Printed Hexagonal Slot Antenna For UWB Applications

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***Abstract*—Ultra wideband micro strip-fed hexagonal slot antenna is presented in this paper. The basic antenna comprises a ground plane with hexagonal slot and U-shape radiating patch. By proper alignment and use of hexagonal slot additional resonances and much wider impedance bandwidth is obtained. The proposed antenna operates over the frequency band from 2.76GHz to 11.06GHz for reflection coefficient (S_{11}) < -10 dB. The proposed antenna is fabricated on FR-4 substrate having dielectric constant of 4.4 with overall optimize dimensions of 28 x 28 x 1.6 mm^3. Surface current distributions shows the effect of different slots. Simulated results are in good agreement with measured results. Designed antenna exhibits good radiation, efficiency greater than 75% within the entire ultra wideband.**

Keywords—Hexagonal slot antenna; UWB applications; U-shape radiating patch.

I. INTRODUCTION

In Feb 2002,the Federal Communication Commission (FCC) declared the 3.1 to 10.6 GHz unlicensed frequency band for UWB communication[1].Due to the huge industrial introduction in UWB applications companies have produced computer, mobile phones, set-up boxes type applications in market[2].Other important application of UWB is ranging and localization due to fine delay resolution[3].Due to the extremely large bandwidth of UWB, the interference between the narrow band and UWB system is a major challenge in UWB.Slot antenna is having slot within the ground plane and it is suitable for application where near-field coupling is required to be minimized.

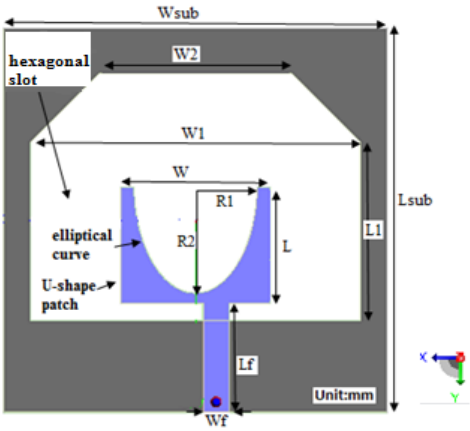


Fig.1. Geometry of proposed antenna

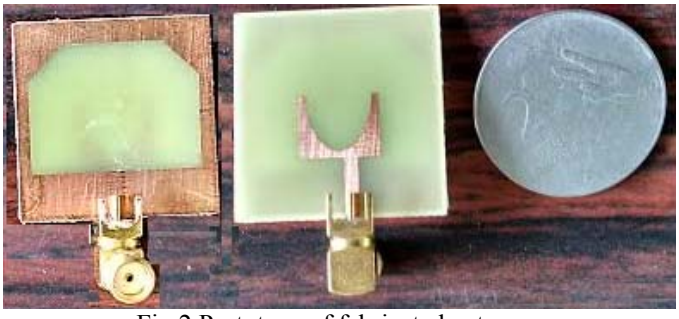


Fig 2.Prototype of fabricated antenna

Half octagonal ring antenna is operative from 3.1 to 14GHz [4]. In [5],a UWB wide slot antenna is presented for multi-input multi-output applications with integrated WLAN. The small square monopole antenna has been designed for UWB applications, along with inverted T-shaped slot and conductor-ground plane to improve the impedance bandwidth[6].Consequently, a different slot antennas having elliptical, tapered shape slot were proposed [7]-[8].For example in [8],a planer slot antenna was proposed for UWB application along with dual-band-notch characteristics. They were notch WiMAX and WLAN by using parasitic slit.
A compact UWB slot micro strip-fed slot antenna has been presented. The proposed structure focuses on a hexagonal slot antenna for UWB applications, which combines U-shape radiating patch.

In [9]-[10], UWB antenna using quarter wavelength slots and inverted L shaped slots for triple band notched and WLAN rejection characteristics respectively. In[11],the antenna operates at Bluetooth frequency along with Quadruple Band notched Characteristics.Different monopole antennas have been investigated for bandwidth enhancement [12]-[13].In[14],rectangular aperture antenna was proposed along with band notched function.

II. ANTENNA DESIGN

A. Design Parameters

Substrate (FR4) having dielectric constant 4.4 and thickness of 1.6 is used for manufacturing the antenna. The length and width of the micro-strip antenna is found by formula given below [15].

Width of Patch is given by,

$$W = \frac{C}{4f_r} \times \sqrt{\frac{2}{\varepsilon_r+1}} \quad (1)$$

Where C is the velocity of light in free space

Effective Dielectric Constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2\sqrt{1+\frac{12h}{W_P}}} \quad (2)$$

Length Extension: Extended distance ΔL along the dimensions of patch length and the normalized extension of the length is given by equation,

$$\frac{\Delta L}{h} = \frac{0.412(\varepsilon_{reff}+0.3)\left(\frac{W_p}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W_p}{h}+0.8\right)} \quad (3)$$

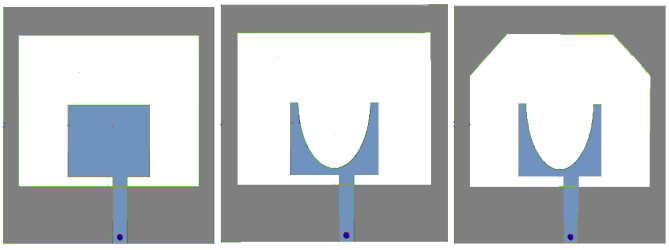
Effective Length:

$$L_{reff} = \frac{C}{4f_r\sqrt{\varepsilon_{reff}}} \quad (4)$$

Length of Patch: Actual length of patch is L and it is calculated by formula given below,

$$L = L_{eff} - 2\Delta L \quad (5)$$

Firstly rectangular slot antenna is designed as shown in Fig (3(a)) which is printed on FR4 substrate of thickness 1.6mm, loss tangent 0.02 and permittivity 4.4.It is fed by 50Ω micro-strip line. Antenna structure consists of a rectangular radiating patch which is fed by 50 Ω micro-strip feed line, ground plane along with rectangular slot. The rectangular patch has a width W and length L. The radiating patch is connected to feed line of width W_f and length L_f. Further, rectangular patch is cut in elliptical shape having radius of 4.5 and 8mm in x and y-direction respectively to form U-shape radiating patch as shown in Fig(3(b))



(a) (b) (c)

Fig.3.(a) The ordinary rectangular slot antenna,(b)the U-shape patch with rectangular slot,(c) the U-shape patch with hexagonal slot antenna.

The proposed geometry has been developed and it is shown in Fig.1.In this, the antenna with U-shape patch and hexagonal slot-backed plane is proposed. Based on the current distribution in UWB frequency band, the rectangular slot is cut at the edges to get hexagonal slot with suitable dimensions(W_1,W_2,L_2) and rectangular patch into U-shape patch with suitable dimensions(in x-direction:4.5mm and in y-direction:8mm).

TABLE I.DIMENSIONS OF PROPOSED ANTENNA

Configuration	Parameter	Value(mm)
Substrate	L_{sub} (Length of substrate)	28
	W_{sub}(Width of substrate)	28
	h (Substrate thickness)	1.6
Patch	W	10.87
	L	8.5
U-slot	R_1	4.5
	R_2	8
Hexagonal Slot	W_1	24
	W_2	14
	L_1	13
Feed Line	W_f	1.86
	L_f	8

III. RESULTS AND DISCUSSIONS

The proposed antenna is fabricated as shown in Fig. 2. The results are obtained using CADFEKO 7.0 simulation software [16].Fig.3.shows the various antenna geometries used for simulation studies. Reflection Coefficient characteristics for ordinary rectangular patch antennas (Fig.3(a)),the U-shape patch with rectangular slot (Fig.3(b)) and (Fig.3(c)) are compared in Fig.4.

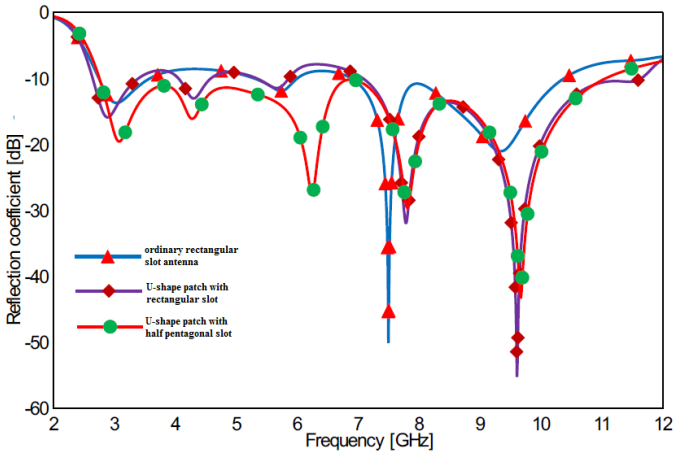


Fig.4.Reflection Coefficient (S_{11}) [dB] characteristics for antenna shown in Fig.3.

As shown in Fig.4, the ordinary rectangular slot antenna can provide resonance at two upper frequencies at 7.5GHz and 9.34GHz.The upper bandwidth is affected by removing elliptical slot from the conducting patch. This behavior is mainly due to change in surface current path inside the U-shape patch as shown in Fig.(5.(c)(d)) as compare to surface current shown in Fig.(5.(a)(b)).In addition, by cutting the edges of rectangular slot into the hexagonal shape slot the bandwidth is effectively improved. This is because of the current distribution as shown in Fig.(5.(e)(f)) and hence we get more resonances at different frequencies as shown in Fig.4.

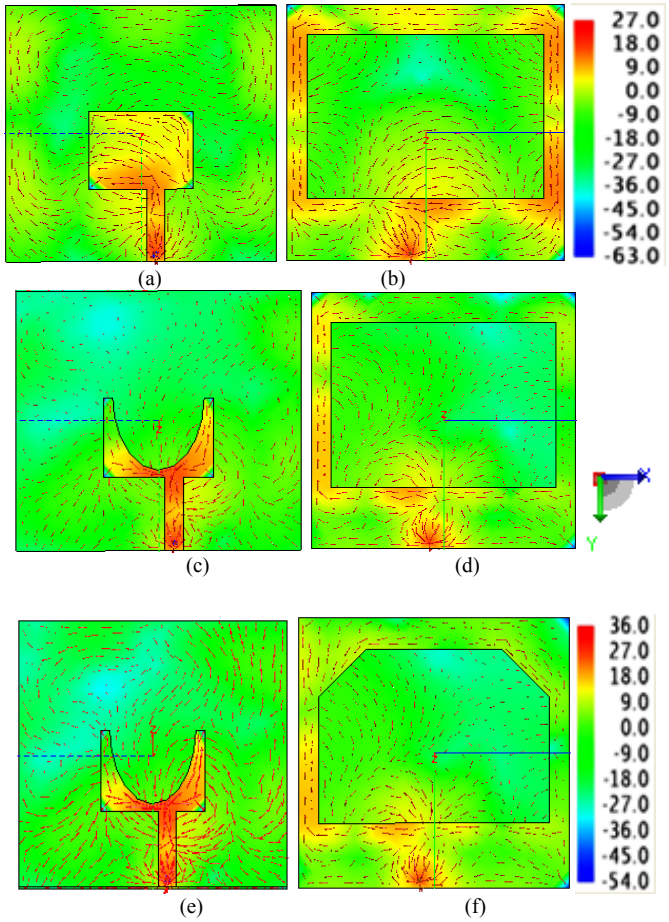


Fig.5.Surface current distributions on the top and bottom layer.

(a)-(b)Rectangular radiating patch and rectangular slot at first resonance (c)-(d) U-shape radiating patch with rectangular slot at second resonance frequency (9.63GHz) frequency (7.5GHz), (e)-(f) U-shape radiating patch with hexagonal slot at fifth resonance frequency (9.5GHz).

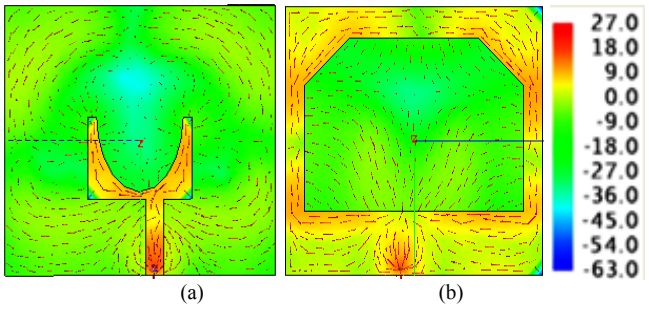


Fig.6.Surface current distribution on the patch and ground plane for the proposed antenna at (a-b) 6.25GHz

As shown in Fig (6(a-b)), the direction of surface current is upward. The simulated and measured reflection coefficient [dB] characteristic of the proposed antenna are shown in Fig 7. The proposed antenna operates at 2.76GHz to 11.06GHz.

Fig.8.shows the graph of simulated efficiency characteristics Vs frequency in GHz, which shows that efficiency of proposed antenna is greater than 75% in entire UWB band. Hence proposed antenna is good candidate in different applications.

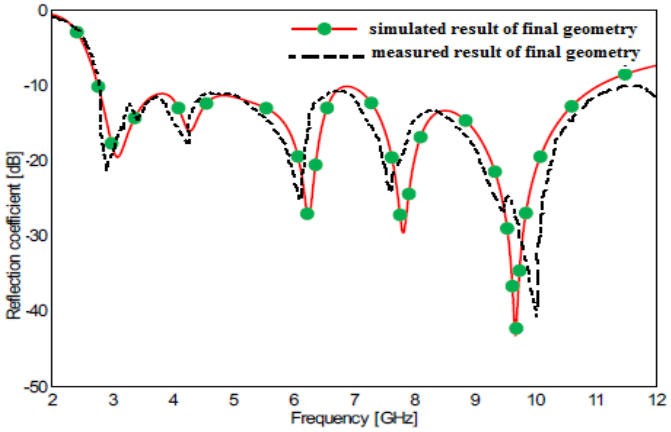


Fig 7.Simulated and measured reflection coefficient [dB] characteristics for proposed antenna.

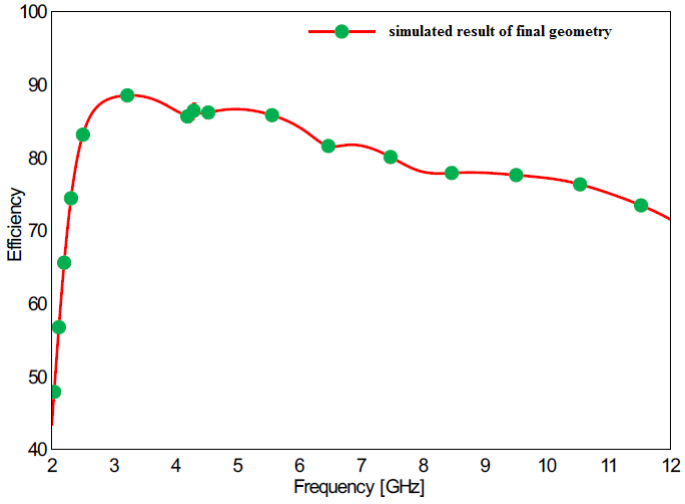


Fig.8.Simulated efficiency characteristics for proposed antenna.

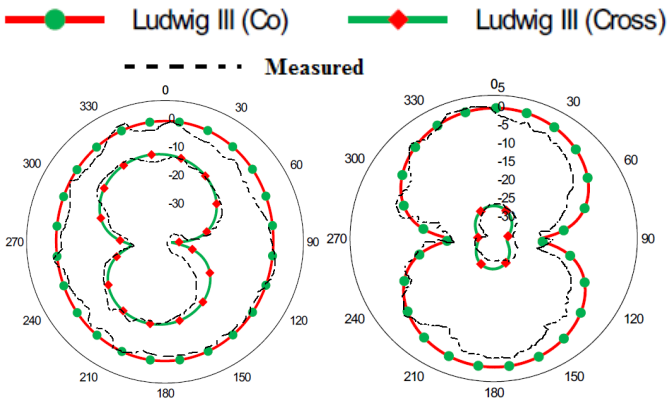


Fig.9.Simulated and measured radiation pattern of the proposed antenna at third resonance frequency (6.25GHz)

Fig.9. shows the simulated and measured radiation pattern of proposed antenna at resonance frequency (6.25GHz). It includes co-polarization and cross-polarization in the H-plane

and E-plane. The cross-polarization is less as compared to co-polarization. It helps to demonstrate that whether antenna radiate properly or not over the entire frequency range. It can be seen that radiation pattern in H-plane is omnidirectional. At third resonant frequency, the simulated radiation patterns agree well with measured radiation pattern.

IV. CONCLUSION

A compact hexagonal slot antenna has been proposed for UWB applications. The antenna operates from 2.76 to 11.06GHz for S_{11} < -10 dB. Additional resonances are excited by etching a hexagonal slot in the ground plane. Controlling the dimensions of the hexagonal slot controls the impedance bandwidth. The proposed antenna exhibits efficiency greater than 75%, dumb-bell shape radiation pattern in E-plane & omnidirectional radiation pattern in H plane showing the suitability of the proposed antenna for UWB applications.

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