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Metamaterial Inspired Star Shape Fractal Antenna for Gain Enhancement

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ABSTRACT

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A metamaterial-based novel compact microstrip antenna is presentedfor ultra-wideband (UWB) applications. The antenna consists of a layer of metamaterial made by etching a crossed-shaped slots, on the the ground plane,respectively. The shunt inductance developeddue to the patterned ground plane lead to theleft-handed behaviour of the metamaterial. The proposed antenna hasa compact size of 45.4 × 31.6 × 1.6mm^3 and is fed by a 50 Ω microstripline. Radiating patch is fractal antenna of star shape with 6mm side length. The impedance bandwidth (−10 dB) is from 3 GHz tomore than 14 GHz with maximum radiation in the horizontal planeand tends towards a directional pattern as the frequency increases. Maximum gain 15.8533db obtained from fractal antenna.

KEYWORDS: ***HFSS, Fractal, Metamaterial, Return Loss, Gain***

INTRODUCTION

The wireless industry is most popular in designing of microstrip patch antenna.Wireless, the rapid growing technology of the communication industry is the generic term meaning without using wires between contract points. Many areas such as wireless sensors networks, automated organization and industries, remote telemedicine, smart home and appliances, intelligent transport systems, etc. have been emerged from research ideas to practical availability. In some application, fractal antenna plays important role. Fractal antennas are similar in geometry & have a large no. of resonant frequencies. At non harmonic frequencies, fractal antenna may used for multiband operations. As compared to non fractal antennas fractal antennas improves impedance, VSWR. On the other hand, at very high frequencies it act as broad band antenna. Different simulation like polarization & phasing may be done in these fractal antennas. As discussed above

many microwave circuits amplify by these fractal antennas. Matching of different component with fractal antenna is does not require to achieve multiband performance. In many cases, the use of fractal elementantennas can simplify circuit design. Often fractal antenna do not require anymatching components to achieve multiband or broadband performance.

In this paper star fractal with two iteration have been generated using Ansoft HFSS tool. Fractal of star length 6mm with different iteration have

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been simulated . There are many application of these fractal antennas .The proposed antenna exhibits excellent performance at 3.45 Ghz and radiation properties is also improves. The advantage of proposed antenna design is compactness. The size reduction of antenna is achieved up to 50%.

The non-integral dimensions, recursive irregularity, andspace filling capability of fractal antennas make it useful forvarious applications in wireless communication includingminiaturized antenna designs [1]. Their property of beingself-similar in the geometry leads to antennas of compact sizewith simplified circuit designs. Antennas, which have fractalgeometry, are self-iterative, exhibiting multiband operation.

Fractal antenna is preferred as compare to conventional antenna due frequency independency property. These antennas are most commonly used because these antennas are of very high gain & minimum return loss.

Metamaterials are artificial materials. These materials are designed by different resonators after a regular interval. Metamaterial have good frequency selective response& have unique properties such as negative permittivity & permeability. It also have negative refractive index which improve antenna performance.

The compositions of metamaterial have adjustable and electromagnetic response vary in accordance to time. As metamaterial used as substrate, it improves gain of the system

The rest of the paper is organized as follows. Section II introduces the complete design of zero iteration star patch antenna. and III & IV tell about 1st iteration star patch antenna & 2nd iteration star patch antenna respectively. Simulated results of the proposed antenna are discussed in Section V. The conclusions are given in Section VI.

Zero Iteration star patch Antenna Design

The proposed antenna uses substrate FR-4 with $\in_r$ 4.4 & 1.6 thick. The octagonal star fractal antenna is used which radiate maximum efficiency.

A patch of dimension 36 ×36 mm was selected. Such a patch resonatedat 3.45 GHz in normal operating condition. Theresonant frequency of the patch antenna is minimized by zero iteration wasetched out from its radiating patch at its center. After that it is compare with second iteration which was etched out from its radiating patch as in star form.

In the design of the zero iterationpatch, the dimension of the star lengthwas varied and the antenna was operate at 3.45GHz using the commercial software HFSS. The final fractal design obtainedis shown in Fig. 1. The length of each side of 2nd iterative antennawas 6 mm.The feedline width was 9.7 mm, which givesa characteristic impedance of 50 Ω. The top view of Zero iteration patch antenna is as shown in the fig 1.

The proposed antenna is compare with metamaterial patch antenna as shown in fig 2. Square rings are cut into the ground plane with 0.2mm distance apart.

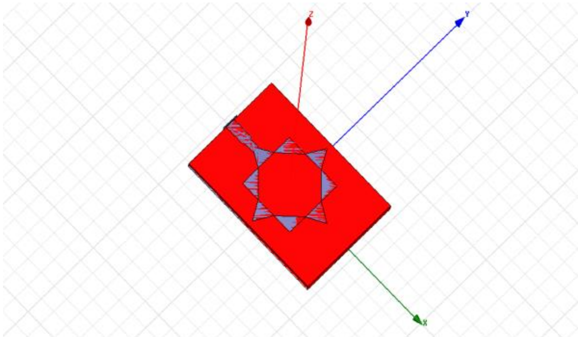

Fig 1. Top View of Zero Iteration Antenna

On the other hand for making star shape cut in ground give 0.3mm star shape antenna. Another ground is designed with 2mm gap to metamaterial. Dimension of ground is 20.6 × 31.6.

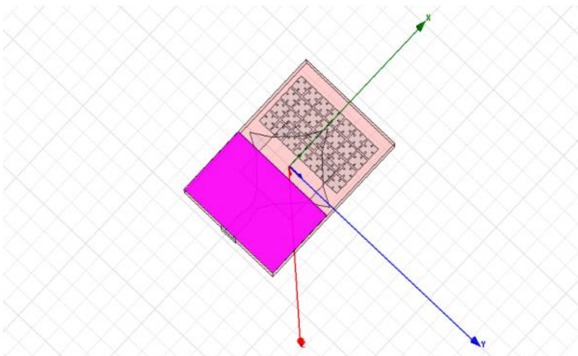

Fig 2. Bottom View of Zero Iteration Antenna

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Return Loss is important parameter for an antenna design. The ideal return loss is assumed to be -10db. Return loss should be minimum. The antenna is simulated in HFSS tool and return loss is measure. In case of zero iteration antenna return loss is -13.220 db. The return loss of zero iteration is given by fig 3. This graphs shows that impedance matching of port to the antenna

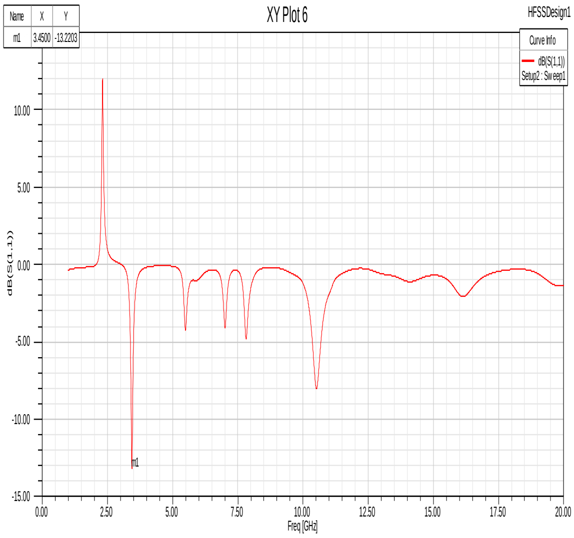

Fig 3. Return Loss of Zero Iteration Antenna

The current distribution gives an idea to distribute a charge to the whole surface. The distributed current is gives in ampere per meter. In case of zero iteration current distribution is given as 1.110 $\times\ e^{+002}$ ampere per m^2 .Current distribution of CSRR is shown in fig 4.

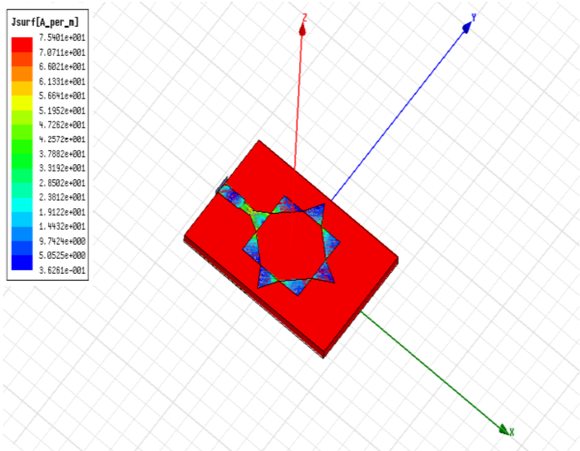

Fig 4. Current Distribution of Zero Iteration Antenna

Gain is also an important parameter to design an antenna. The Gain enhanced by drawing different slots. Radiation pattern of gain given in fig 5. Gain of zeroth iteration antenna is 7.6309 db

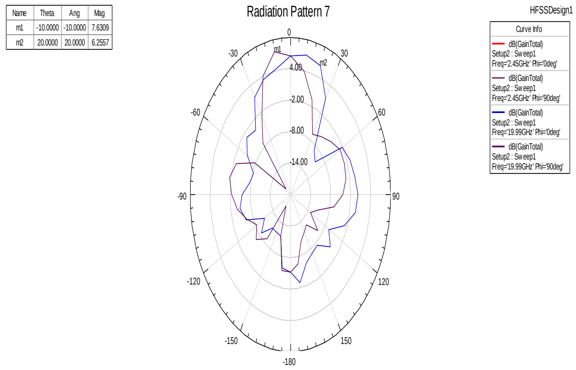

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Fig 5. Radiation Pattern of Gain of Zero Iteration Antenna

First Iteration star patch Antenna Design

The First iteration antenna is compare with zeroth patch antenna as shown in fig 6. Same shape as previous antenna is designed.Side of iterative star antenna is reducingto 4mm. On the other hand air gap in two iteration is 1 mm.

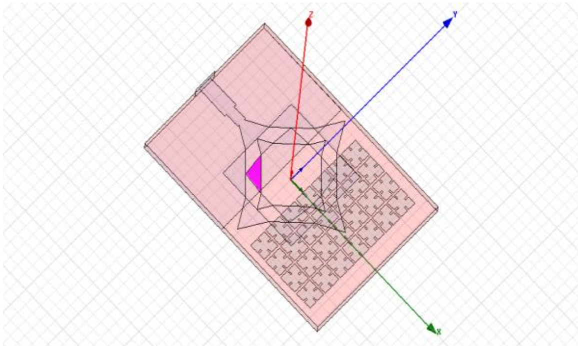

Fig 6. Top View of First Iteration Antenna

In case of 1st iteration return loss is -15.7035 db. The return loss of 1st iteration is given by fig 7. This graphs shows that return loss becomes more negative as compared to zeroth iterrative antenna.

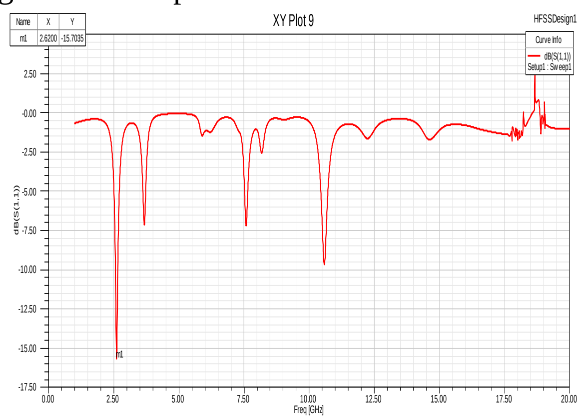

Fig 7. Return Loss of First Iteration Antenna

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The currentdistribution is improved in 1st iteration. The distributed current is gives in ampere per meter. In case of 1st iteration current distribution is given as 1.11 e^{+002} ampere per m^2 .Current distribution of 1st iteration is shown in fig 8.

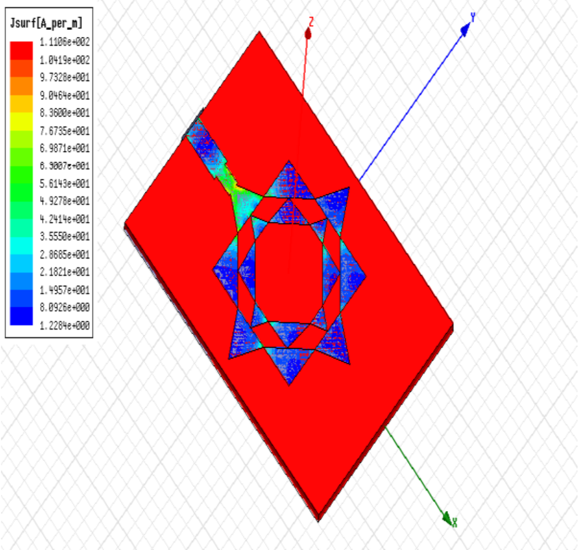

Fig 8. Current Distribution of First Iteration Antenna

Gain is improved with repeating shape. Radiation pattern of gain given in fig 9. Gain of 1st iteration antenna is 10.0762 db.

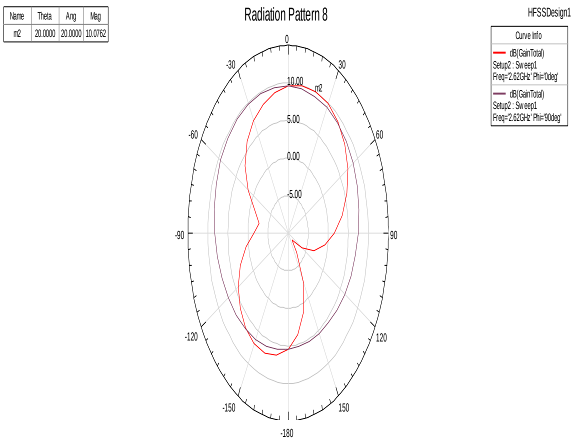

Fig 9. Radiation Pattern of Gain of First Iteration Antenna

Second Iteration star patch Antenna Design

Second iteration is designed with repeating of 0th& 1st iteration antenna. This shape provides identical results of an antenna. The fractal having side of 6mm and gap between them is 2mm. Bottom view of 2nditeration is shown in fig 10.

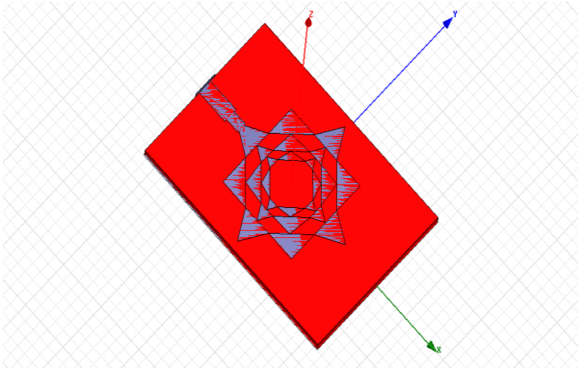

Fig 10.Top View of Second Iteration Antenna

In case of 2nd iteration return loss is -17.4276 db. The return loss of 2nd iteration is given by fig 11. This graphs shows that return loss becomes more negative as compared to zeroth iterative & 1st iterative antenna.

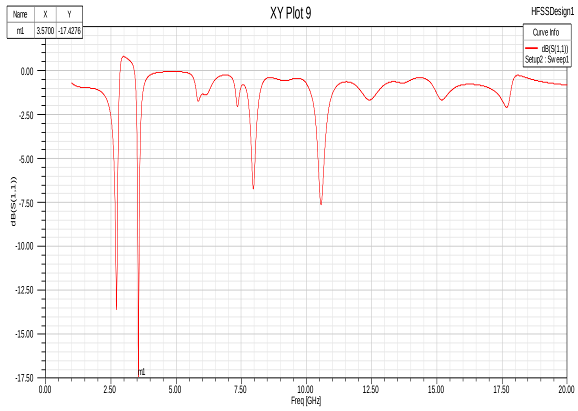

Fig 11. Return Loss of Second Iteration Antenna

The current distribution is improved in 2nd iteration. The distributed current is gives in ampere per meter. In case of 2nd iteration current distribution is given as 1.437 e^{+002} ampere per m^2.Current distribution of 2nd iteration is shown in fig 12.

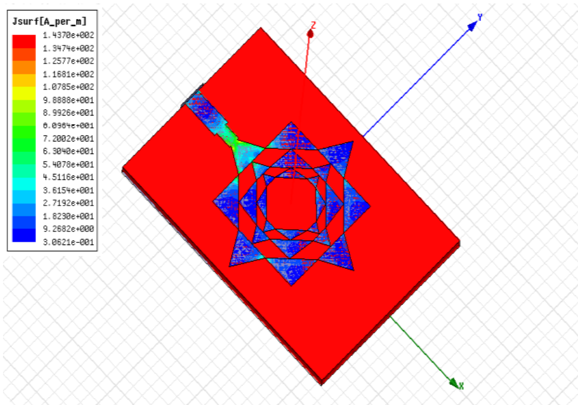

Fig 12. Current Distribution of Second Iteration Antenna

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Gain is improved with repeating shape. Radiation pattern of gain given in fig 13. Gain of 2nd iteration antenna is 15.8533 db.

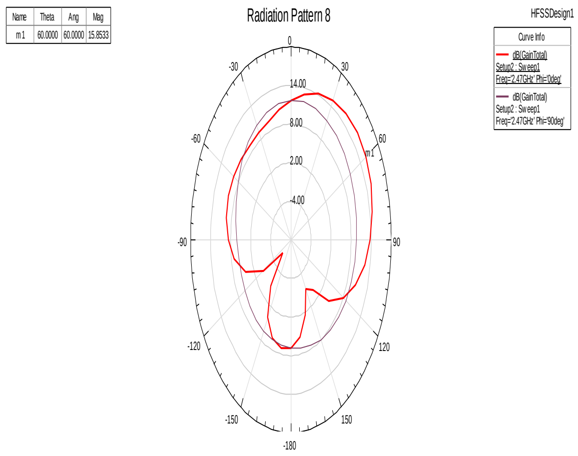

Fig 13. Radiation Pattern of Gain of Second Iteration Antenna

Comparative Analysis

In this section, comparative of two configurations is shown in tabular form. Return loss and bandwidth is compared in table 1.

Table-1. Comparative analysis of different iteration of Antenna

Sr. No	Parameter	0th Iteration Antenna	1st Iteration Antenna	2nd Iteration Antenna
1.	F_L	3.12	3.06	2.97
2.	F_H	3.68	3.92	4.12
3.	F_0	3.45	3.45	3.45
4.	% B.W	16.23	24.9	33.33
5.	Return Loss	-13.220	-15.7035	-17.4276
6.	Gain	7.6309	10.0762	15.8533

Conclusion

After Simulation, it is found that zero iteration fractalpatchantenna has low return loss with high gain andbandwidth. Simulated return loss is -17.4276 with gain 15.8533 db and bandwidth 33.33% is obtained from multi iteration patch antenna

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