical parameter are analyzed. For the aperture antenna, the rectangle-shaped tuning stub is introduced to enhance the coupling between the slot and the feed line so as to achieve the ultra wideband property of the antenna. The ground has a same size as the substrate and the inner profile of the ground is a rectangular cut. The commercial simulation software Ansoft HFSS 13.0 based on the finite element method (FEM) is employed to perform the design and optimization process.

Table 1: Parameter values of antenna.

Parameter	Description	Value(mm)
W1	Width of ground plane	34
L1	Length of ground plane	29
W2	Width of slot	18
L2	Length of slot	13
W_h	Width of hexagon	9
L_h	Length of hexagon	8.7
Wf	Width of feedline	3.6
Lf	Length of feedline	10
T	Spacing between ground plane edge and stub	2
G	Gap of distance	0.4
H	Height of substrate	1.5

3. Simulated Results and Discussions

To evaluate the performance of the proposed antenna, it is designed and simulated using Ansoft HFSS 13.0 software tool. The analysis of the antenna for different physical parameter values has been done by varying one of them and keeping others as constant. The optimal parameter values of the antenna are listed in the table 1. The simulated return loss & VSWR of the proposed antenna is shown in fig 2 and fig 3.

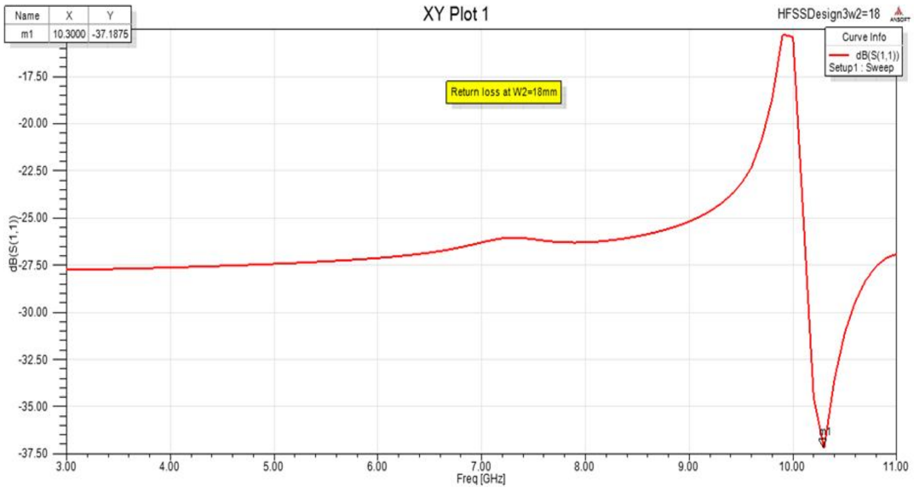

Fig. 2: Return loss of proposed antenna

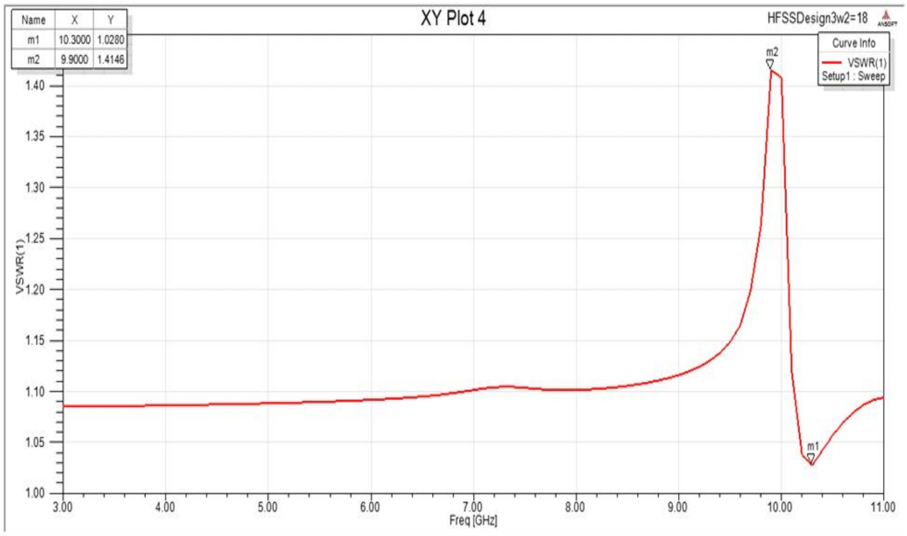

Fig. 3: VSWR of proposed antenna.

From Fig. 2 and Fig. 3 it is seen that the proposed antenna achieves return loss of -37.18dB and VSWR 1.02 at 10 GHz. The length and width of the rectangular slot has been varied in order to see the effect on the return loss and VSWR of the antenna.

A. Effect due to change of parameter W2 (Width of slot)

The width of the slot was decreased to 16mm and 14mm keeping the length of slot fixed at 13mm. Fig 4and 5 shows the simulated results of return loss and VSWR respectively when W2=16mm. Fig 6 and 7 shows the simulated results of return loss and VSWR respectively when W2=14mm.

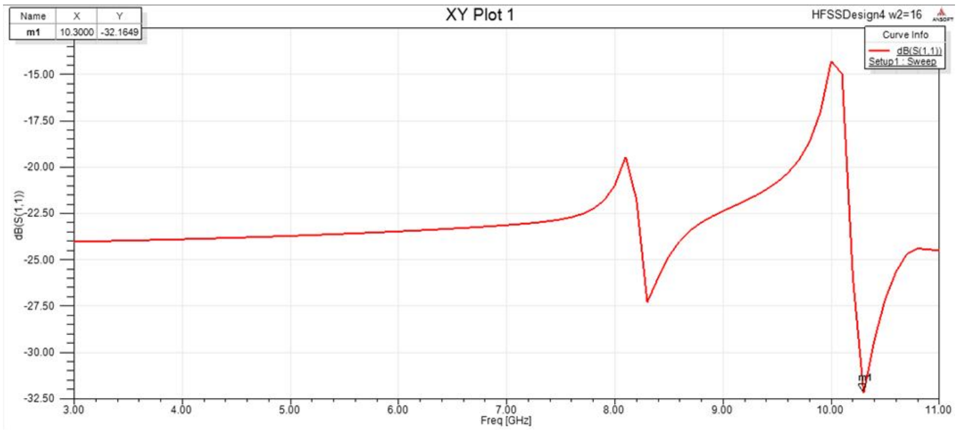

Fig. 4: Return loss at W2=16mm.

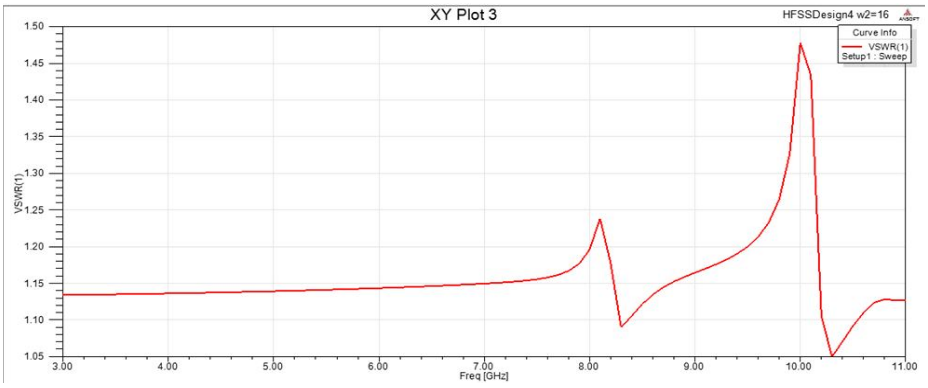

Fig. 5: VSWR at W2=16mm.

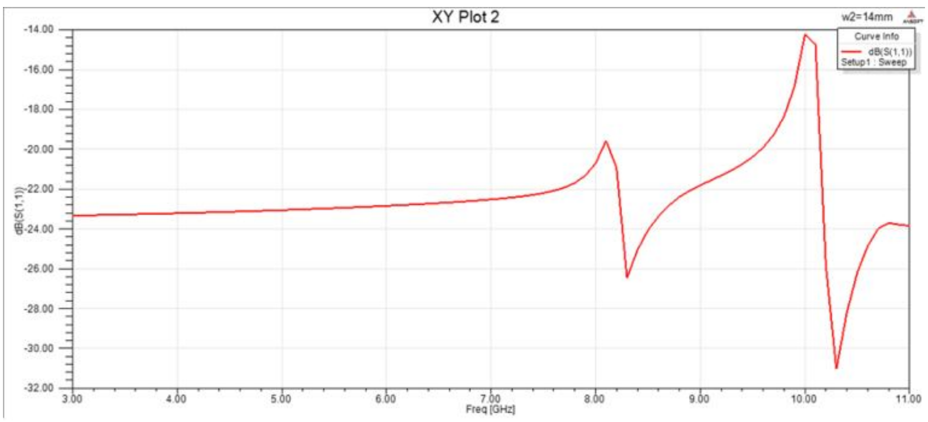

Fig. 6: Return loss at W2 = 14mm.

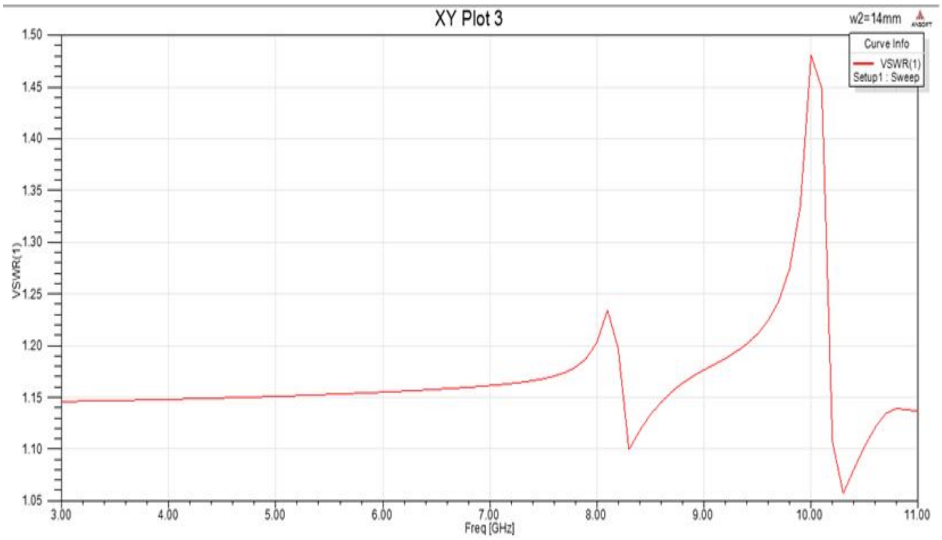

Fig. 7: VSWR at W2 = 14mm.

B. Effect due to change in parameter L2 (Length of slot)

The length of the slot was first decreased to 12mm and then increased to 14mm keeping the width of slot fixed at 18mm. Fig 8and 9 shows the simulated results of return loss and VSWR respectively when L2=12mm. Fig 10 and 11 shows the simulated results of return loss and VSWR respectively when L2=14mm.

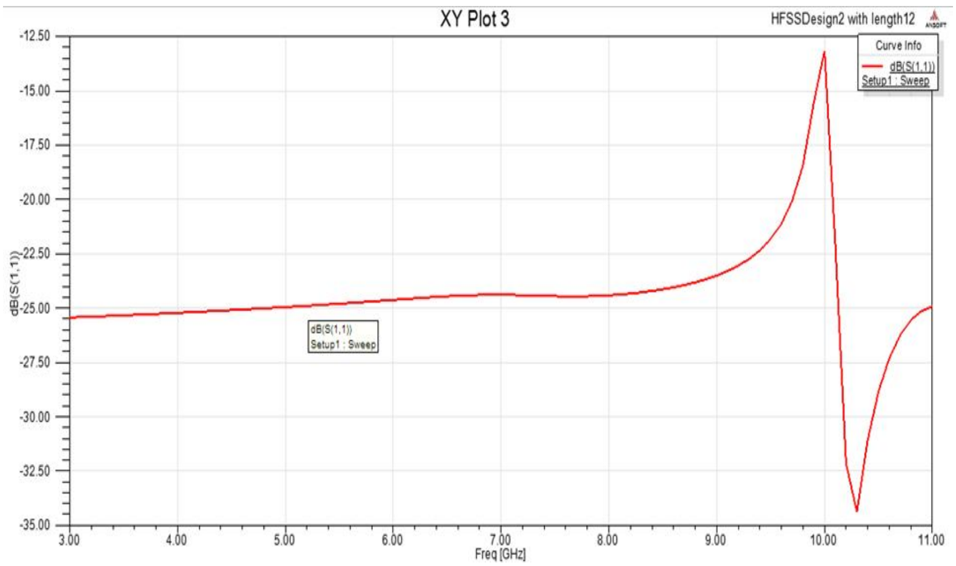

Fig .8: Return loss at L2 = 12mm.

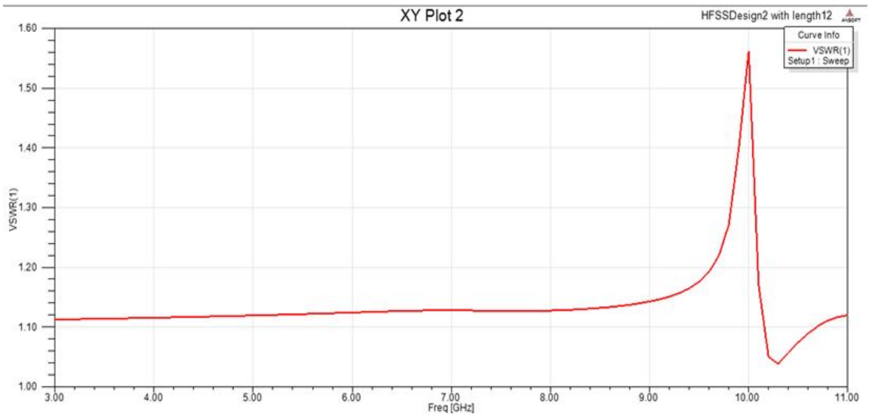

Fig. 9: VSWR at L2 = 12mm.

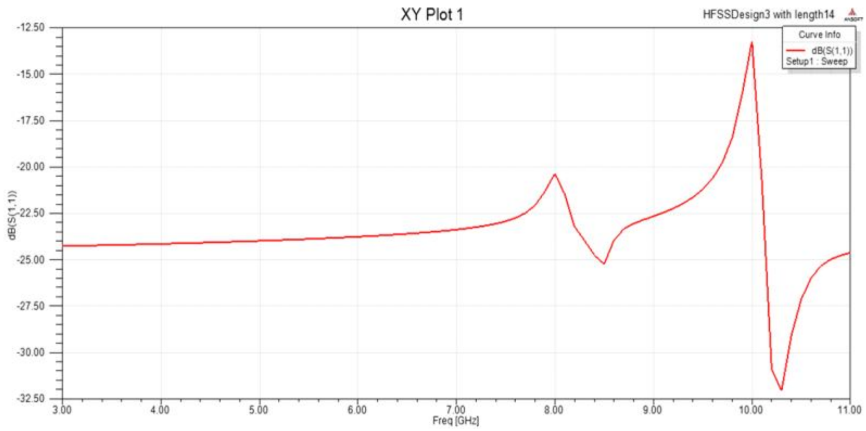

Fig. 10: Return loss at L2 = 14mm

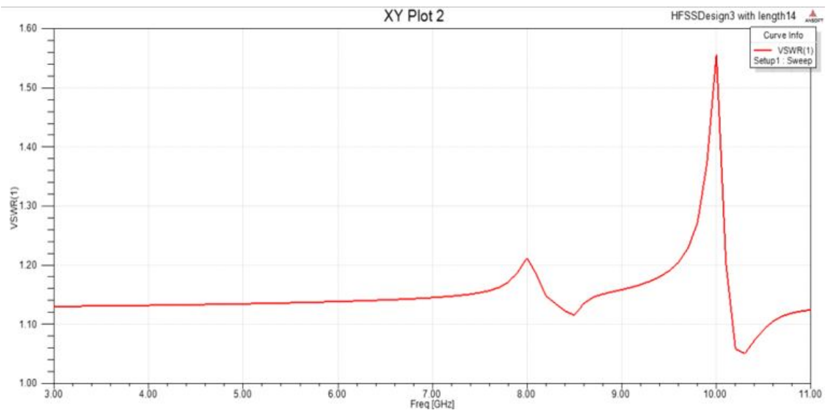

Fig. 11: VSWR at L2 = 14mm.

Comparison results at 10 GHz

Comparing, Fig. 2 and 3 with Fig. 4 to Fig. 11 it has been observed that as width of slot W2 was decreased keeping L2 fixed the return loss has increased from -37.18 dB to -30.83dB at 10 GHz and the VSWR values has remained less than 1.5. In other case when length of slot L2 was decreased to 12mm keeping W2 constant at 18 mm, the return loss increased from -37.18dB to -34.19dB at 10 GHz. It is also seen that when L2 was increased to14 mm, the return loss increased from -34.19 dB to -31.97dB. So, as length and width of slot decreases the return loss decreases accordingly where,

Width (W2) (mm)	**Length (L2) (mm)**	**Return loss (S_{11}<-10dB)**
18	13	-37.18
16	13	-32.16
14	13	-30.83
18	12	-34.19
18	14	-31.97

VSWR remains less than 1.5 in all cases.

Fig. 12 and 13 show the simulated E and H plane pattern respectively at 10 GHz. The beam width seems to be broad. It can cover wide direction of communication.

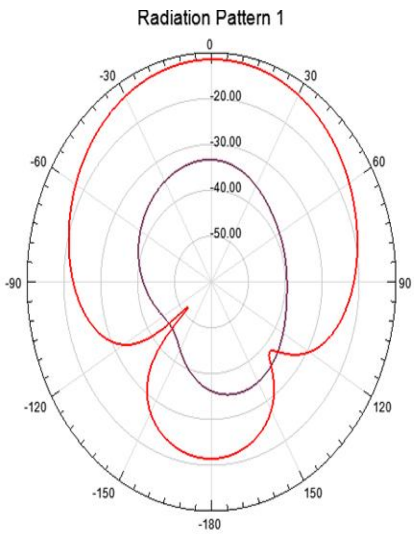

Fig. 12: E plane pattern at 10 GHz.

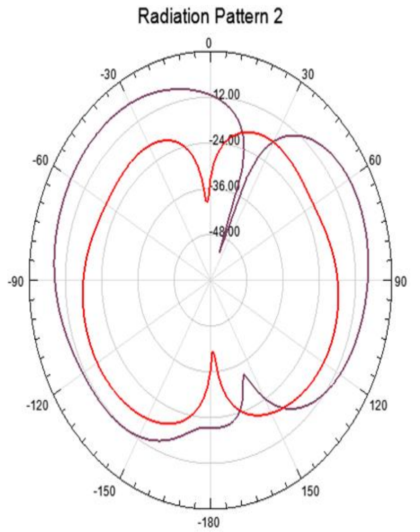

Fig. 13: H plane pattern at 10 GHz.

4. Conclusion

A parametric study has been done for rectangle shaped planar slot antenna. The simulation results show that the proposed antenna can offer good performance for UWB application ranging from 3.1GHz to 10.6GHz. Hence this type of antenna is suitable for UWB application. The practical implementation and measurement of this antenna can be carried out in future.

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