Design and Analysis of Ultra Wide Band Giuseppe Peano Fractal Antenna at Different Height Level of Substrate

Er.Parvesh Kumar[1], Er.Sumit Kaushik[2],
Senior Engineer, Bharat Electronics Ltd 1
Executive Engineer, Bharti Airtel 2

Abstract

In this paper microstrip patch antenna is designed for ultra wide band application. Giuseppe Peano algorithm is applied on microstrip patch antenna with rectangular patch of size 30× 24 mm^2. Coaxial Feed line is used with the patch antenna and results are carried out by using FR-4 as dielectric substrate. The proposed antenna obtained an ultra wide band of 4.94GHz bandwidth having minimum return loss of –32.73dB. The maximum gain produced by the proposed antenna in this ultra wide band range is 2.37 dBi. Hence, the proposed antenna covers C and X band so it can be used for RADAR applications. The change in antenna height is also analysed. Design and simulation is carried out using IE3D simulation software.

Keywords - *Microstrip patch antenna, FR-4 substrate, Giuseppe Peano fractal geometry, coaxial feed line. IE3D software*

I. INTRODUCTION

Antenna is important component of communication system. The patch antenna is useful because they are printed directly on to the circuit board. Microstrip patch antenna consists of a conducting patch on one side and dielectric substrate with a ground plane on the other side. The two feeding techniques used to feed microstrip antenna are contacting and non-contacting. Contacting feeding techniques aremicrostrip line feed and coaxial feed. Non-contacting feeding techniques are aperture and proximity coupled feed. Advantages of patch antenna are simple and inexpensive, compatible with MIC designs, low fabrication cost, less weight. Fractal geometries are used to reduce the size of antenna. Fractal is rough of fragmented geometric shape which can be sub-divided into parts. Fractals have features like finite structure at small scale, self similar, simple and recursive. Self similar property is designed to receive and transmit over a wide range of frequency. Space filling property is used by fractal to reduce antenna size. . Fractals have applications in Astronomy, Computer science, Telecommunication, Medicine, mobile application.

II. LITERARURE SURVEY

Nagpal et al. [1] proposed E-shaped fractal microstrip patch antenna with defected ground structure for wireless applications. Different iterations of fractal geometry caused self-similar E shape structures. For obtaining good bandwidth, Different DGS configurations had been applied. This antenna was designed using FR-4 as substrate and operated at 3.7GHz, 6.7 GHz, 7.9 GHz and 8.7 GHz with bandwidth of 120 MHz, 500 MHz, 225 MHz and 315 MHz. This antenna found its application for Wi-Max, C Band and X band applications. This antenna is having small dimensions of 20X25 mm^2. Results have been compared first making E-shaped patch which modified to form wang shape followed by fractal antenna.

Khidre et al. [2] presented U slot microstrip antenna for higher mode applications. This antenna resonated ina a band from 5.17 GHz to 5.81 GHz hence useful for number of applications. This antenna was having dual radiation beams with both beams were directed at center frequency. This antenna was having a gain of 7.92 dBi. This antenna found its applications for different wireless applications. This antenna exhibit impedance bandwidth of 11 % at VSWR less than two. This antenna was having dimensions of 64X 74 mm^2. Substrate was having a dielectric constant of 2.2 and thickness of 3.1 mm. Design and simulation had been carried out using HFSS.

Gupta et al. [3] designed multiple band microstrip patch antenna. This antenna had been useful for c band and x band applications. This microstrip antenna was having a patch with different slots so as to have good antenna characteristics. These slots were four u slots, two small and two large and one I shaped slots. This antenna was having compact size of 25 X 23 mm^2. Feed to this antenna is given by coaxial feeding technique and feed point is chosen properly. Design and simulation had been carried out using HFSS simulation software. This antenna was having bandwidth of 140 MHz from 5.85 GHz to 6 GHz and 1.21 GHz from 7.87 to 9 GHz. This antenna can be used for WLAN, C band and X band applications.

Janani.A et al. [4] designed E-shaped fractal patch antenna for multiband applications. For obtaining multiple bands, fractal geometry had been used. First of all, entire length was divided to form E shape patch by cutting two slots. On each section, fractal geometry was applied so as to make fractal antenna. . The proposed antenna had dimensions of 150 mm by 130 mm using two FR-4 having thickness of h=0.8 mm and h= 1.6 mm and an air gap having thickness h= 4 mm between two FR-4 as substrate. The design and simulation had been carried out using HFSS simulation software. The main parameters at operating bands such as return loss, impedance, gain had been studied. This antenna found its application for different applications for mobile communication.

RamavathA et al.[5] Design of Hybrid Fractal Antenna For UWB Application. It uses antenna of size 30×25mm^2 and is designed using Giuseppe peano and Sierpinski Carpet fractal geometry. The antenna feed is through microstrip line. It uses only FR-4 substrate.FR-4 has dielectric constant is 4.4, thickness of substrate is 1.6mm. Giuseppe peano fractal geometry is applied to edges of rectangular patch and Sierpinski Carpet fractal is implemented by making circles by cutting slots on patch antenna. This antenna is analyzed using CST Microwave studio suite 2011. Antenna is placed on semi elliptical ground plane and produce gain and omnidirectional pattern.

III. ANTENNA DESIGN

Giuseppe peano geometry is applied on microstrip patch antenna with two level iterations. Antenna height is 2 mm in all iterations.

A. Design of Giuseppe Peano fractal patch antenna

Rectangular patch is designed using Giuseppe peano geometry with all dimensions given in table 1.It is depicted from figure 1 that 0th iteration is done on ground and no fractal geometry is applied on it. . FR-4 has been used as substrate. The 1st iteration antenna design is shown below in figure 2

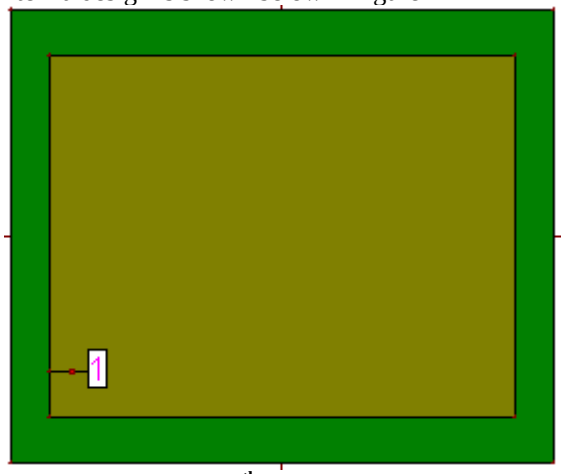


Figure 1. 0th iteration design

Table 1:- Dimensions of Giusepe Peano fractal antenna

Variable	Value
Length of patch	30 mm
Width of patch	24 mm
Length of ground	35 mm
Width of ground	30 mm
Thickness of substrate	2mm
Feeding technique used	Coaxial
Substrate used	FR-4
Dielectric constant	4.4
Loss Tangent	0.02
Feed point	-12 , -8.8

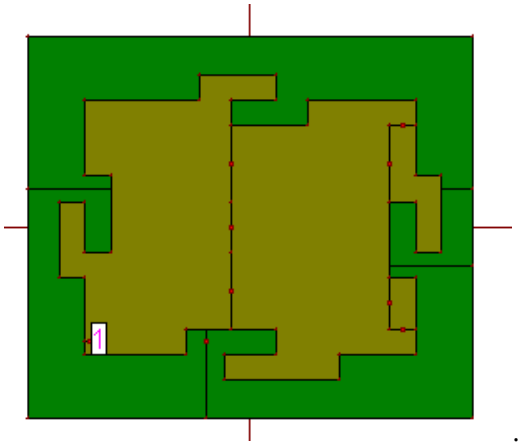
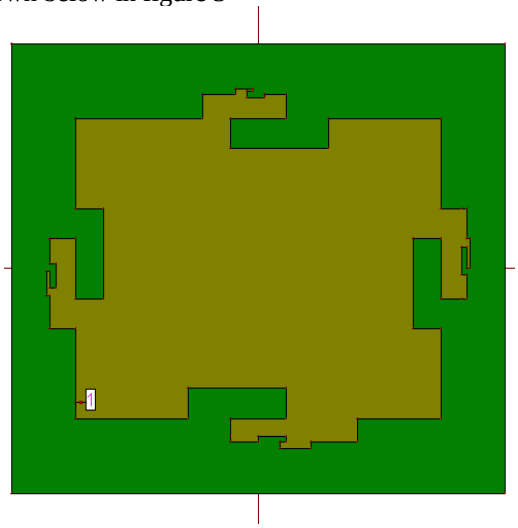


Figure 2. 1st iteration design

On the patch antenna Giuseppe peano geometry is again implemented on 1st iteration design which is shown below in figure 3



IV. RESULTS & DISCUSSION

Figure 3. 2nd iteration design

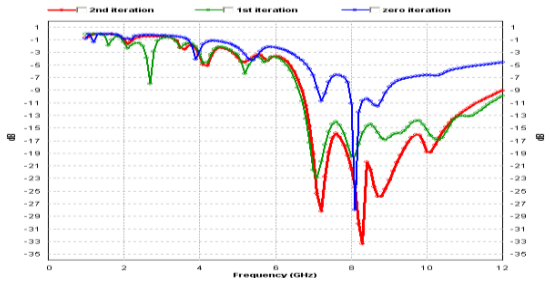


Figure 4. Return loss versus frequency for different iterations

Table 2:- Comparison Results of Different Iterations

Iteration Number	Resonance band (GHz)	Return Loss(dB)	Gain (dBi)	Directivity (dBi)	Bandwidth (GHz)
0th Iteration	7.96 to 8.88	-19.59	1.49	11.46	0.882
1st Iteration	6.64 to 11.95	-22.83	2.26	10.61	5.44
2nd iteration	6.74 to 11.68	-32.73	2.37	10.69	4.94

Figure 4 shows comparison result of all iteration. It covers the range of ultra wide band applications. The antenna characteristics for 2nd iteration are better than 0th and 1st iteration designs. It has bandwidth of 4.94GHz and gain is 2.37dBi. It covers C and X microwave bands. The proposed antenna can be used for long distance radio telecommunications, microwave relay, wi-fi , satellite communciation and Radar. Now the effect of change of height has been studied.

A. Effect of change of height

The effect of using different height is also studied. Firstly the proposed design has been made using FR-4 as substrate. Then the effects on antenna characteristics are studied by changing the height as 2.4mm and 1.8mm. Both of these effects are discussed below.

Effect of height on rectangular patch antenna with Height 2.4mm

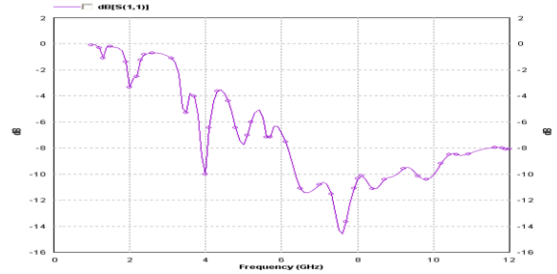


Figure 5 Return Loss versus Frequency for antenna height 2.4mm

From figure 5 it is observed that antenna with 2.4mm height produces ultra wide band of 3.64GHz and has a maximum return loss of -14.53dB.

Effect of height on rectangular patch antenna with Height 1.8mm

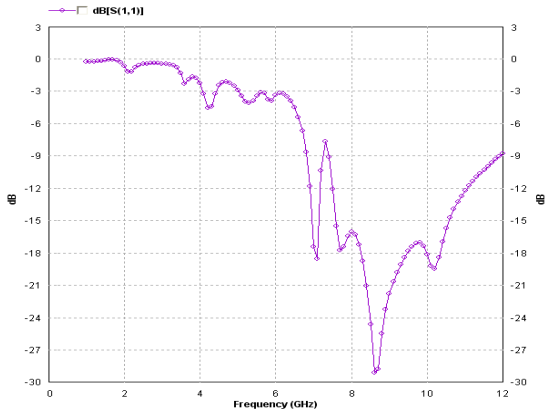


Figure 6 Return loss versus frequency for antenna height 1.8mm

This antenna resonates at 7.1GHz and 8.61GHz having return loss of -18.31dB and -29.07dB respectively

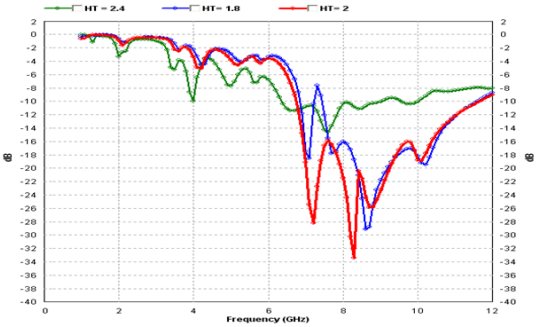


Figure 7 Comparison of return loss versus frequency for different height

Table 3 Antenna Parameters using Different height

Antenna height	Resonance band (GHz)	Return Loss(dB)	Gain (dBi)	Directivity (dBi)	Bandwidth (GHz)
2mm	**6.74 to 11.68**	**-32.73**	**2.37**	**10.69**	**4.94**
2.4mm	6.3 to 10	-14.53	2.41	10.26	3.64
1.8mm	6.86 to 11.59	-28.89	2.73	11.09	4.72

From figure 7 the antenna height 2mm produces better results than the other two heights. It produces an ultra wide band of 4.94GHz with maximum return loss of -32.73 dB.

V. CONCLUSION

Microstrip Patch Antenna was designed using Giuseppe Peano Fractal Geometery.The antenna is simulated using coaxial feed line and FR-4 dielectric substrate. Two level iterations have been applied on the patch. The results for change in antenna height are also analyzed. The antenna with height 2mm obtained an ultra wide band of 4.94GHz bandwidth with minimum return loss of –32.73dB and maximum gain produced by the antenna in this ultra wide band range is 2.37 dBi. Hence, the proposed antenna covers C and X band so it can be used in RADAR, radio telecommunication, satelitte communication application.

REFRENCES

[1] B.Roy, A. Bhattacharya, S.K.Chowdhury, A.K. Bhattacharjee 2016. "Optimization of resonant frequency of a Sierpinski triangular CMPA using genetic algorithm", IEEE antenna and wireless communications letters National Institute of Technology, Durgapur, India,Vol 16.2017

[2] Ashok V, Uma Maheswari S 2016." Miniaturized UWB Microstrip Fractal Antenna",IEEE2016 International Conference on Circuit, Power and Computing Technologies [ICCPCT].

[3] SangeethaVelan, Ester Florence Sundersingh, MalathiKangasabai, Member, Aswathy K. Sharma, ChinnambetiRaviteja, RamprabhuSivasamy, and JayaramKizhekkePakkathillam, 2015. "Dual-Band EBG Integrated Monopole Antenna Deploying Fractal Geometry for Wearable Applications," IEEE antenna and wireless communication letters, Vol 14.

[4] AmrollahAmini, homayoonOraizi, Mohammad Amin ChaychiZadeh, 2015. "Miniaturized UWB Log-Periodic Square Fractal Antenna," IEEE antenna and wireless communication letters, Vol 14.

[5] Shrivishal Tripathi, Akhilesh Mohan, SandeepYadav, 2015. "A Compact Kotch Fractal UWB MIMO Antenna with WLAN Band- Rejection," IEEE antenna and wireless communication letters, Vol 14.

[6] V.Dinesh, Dr. G Karunakar, 2015. "Analysis of Microstrip rectangular carpet shaped fractal antenna", SPACES-2015, Department of ECE, K.L.University.

[7] Pratik Lande, Daison Davis, Nigel Mascarenhas, Freda Fernandes, AshwiniKotrashetti, 2015. "Design and development of printed Sierpinski carpet, Sierpinski gasket and kotch snowflake fractal antenna for GSM and WLAN applications" International conference on technologies for sustainable development (ICTSD-2015).

[8] Yogesh Kumar Choukiker, Satish K. Sharma and Santanu K. Behera, 2014. "Hybrid Fractal Planer Monopole Antenna Covering multiple Wireless Communication With (MIMO) Implementation For Handheld Devices," IEEE transactions on antenna and propagation, Vol 62, No. 3, March 2014.

[9] T.Shanmuganantham, S.Raghavan, 2008. "Design Of a Compact Microstrip Patch Antenna With Probe Feeding for Wireless Applications," International Journal for Electronics and Communication pp. 653-659.

[10] S.Chaimool, C. Chokchai and P. Akkeraekthalin, 2012. "Multiband Loaded Fractal Loop Monopole Antenna For USB Dongle Application," Electronics letters, Vol 48, No. 23.

[11] Xue-Xea Yang, Bing-Cheng Shao, Fan Yang, Atef Z. Elsherbeniamd Bo Gong, 2012. "A Polarization Reconfigurable Patch Antenna With Loop Slots On Ground Plane," IEEE antenna and wireless communication letters, Vol 11.

[12] Christos G. Christodoulou, Youssef Tawk, Steven A. Lane, and Scott R. Erwin, 2012. " Reconfigurable Antennas For Wireless And Space Applications," Proceedings of the IEEE, Vol 100, No. 7.

[13] Vahid Sathi, NasrinEhteshami, JavadNourinia, 2012. "New Frequency-Reconfigurable Microstrip Antenna Composed Of Organic Semiconductor Polymer," Organic Electronics 13(2012), page 1192-1196.

[14] Nagpal A., Singh S. and Marwaha A., 2013. "Multiband E-Shaped Fractal Microstrip Patch Antenna with DGS for Wireless Applications", Proceedings of 5th IEEE International Conference on Computational Intelligence and Communication Networks, Mathura, India,pp22-26.

[15] Khidre, Lee, Elsherbeni Z., and Fan Yang, 2013. "Wide Band Dual-Beam U-Slot Microstrip Antenna", IEEE Transactions on Antennasand Propagation, Vol. 61, No. 3, pp 1415-1418.

[16] Gupta, Singh S. and Marwaha A., 2013. "Dual Band U-Slotted Microstrip Patch Antenna for C band and X band Radar", Proceedings of 5th IEEE International Conference on Computational Intelligence and Communication Networks, India, pp 41-45.

[17] Janani A., Priya A., 2013. "Design of E-Shape Fractal Simple Multiband Patch Antenna for S-Band LTE and Various Mobile Standards", International Journal Of Engineering And Science Vol.3, Issue 1, PP 12-19.

Authors:

Er.Parvesh Kumar

He received his B.Tech degree in ECE from Doon valley engg. College, Karnal, Haryana. His research interests are IPV4 based Network designing,MPLS, MPLS-TP, DWDM,SDH, Radio Access Network,Fractal Antenna, Reconfigurable antenna, Microstrip Patch antenna, Embedded Systems and Network Security. Formally worked as Senior Technical Officer in Electronics Corporation of India Ltd(Department of Atomic Energy). Currently working as Senior Engineer in Bharat Electronics Ltd (Ministry of Defence).

Er.Sumit Kaushik

He received his B.Tech degree in ECE from Doon valley engg. College, Karnal, Haryana, received his M.Tech from Ambala College of Engineering and Applied Research, Devsthali, Ambala, Haryana. His research interests are IPV4 based Network designing,MPLS, MPLS-TP, DWDM,SDH, Radio Access Network,Fractal Antenna, Reconfigurable antenna, Microstrip Patch antenna. Formally worked as Asst. Professor in LR group of Inst.[Solan], Formally worked as transmission engineer in Hi-tech[Chandigarh]. Formally worked as a Network Engineer in CSS Corp [Gurgaon].Currently working as Executive Engineer in Bharti Airtel [Gurgaon]. Several papers published in International Journals & IEEE conferences..