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A Novel UWBModified Hexagonal Microstrip Antenna With Improved Gain

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***Abstract*—In this papera Novel UWB modified Hexagonal microstrip antenna with curved partial ground plane (HMSA-CG) is proposed. The hexagonal patch is a flower like structure. This paper investigates performance improvement of the patch antenna in terms of Gain and Group delay. Simulation results are obtained using Ansoft HFSS. Design issimulated on Rogers RT Duroid 6002 substrate.The Modified Hexagonal MSA shows improved average gain characteristics of3.6 dB(maximum gain varies from 1.9 dB to 5.4 dB in UWB), almost flat Group delay and impedance bandwidth from 3-11.3 GHz. Radiation pattern observed is Omnidirectional.**

Keywords*—UWB(Ultra Wide Band); Gain;Group Delay;Hexagonal Microstrip Patch Antenna with Curved Ground Plane (HMSA-CG).

I .INTRODUCTION

In 2002, for the use of indoor and hand-held systems, the Federal Communication Commission (FCC) released ultra-wide band (UWB) from 3.1-10.6 GHz. Enormous research is going on UWB antennas in both academia and industry for applications in wireless transmission systems. Very low power pulses, below the transmission noise threshold are emitted by an UWB system[1].

The UWB antenna should be compact, planar and low cost. Integration of antenna with electronic PCB circuits should also be feasible[2].

Not only return loss, radiation patterns and gain, for short-range high- speed low power UWB communication, it is important to evaluate waveform distortions also[3].

In 2008 HadiBadjian and Chakrabarty reported a UWB patch antenna design on FR-4 substrate operating in frequency band of 1.78 – 6.59 GHz. This antenna consists of a rectangular patch with one step and partial ground plane [4]. In same year, Lim, Nagalingamand Tan presented a compact design of microstrip UWB antenna operating between 4.1 GHz to 10 GHz. The antenna parameters are demonstrated in frequencyand time domain as well[5]. A planar Ultra-wideband Monopole Antenna with WLAN notch is designed by Wang, Li and Quan [6]. In this, radiating element is a hexagon and UWB is achieved by implementing partially modified ground plane. Rejection characteristics is obtained by etching an arc slot.

In 2010, Azim, Mobashsher, Tariqul Islamand Norbahiah designed a square shaped planar antenna having partial ground plane with a slot, operating in 2.95 to 15.44 GHz [7]. Ping, Chakrabarty and Amir Khanhave designed an Impulse-Ultra Wideband (I-UWB) slotted rectangular patch antenna with partial ground plane operating in 3.34 GHz to 20 GHz [8]. A pentagon shaped CPW feed monopole antenna on foam substratewas proposed by Robert A. Moody and Satish K. Sharmain [9]. They studied the effect of rectangular slots in both the ground plane and the planar monopole on gain and radiation pattern of the antenna.

In 2011, an UWB printed slot antenna was presented by M. Kumar, A. Basu, and S. K. Koul[3].The antenna covers band of 3.1 to 10.6 GHz on a piece of dielectric substrate of size 30.4mm × 35.4 mmwith improved performance in time and frequency domain. Mandal and Dashave reported a UWB printed regular hexagonal monopole antenna fed by a microstrip line [10].In this design an inverted U-shape slot is etched in patch which createda notch band at the wireless local area network (WLAN) (5.1-5.8 GHz). Slot dimensions are controllable. Operating bandwidth obtained is 2.74 to 11.05 GHz and notch band is created in 4.95 to 5.92 GHz. Peak gain varies from 1.53 dB to 4.05 dB.

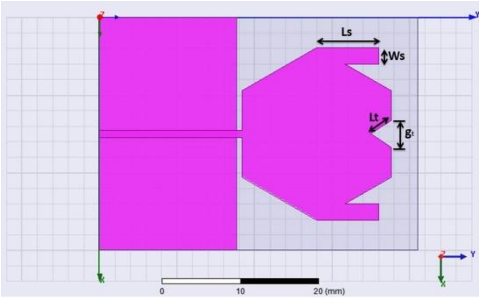

Fig. 1. Top view of modified HMSA[11]

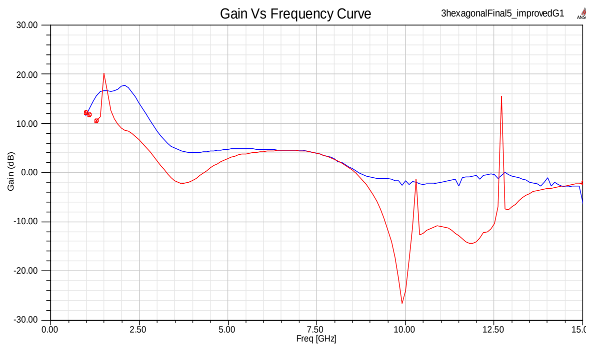

Fig. 2.Gain Vs Frequency Curve of conventional (Red)& modified HMSA (Blue)[11]

In 2014, in our own paper [11] we proposed a Novel UWB modified Hexagonal microstrip patch antenna (HMSA-FS). The conventional hexagonal patch was modified to form a flower like structure. Simulation results were obtained on Rogers RT Duroid 6002substrate . The HMSA-FS shows improved average gain characteristics from -1.41 dB to 3.3 dB, almost flat Group delay and enhanced impedance bandwidth (2.28-12.28 GHz) as compared to conventional design HMSA-PG (2.72 GHz to 11.43 GHz). Radiation pattern observed were Omnidirectional. But still in that design gain at upper side of UWB is below 0 dB.

In this paper we further worked on our previous design (shown in Fig. 1) to improve gain at upper side of UWB (shown in Fig. 2).

Proposed HMSA -CG is designed on Rogers RT Duroid 6002 dielectric substrate (ε_r = 2.94) with curved partial ground. In this design we have shown that Gain is improved in comparison to previous design. Simulation results show that average gain improved from 3.3 dB to 3.6 dB (maximum gain varies from 1.9 dB to 5.4 dB in UWB).

The rest of the paper is organized as follows: Section II describes geometrical dimensions of modified HMSA-CG. Section III discusses the simulation results and Section IV presents conclusion.

II. PROPOSED DESIGN

In this section single element direct-fed printed monopoleHMSA is proposed on Rogers RT Duroid 6002 dielectric substrate with curved partial ground.

Geometry

Fig. 3 illustrates the geometry of a Direct-fed HMSA-CG on a dielectric material (ε_r = 2.94) at 6 GHz operating frequency. A direct feed line with a width of 1 mm (W_f) and a hexagonal patch with r = 11.1 mm is designed on 0.381 mm thick (h)& 30mm x 41mm(L×W) Rogers RT/Duroid 6002 substrate. On the other side of the substrate a 30mm x 17.7 mm (Lg)partial ground plane is located.We cut a triangular open slot (with g_t = 3.4mm & L_t=3.14mm) on the side of hexagon opposite to feed side. Also we have added two strips (with Ls×Ws= 8mm×2.1mm) on the two opposite corners of hexagon in y-direction.

Additionally, using fillet option in HFSS, fillet of radius R = 6mm (optimized) is created at the two corners of ground plane adjacent to the patch.

III. SIMULATION RESULTS & DISCUSSION

A. *Results of Modified Design*

In fig. 4, optimized return loss (S11) is plotted (in Brown Color). Bandwidth obtained is 3 GHz to 11.3 GHz. In fig. 5 Gain vs. frequency plot of the antenna is shown(in Brown Color). Average Gain in the UWB range is 3.6dB.Maximum gain varies from 1.9 dB to 5.4 dB in UWB. In fig. 6, group delay obtained is almost flat. In fig. 7, the radiation pattern is

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shown. It is easily observed that the radiation pattern is Omni directional.

B. Discussion & Comparison

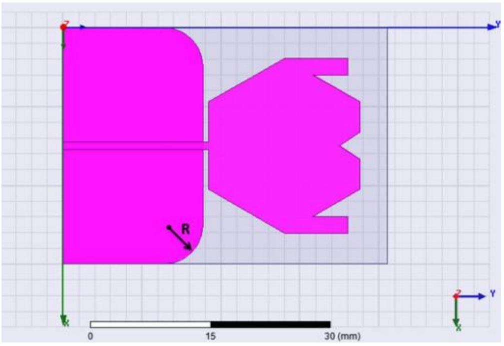

Fig. 3. Top view of HMSA-CG

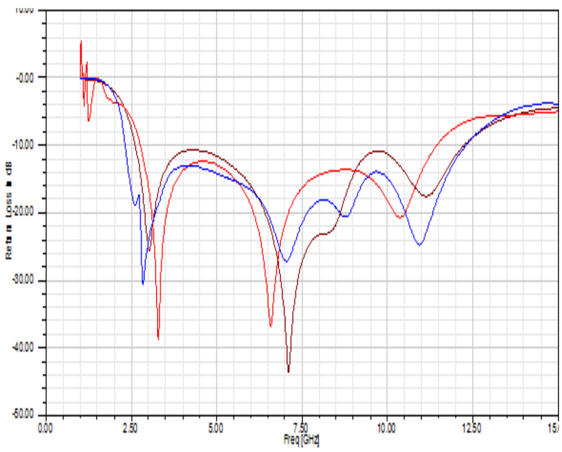

Fig. 4.Comparison of Return Loss of HMSA-PG (red), HMSA-FS (blue) and HMSA-CG (brown)

Table I shows the comparison of the two proposed antennas. Both antennas are UWB in nature and omni-directional but the average gain and group delay is better in HMSA-CG. At upper region of UWB, gain improved due to curved ground. Average gain is calculated for UWB range i.e. 3.1-10.6 GHz. Although gain obtained is low but a low gain is of little concern in UWBsystems, where power may actually be intentionally reduced to noise levels. More important is flat Gain and group delay [3] and we have achieved this goal to some extent in this paper.

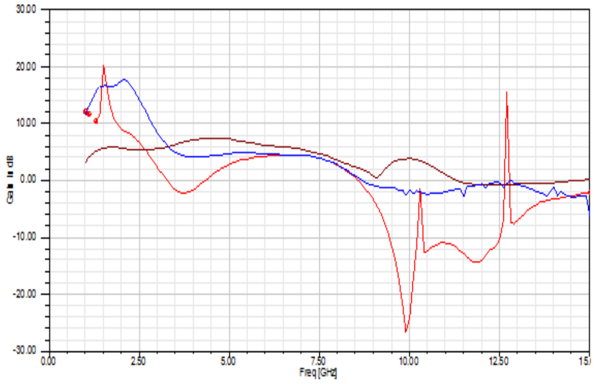

Fig.5.Gain Vs Frequency Curve of HMSA-PG (Red), HMSA-FS (Blue) and HMSA-CG (brown)

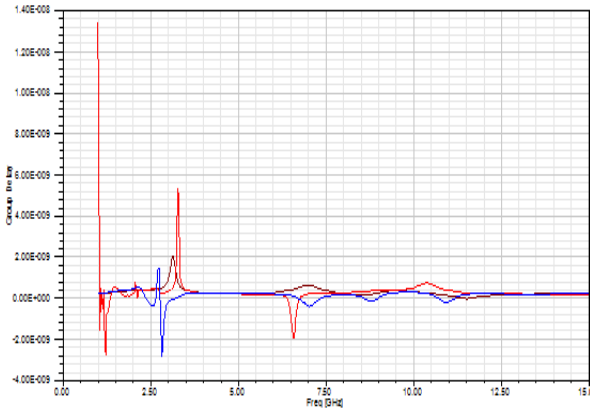

Fig.6.Group Delay of HMSA-PG (Red), HMSA-FS (Blue) and HMSA-CG (brown)

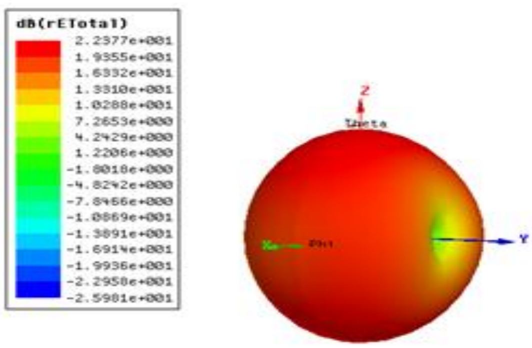

Fig. 7: 3D Radiation pattern of HMSA-CG

Table I: Comparative Analysis

Antenna Parameters	Comparison of Antennas	
	HMSA-CG	*Modified HMSA-FS[11]*
Bandwidth	3- 11.3 GHz (8.3 GHz)	2.28-12.28 GHz (10 GHz)
Average Gain	3.6 dB	3.3 dB
Group Delay	Almost constant	Almost constant

IV. CONCLUSION

The modified hexagonal microstrip antenna with curved partial ground has been proposed for UWB communication systems. It has been demonstrated bysimulated results that the gain and group delay of this antenna isbetter and stable than the previousdesigned HMSA-FS. Further a stop band at approximately 5 GHz to 6 GHz frequency range can be implemented to avoid interference from WLAN or HYPERLAN bands.

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