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Pythagorean Tree Multiband Fractal Antenna

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Abstract— In this paper the design and analysis of the Pythagorean tree fractal antenna is proposed, which uses a unique fractal geometry known as Pythagoras tree. It was simulated using IE3D electromagnetic simulator by which antenna properties such as return loss, gain, VSWR, Directivity and Bandwidth are analyzed. This antenna has a compact size of base patch 41.34*41.34*1.6 mm^3 .The antenna has been designed for the frequency ranges of 0 GHz to 6 GHz for which VSWR< 2 which includes the WLAN, Wi-Max & other wireless communication applications.

Keywords— Fractal, Multiband, Fractal antenna, Pythagorean tree, self-similarity, Iteration, Iterated function system.

INTRODUCTION

Antenna design is a very tricky problem. As the conventional antenna are intrinsically a very narrow band devices which does not helps to operate multiple applications with a single antenna and its behavior is depend on the size of antenna for their desired frequency. This has initiated antenna research in various directions, one of which is the fractal antenna [1]. The word fractal was derived from the Latin fractus meaning "broken" or "fractured" [2]. The concept of fractal was exposed by Benoit Mandelbrot the French mathematician during 1975 while conducting research on several naturally occurring irregular and fragmented geometries [3]. From this Fractal antenna was come and those provides the multiband behavior, self-similarity[4] & space filling properties[5], [6]. Fractal concept has emerged as novel method for designing multiband antennas[1][7]and which will expand the bandwidth and reduce the dimensions of the antenna [8]. Fractal engineering has the great ability in antenna miniaturization, multi-frequency and multiband application [9]. Fractal antenna is the field that uses the Fractal Geometries with iteration function system (IFS) for antenna design [10] [11]. The modern communication system has been developed to the broadband and integration; meanwhile people's needs for portable mobile communication are higher. This requires antenna development corresponding broadband technology, multifrequency technology and miniaturization.

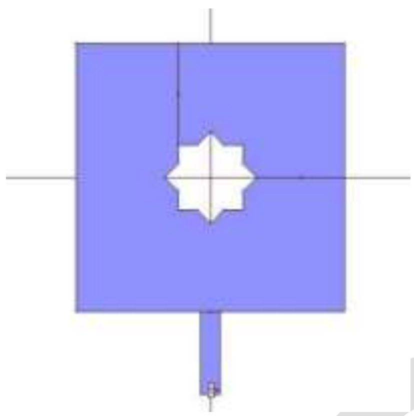
In this paper, a fractal antenna using Pythagorean tree shape as the fractal geometry is design for multiband frequency bandwidth. The existence of infinite fractal geometries and their advantages opens the door to endless possibilities to accomplish the task at hand. The use of fractals provides us with a bigger set of parameters to control the antenna characteristics.

ANTENNA CONFIGURATION AND DESIGN

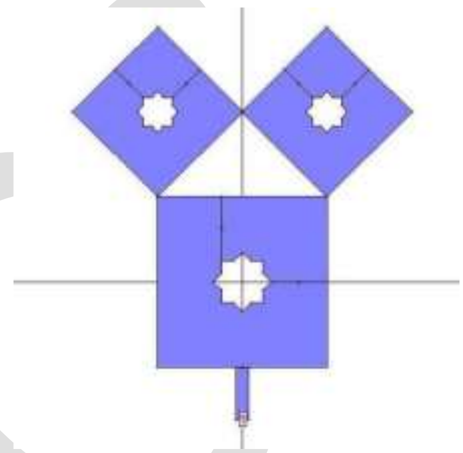
The procedure for designing the proposed antenna in IE3D software (ver. 14.10) is explained here. As, the Pythagorean shape Fractal tree is 2-D planar fractal antenna, constructed by squares patches [12], [13] and named after Greek mathematician Pythagoras. This antenna obey the Pythagoras theorem where each triple of touching of squares enclose a right triangle. If the base square (largest) has a size of L×L, the entire antenna fits inside a box of size 6L×4L. [13] Rest of the squares are iterated on the base square and each square is further scaled down by the factor of $(1/2)\times\sqrt{2}$. The proposed antenna is printed on RT/Duroid substrate with permittivity of 2.2 and loss tangent $\tan\delta$ =.001 and thickness of substrate h=1.6 mm and compact dimension of 41.34*41.34*1.6mm^3. At centre of each patch an etching is carried out which is approximate 25% of dimension of respected patch i.e. having a shape of two overlapped squares with a difference of 45^0 to each other.

If ' i ' is the iteration factor then, Number of squares in each iteration will be equal to 2^i . So size of patch scale down after i iteration will be $[1/\sqrt{2}]^i$. The microstrip patch antenna parameters helps for the calculation of basic patch for this antenna at frequency of 2.4 GHz. Antenna is feeded by the microstrip feeding of 13 mm length & 3 mm width to achieve 50Ω impedance characteristic [4]. Each square patch follows the Pythagoras theorem as they are iterated on the base patch making a right angle between two square patches touches base patch.

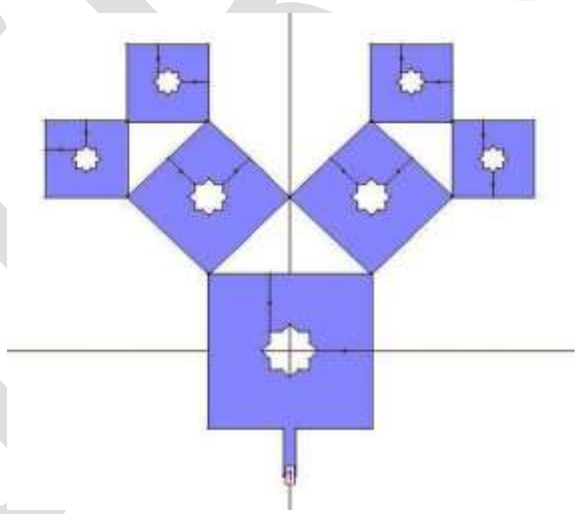
The designing of antenna consists of L_1=W_1= 41.34 mm, L_{E1}=W_{E1}=10mm, L_2=W_2=29.23mm, L_{E2}=W_{E2}=7mm, L_3=W_3=20.66, L_{E3}=W_{E3}=5mm, and W_f = 3 mm, L_f =13. Where L and W denotes the length and width of patch, L_E and W_E denotes the etching length and width, and L_f and W_f denotes the feeding length and width respectively.



Iteration 0



Iteration 1



Iteration 2

Fig:1 Proposed antenna design

RESULT AND DISCUSSION

The performance of the proposed antenna at different iterations haven been using integral Equation in three dimension (IE3D) software and characteristics have been analyze in term of return loss, VSWR, impedance bandwidth and radiation characteristic etc.

Fig:4 shows the Zero iteration, it is observed that at this the antenna resonates at frequency f = 4.692 GHz minimum value of return loss (RL)= -12.2824 dB means at this frequency antenna is capable to radiates its maximum value of energy towards the receiver and at f=5.23156 GHz value of return loss (RL)= -10.4231 dB. In First iteration the antenna resonates at frequency f = 4.67213

GHz minimum value of return loss (RL)= -11.5422dB , f=5.1332 GHz with RL= -10.1585 dB and at f=5.64 with RL=-13.5852. In iteration third the multiband behavior is achieved at frequency of 4.67213 GHz with return loss (RL) = -10.1427dB, second band is at 5.40369 GHz with RL = -24.4221dB, and third band at 5.80818 GHz with RL= -33.0563 and VSWR = 1.04853. Maximum Total Field gain = 6.58366 dBi.

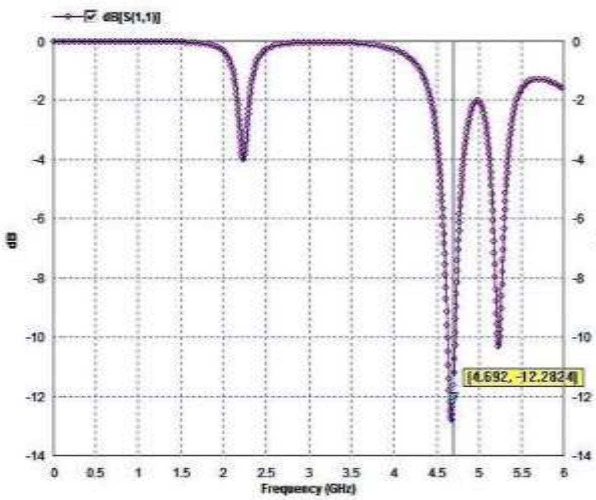


Fig 2: Return loss in case of iteration 0

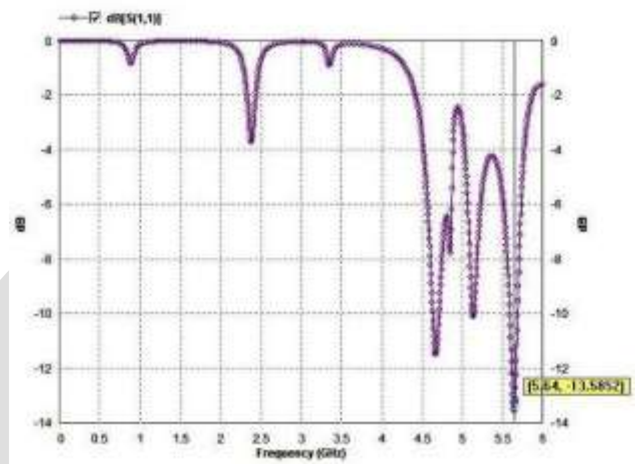


Fig 3: Return loss in case of iteration 1

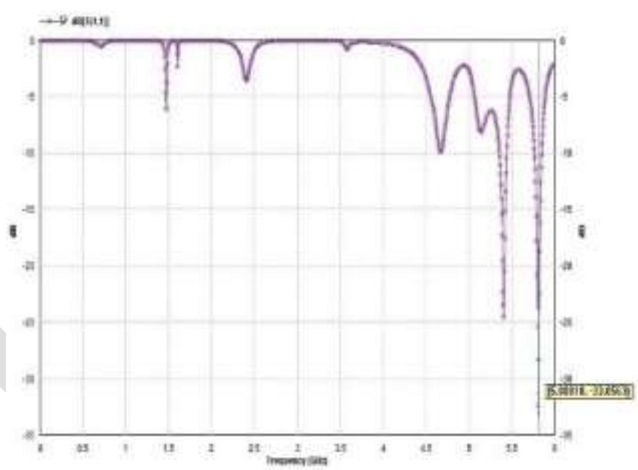


Fig 4: Return loss in case of iteration 2

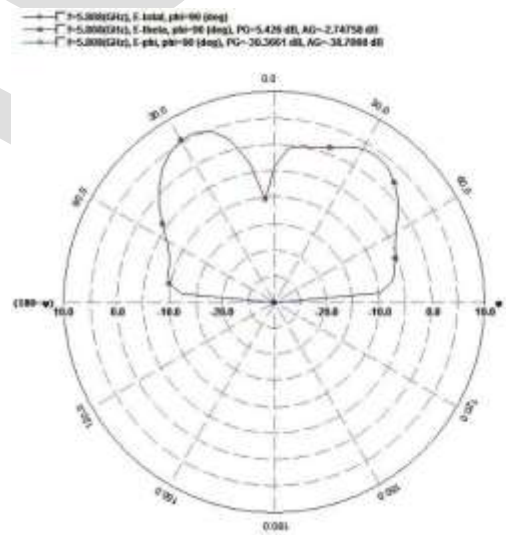


Fig5: 2D Radiation pattern of iteration 2

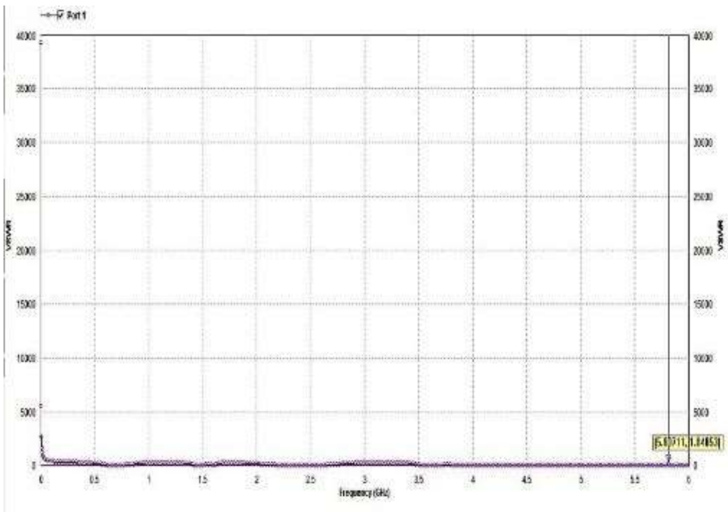


Fig 6: VSWR Pattern plot of iteration 2

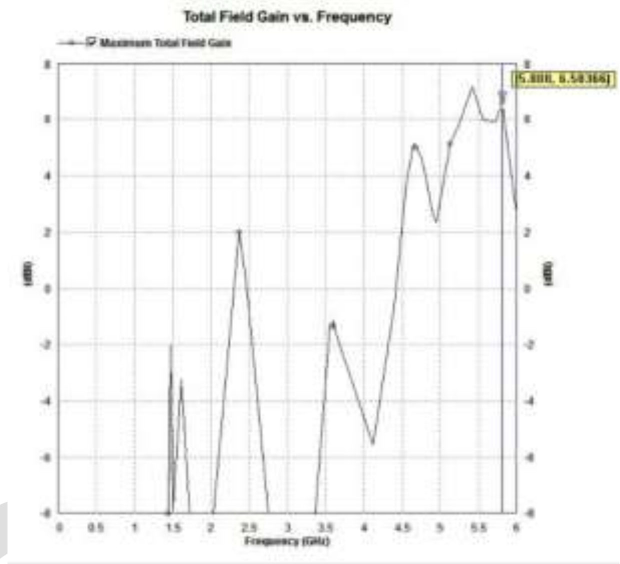


Fig7: Total Field Gain Vs Frequency of Iteration 2

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CONCLUSION

A Pythagorean Tree Fractal Antenna With Microstrip line feeding was investigated. It is observed that increasing the fractal iteration will generate the several bands and a good impedance matching was obtained. This particular antenna is capable to operate for WLAN (2.4 GHz) and also usable for the IEEE.11a (5.180-5.825 GHz). So the use of Pythagoras tree fractal geometry results in a multi-frequency and wide bandwidth operation of the antenna without employing any further modification.

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