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PENTAGONAL FRACTAL ANTENNA FOR UWB APPLICATIONS WITH BANDWIDTH ENHANCEMENT

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ABSTRACT
This paper, presents design of microstrip patch antenna at frequencies 3.1 to 10.6 GHz. Further by introducing fractal concept to the pentagonal-shaped microstrip antenna is designed .The Ansoft HFSS finite element electromagnetic computer package was used to model, simulate and analyze pentagonal fractal antenna that operates at UWB frequencies. From space-filling property of fractal geometry, this antenna gives lower resonant frequencies, it is found that as iteration and iteration factor increases, the resonant frequency of this patch antenna decreases. The material used for substrate is FR4 with relative permittivity of 4.4 and thickness is about 1.53 mm. Microstrip line is used to feed the antenna. HFSS V13 software is used to design and simulate the proposed antenna. The results show that the proposed antenna offers good performance in multi band frequencies which is suitable for wireless point to point applications.

KEYWORDS: Bandwidth, Fractal, HFSS ,Microstrip Patch Antenna, ultra wideband(UWB) antenna

INTRODUCTION
STRUCTURE DESCRIPTION
Different fractal types i.e, Sierpinski gasket and carpet, Koch curve, Cantors set, has variety of applications of operating in multiband[1,2]. Due to its unique self-similarity nature and to make a compact antenna with more ,conductivity it has a wide application in the design of miniaturized patch antennas.

FRACTALS WITH PENTAGONAL GEOMETRY
In this project, a wideband antenna using pentagonal fractal geometry is constructed. Addition of patches became necessary in order to achieve ultra-wideband bandwidth. Project takes inspiration from Sierpinski carpet with rectangle as the base structure and Koch snowflake with pentagon as base structure. Many UWB[4] antennas have been constructed using basic shapes like rectangle, triangle. Hence, we decided to construct an UWB antenna with a pentagon as the base geometry. UWB has a wide range of applications [4,5]across numerous fields ranging from military operations to tracking to personal area networks thus the focus is on UWB .

RELATED WORK
Designers used to design antenna with different structures [1], [2] and getting the different values of return loss.With change in the substrate thickness and feeding point there will be a change in simulation results. Then the antenna compactness is increasing demand among customers. Aliakbar Dastranj, Ali Imani, and Mohammad Naser-Moghaddasiin October 2008 presented design and analysis of a novel printed wide-slot antenna, fed by a microstrip line, for wideband communication systems, The designed antenna has a wide operating bandwidth. In addition to being small in size . [3]. Tong Cai, Guang-Ming Wang, Xiao-Fei Zhang, and Jun-Peng Shi in may 2015proposed A novel low-profile and compact circularly-polarized (CP) antenna and comprehensively investigated based on the combination of fractal metasurface and fractal resonator. The results indicate that the proposed antenna achieves a compact layout of 40mm×45mm×2.5mm at 3.5 GHz, a relative wide bandwidth of more than 1.86% and also a comparable gain of about 6.3 dBic. [8]Malek A.H. Muhi* and Mohammed A.Z. Habeeb in December, 2013 proposed ‘ Modeling and Simulation of Sierpinski Pentagon Fractal Antennas’ and indicate that they can operate in the UMTS (2000 MHz–2200 MHz),

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Bluetooth (2400 MHz–2480 MHz), WLAN (2.4 GHz) and HIPERLAN (5.2 GHz) bands. Also, the computed results show, in general, good agreement with measured data for the S-parameter and radiation patterns.[9]

PROPOSED ANTENNA DESIGN:

Koch snowflake and Sierpinski gasket [1-5]with single iteration is designed for the multi band frequency of operation. Antenna can be fed by different feeding technique such as micro strip line feeding[11], inset feeding, coaxial feeding, proximity coupling feeding and aperture couple feeding. Proposed antenna design uses microstrip line feeding on opposite side of substrate. Different parameters have been observed at different frequency bands of operation .

A. SUBSTRATE MATERIAL

FR4 is the fire retardant dielectric material with permittivity of 4.4 and loss tangent of 0.02 and the thickness is 1.53mm.this material of substrate is chosen because of its low profile and low cost material is chosen to make antenna cost effective.

B. DESIGN PROCEDURE

Initial geometry of proposed pentagonal patch is calculated using equations (1) to (3) radius of circle is calculated as R=12.6 mm [7]with help of different parameters such as dielectric constant ,height of substrate and resonant frequency of antenna .In this design FR4 epoxy substrate with dielectric constant 4.4 ,height of substrate 1.53mm and resonant frequency of 3.2 GHz is used .

$$a = F\left\{1 + \frac{2h}{\pi F \varepsilon_r}\left[ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{-1/2} \quad (1)$$

$$F = \frac{8.791\times 10^9}{f_r\sqrt{\varepsilon r}} \quad (2)$$

$$a_e = a\left\{1 + \frac{2h}{\pi a \varepsilon_r}\left[ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2} \quad (3)$$

Where :
a = radius of circle
a_e = effective radius of circle
c= velocity of light in free space
fr=resonant frequency
h=height of substrate
εr=dielectric constant of substrate

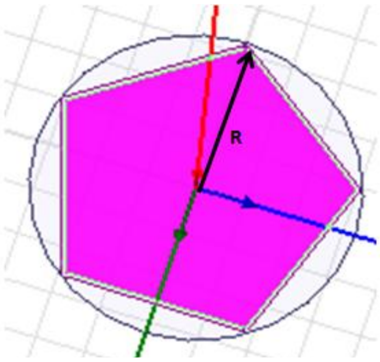


Figure1: proposed antenna initial geometry

The initiator as shown in figure1 pentagon with radius 12.6mm[7].Geometry constructed as combination of Sierpinski gasket and Koch curve where 1ts pentagon is taken in plane as initiator. In the second stage, small copies of pentagon are obtained when scaling down by factor. Then each one of small pieces is placed at edges outside large one. Figure illustrates the structure of initiator and 1st iteration. Further iterations also possible for the geometry.

The radiating patch: The radiating patch of the antenna is based on pentagonal geometry. The initiator is a pentagon with microstrip line feeding.

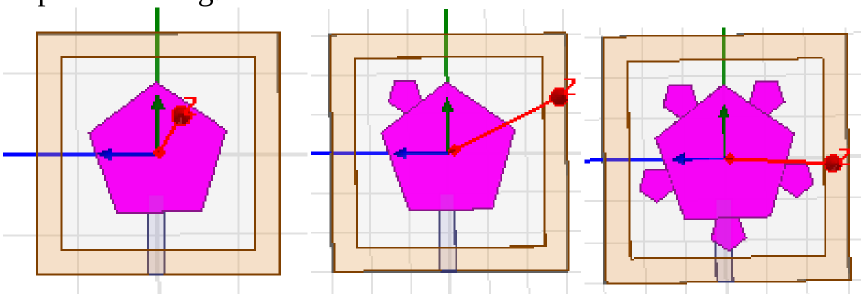


Figure2 :(a)Stage 0 Initiator (b) scaled down pentagon at outside the edge (c)proposed antenna

Patch can have as much iteration as required. After a few iterations, the results obtained gives acceptable values of parameters and thus no further iterations will be necessary.

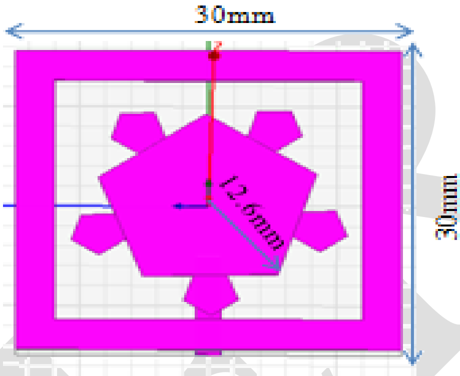


Figure3: Final dimensions of radiating patch

DIMENSIONS OF PROPOSED ANTENNA

Table1:Dimensions of antenna

Parameter	Values
Substrate	Length=30mm,width=30mm,thickness=1.53mm
Feed line	Length=10mm,width=2mm
Central Pentagon	Radius=12.6 scaling factor 0.5
Outer pentagons	Radius=12.6 scaling factor 0.25

RESULT AND DISCUSSIONS

3.1RETURN LOSS AND VSWR

Return loss versus frequency plot and VSWR of proposed antenna is shown in figure4 and figure5

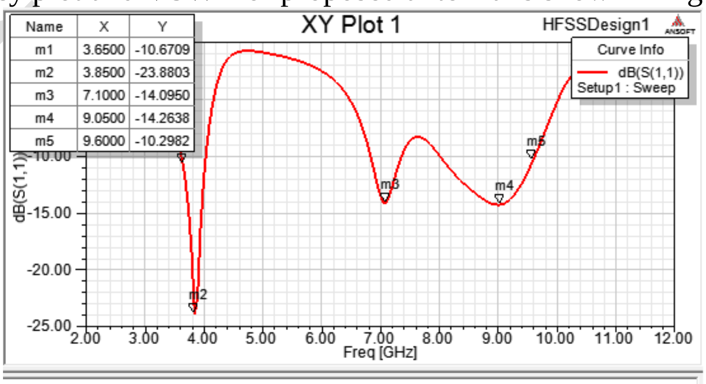


Figure4: Return loss versus frequency plot

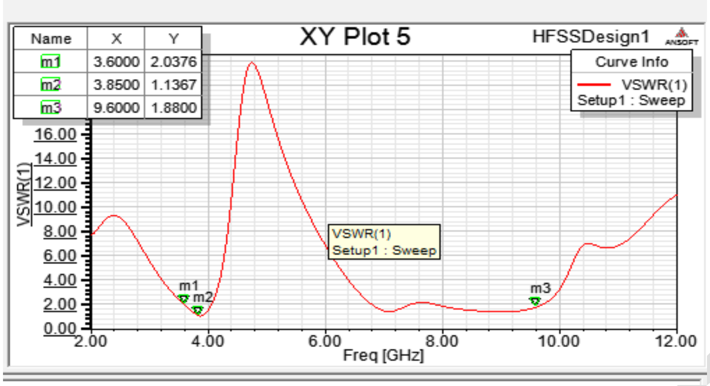


Figure5: VSWR versus frequency plot

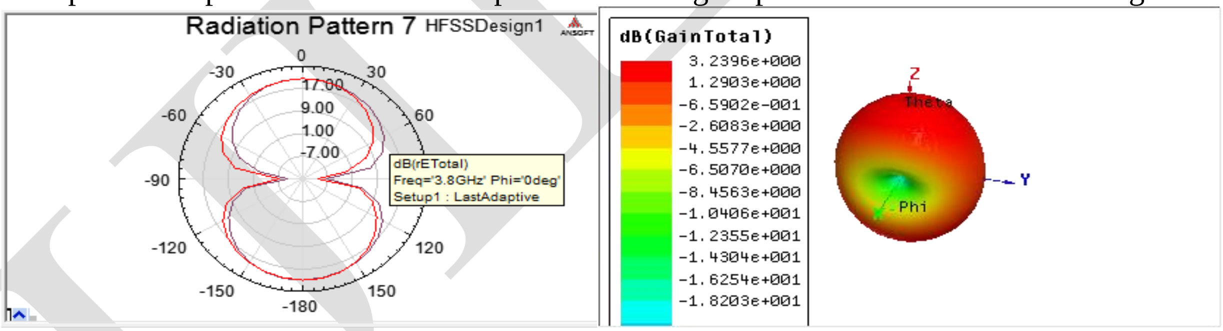
The antenna with pentagonal patch with line feed works on resonant frequency bands such as 3.8 GHz,7.1GHZ, 9GHz.The values of return loss at all frequency bands are at acceptable level (return loss less than -10dB)VSWR versus frequency curve of proposed antenna given in figure .Values of VSWR at all frequency bands are also at acceptable level (VSWR less than 2).

Table2 Proposed antenna simulated results

Frequency (GHz)	Return loss(dB)	VSWR
3.85	-23.88	1.13
7.10	-14.09	1.6
9.06	-14.06	1.83

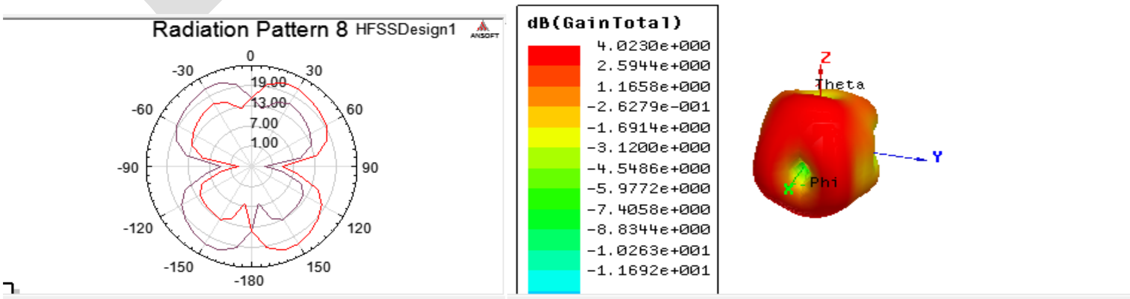
3.2 GAIN AND RADIATION PATTERN

The gain of antenna is simulated at all frequencies .Value of gain is at acceptable level as shown in table radiation pattern is graphical representation of relative field strength of antenna Useful portion of radiation pattern is at phi=0 and phi=180°.2Dradiation pattern and 3D gain plot of antenna is shown in figure below



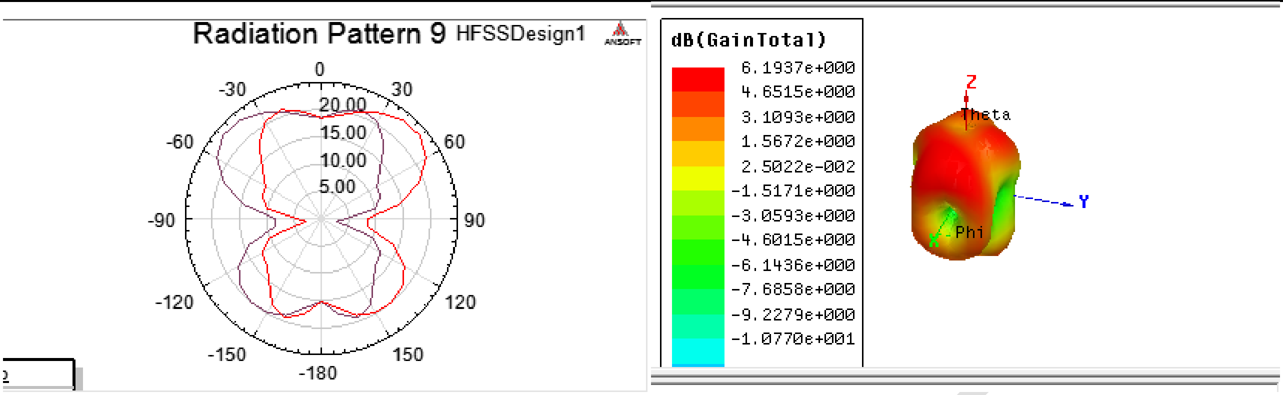
(a) **(b)**

Figure6:2Dradiation pattern(a) and 3D gain plot (b)at 3.8GHz



(a) **(b)**

Figure7:2Dradiation pattern(a) and 3D gain plot (b)at 7.1GHz



(a) **(b)**

Figure8:2Dradiation pattern(a) and 3D gain plot (b)at 9GHz

Table3:Simulated gain of proposed antenna

Frequency(GHz)	**Gain(dB)**
3.85	3.23
7.10	4.02
9.06	6.19

CONCLUSION

This paper presents design of compact pentagonal fractal antenna with line feed .antenna design reports wide bandwidth of 5.95GHZ(3.65-9.6GHz) which is enhanced by 1.74GHz compared with reference antennas. The value of maximum gain is 6.19dB at 9.0GHz frequency. Antenna with its compactness useful for wireless applications such as WIMAX,802.11AWLAN,HIPERLAN/2.

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