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Modelling and Simulation of Compact Pentagonal Fractal Antenna with Bandwidth Enhancement for UWB Applications

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Abstract: Pentagonal microstrip patch fractal antenna fed with microstrip line for bandwidth enhancement and size reduction is proposed and investigated using Ansoft HFSS finite element computer package. Radiation and impedance characteristics are studied. Self similarity concept can achieve wide bandwidth because of different parts are similar to each other at different scale. Material used is FR4 with relative permittivity of 4.4 and thickness is about 1.6 mm. Proposed antenna gives a wide bandwidth of 11.1GHz (3.7-14.8GHz), which is more than twice that of the reference antenna. Proposed antenna gives good performance in UWB, suitable for wireless point to point applications.

KEYWORDS: Bandwidth enhancement, Fractal, HFSS, Microstrip Patch, UWB

I.INTRODUCTION

Fractals have complexity and can be used to reduce antenna size. Self similarity concept can achieve wide bandwidth because of different parts are similar to each other at different scale [2].Infinite complexity and self-similarity made possible to design antennas with wideband performances. Different types of fractal i.e Carpet ,Sierpinski gasket, Cantors set ,Koch curve has variety of applications .A wideband antenna using pentagonal fractal geometry is constructed and studied. Inspiration from Sierpinski carpet with rectangle as the base structure is taken to carry out work .Basic shapes like rectangle, triangle, circle are used to construct antenna . Thus we decided to construct an UWB antenna with a pentagon as the base geometry of proposed work. Here compact (30mm×30mm) design of microstrip feed pentagonal fractal antenna proposed for ultra wide band applications. We need fractal antenna for some advantages such as broadband and multiband frequency response, compact size compared with conventional antennas, Mechanical simplicity and robustness .UWB has a wide range of applications [5,6]

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. The compact antennas for different applications are in 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 shows antenna indicates compact size 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), 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]

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II.ANTENNA DESIGN

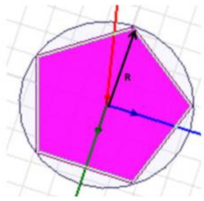


Figure 1: Antenna initiator

Figure 1 shows the initiator of proposed antenna The radius of proposed patch is calculated by using equations (1) to (3)as R=8.7mm [7]using different parameters such as,height of substrate, dielectric constant and resonant frequency of antenna . FR4 epoxy substrate with dielectric constant 4.4 ,height of substrate 1.6mm and resonant frequency of 4.77 GHz is used in this design.

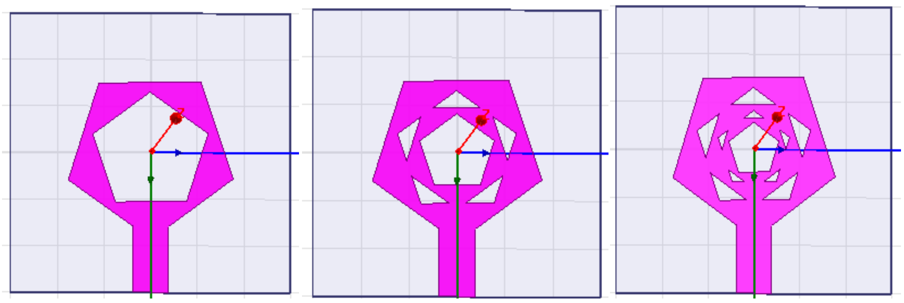
$$a = F\left\{1 + \frac{2h}{\pi F \varepsilon_r}\left[ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{-1/2} \quad (1)$$

$$F = \frac{8.791\times10^9}{f_{r\sqrt{\varepsilon r}}} \quad (2)$$

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

Where:
a = circle radius
a_e = effective radius of circle
fr=resonant frequency
h=height of substrate
εr=dielectric constant of substrate

The initiator is as shown in figure1 pentagon with radius 8.7mm[7].Geometry constructed as Sierpinski gasket where the subsequent iterative stages are achieved by scaling the pentagon in current stage and adding the newly obtained pentagon to the previous structure shown in figure 2 . For ultra wide band frequency of operation Sierpinski gasket [1-5]with three iteration is designed. Antenna can be fed by different feeding technique such as inset feeding ,micro strip line feeding [11], proximity coupling, coaxial feeding.



(a) Stage 0 Initiator **(b) Stage 1** **(c) Stage 2**

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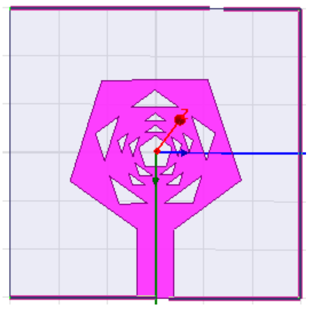

(d)Stage 3

Figure 2 :Proposed antenna geometry

Patch can have as much iteration as required. The results obtained gives acceptable values of parameters after a few iterations, and thus no further iterations will be necessary. The ground plane was modified from full ground plane to less than half of its area. Reduction of ground plane results in reduction of copper loss and surface waves and thus better radiation and bandwidth of radiation. A comparative study was conducted and the best result was obtained when the dimensions of the ground plane as shown in figure 3

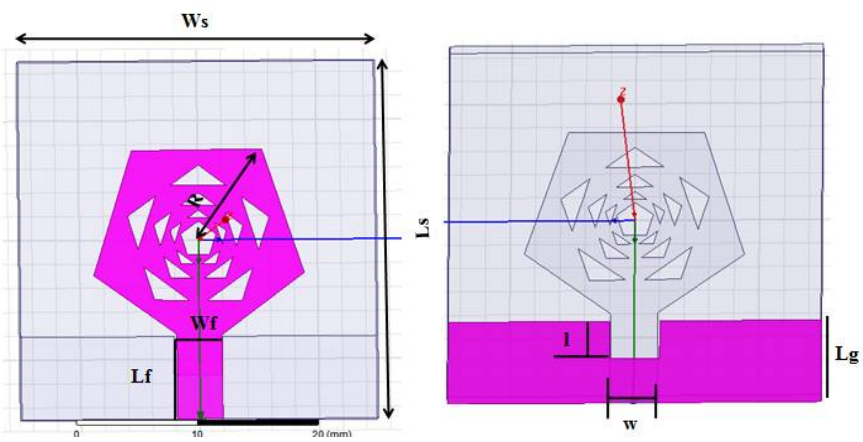

Figure 3: Final dimensions of radiating patch and ground

Table1:Proposed antenna parametric values

Sr.no	Parameters	Description	Values
1	Ws	Width of substrate	30mm
2	Ls	Length of substrate	29.92mm
3	Wf	Width of feed	3.8mm
4	Lf	Length of feed	8mm
5	Lg	Length of ground	7mm
6	l	Length of slot	3.2mm
7	w	Width of slot	4mm

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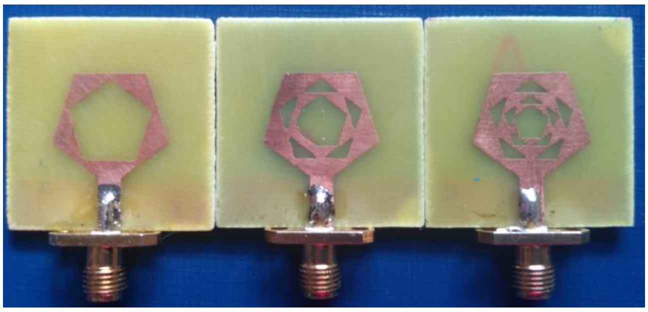

Figure 4: Pentagonal fractal patch antenna configuration with line feed top view

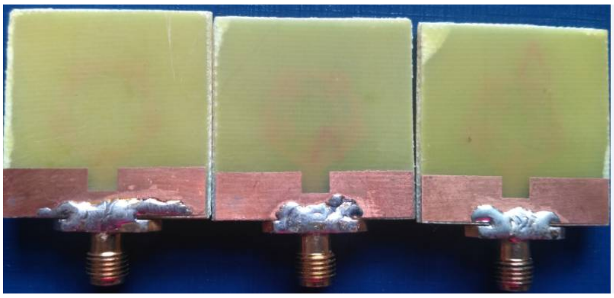

Figure 5 : antenna bottom view with partial ground plane

III. RESULT AND DISCUSSIONS

3.1Simulated results

3.1 .1Return loss and VSWR

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

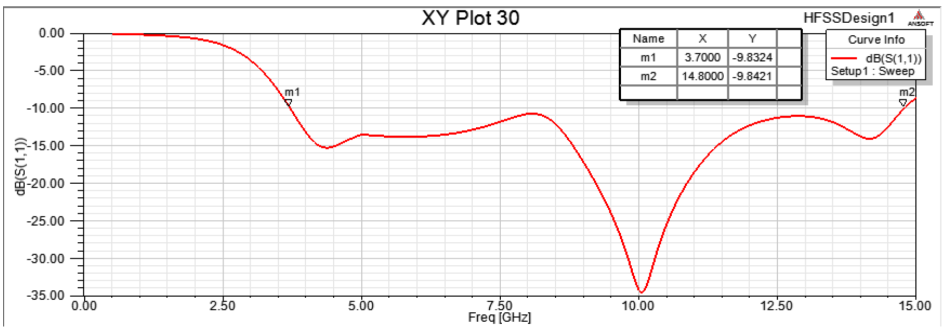

Figure 6: Return loss plot

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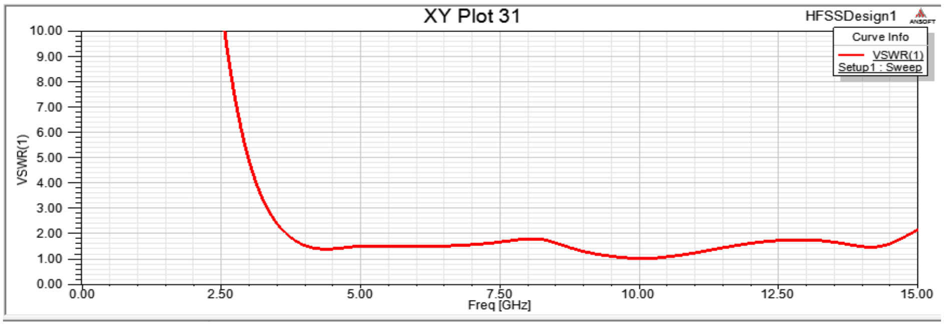

Figure 7: VSWR plot

The pentagonal fractal patch antenna with line feed works on frequency bands from 3.7 to 14.8GHz.Return loss at all frequency bands are at acceptable level {return loss < -10dB}VSWR versus frequency curve of proposed antenna given in figure 7 . VSWR at all frequency bands are also at acceptable level {VSWR < 2}.

3.1.2 Gain and radiation pattern

The gain and radiation pattern of antenna is simulated at all frequencies .Value of gain is at acceptable level as shown in table. Graphical representation of relative field strength of antenna is called radiation pattern is figure of eight ,similar with radiation pattern of dipole antenna.2Dradiation pattern and 3D gain plot of antenna is shown in figure below

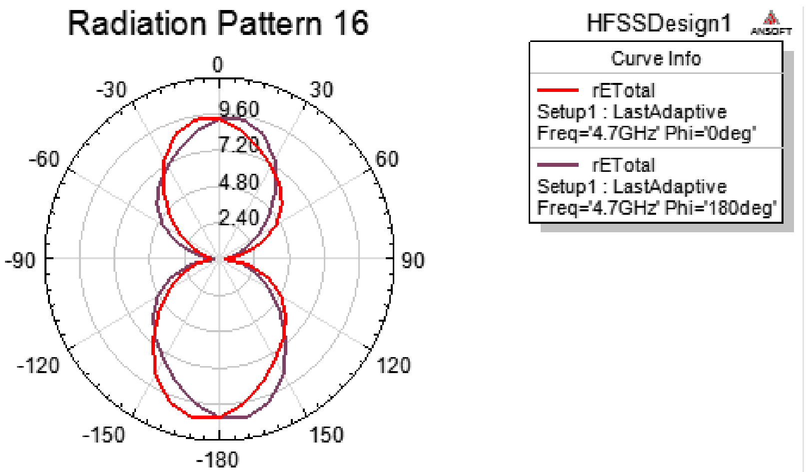

Figure 8:2D radiation pattern

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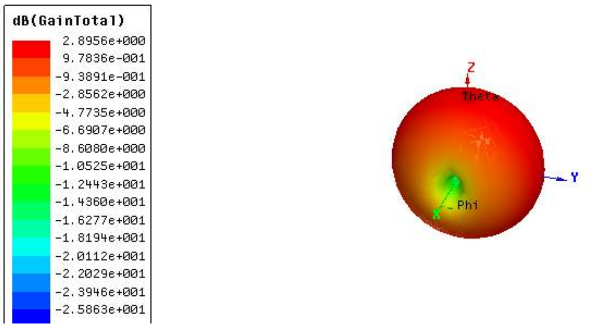
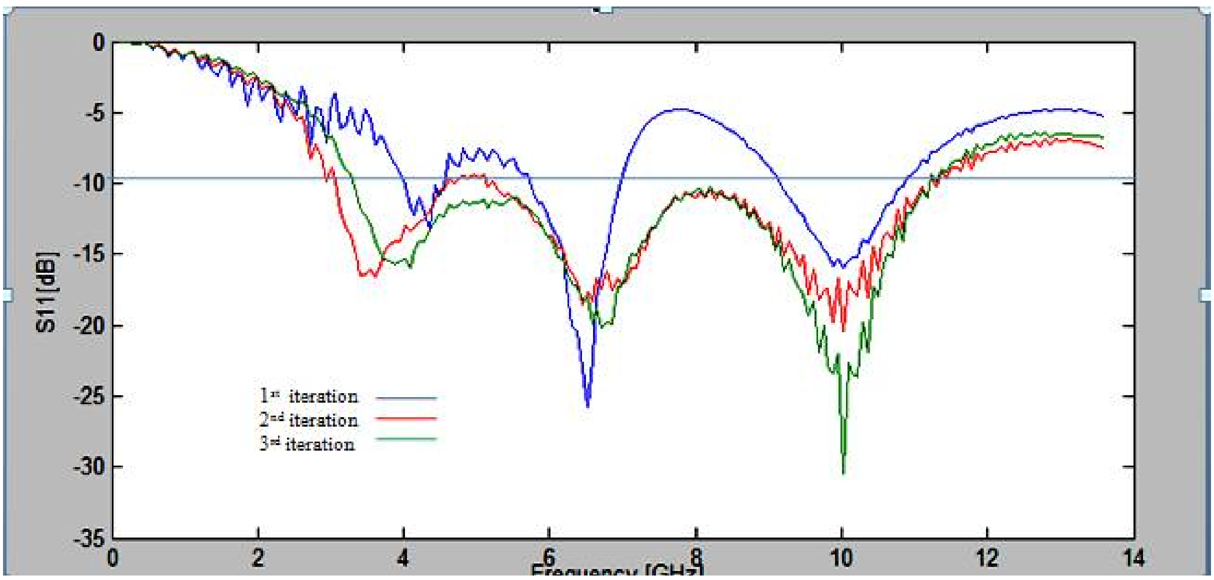


Figure 9:3D Gain plot

3.2Experimental results

3.2.1Return loss and VSWR



(a)Return loss

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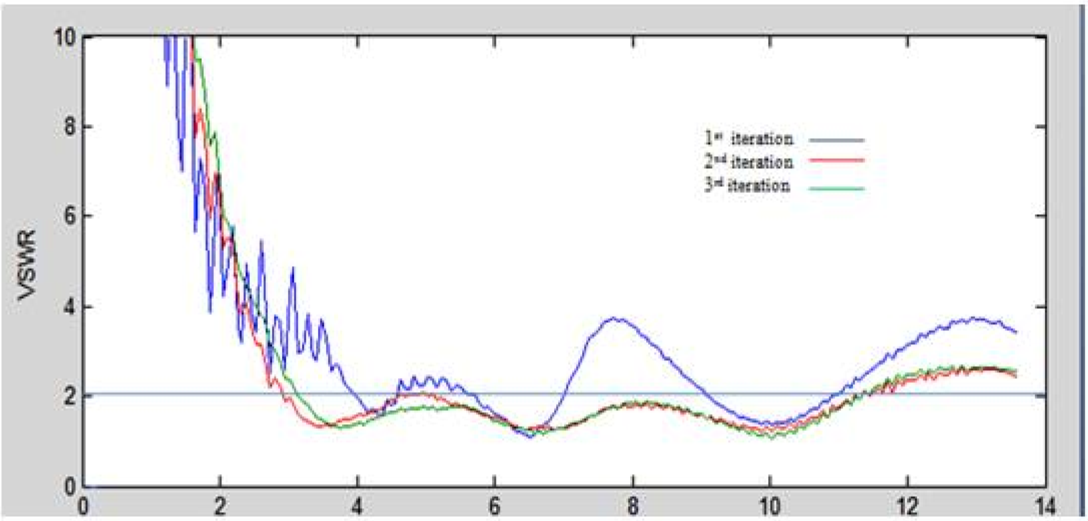

(b)VSWR

IV. CONCLUSION

Compact(30mm×30mm) pentagonal fractal antenna with line feed presented in this paper. Antenna design gives wide bandwidth of 11.1GHz(3.7-14.8GHz) which is more than twice that of reference antennas. The value of maximum gain is 2.8dB. They cover a wide range of applications in UWB , e.g. Personal Area Network with its compactness. Results obtained from the HFSS software show good agreement with measured results on VNA for S11 parameter and VSWR.

FUTURE WORK

Antenna size reduction can be done by scaling it to optimum configuration

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