Iterated Pythagorean Fractal Tree Multiband Antenna

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Abstract- This paper presents the design & analysis of a planar multiband antenna (Iterated Pythagorean fractal tree antenna) with impedance steps in base path. Impedance steps are adopted with finite ground plane for better impedance matching, multiband & bandwidth characteristics as compare to non-iterated form. As tree iteration increases new resonance frequency will obtained, Iterated Pythagorean fractal multiband tree antenna (IPTFA) has compact size of 41.08*41.08*1.57 mm^3 and operates over the frequency band of 2.4 GHz. The improvement in multiband behavior id investigated & discussed with VSWR<2.

Index Terms- planar fractal antenna (PFA), Pythagorean fractal tree (PFT), Impedance steps, Multiband.

I. INTRODUCTION

In the past several years antenna have capability to operate at a single midband frequency & in narrow bandwidth which limits the operational capability of antenna.Modern fast communication urged large amount of bandwidth, dual band, multiband & UWB (3.1 GHz – 10.6 GHz) communication antennas. Fractal antenna provides the multiband behavior having self-similarity [1], [2] & space filling properties. Fractal concept has emerged as novel method for designing multiband antennas [1], [3].

This paper presents the designing of a novel modified Iterated Pythagorean fractal multiband tree (IPFT) antenna based on multifractal technique, Most of the fractal objects have self -similar shape although there are some fractal objects exist that are hardly self-similar at all and have endless complexity and details [4]. Fractal Geometry was first defined by B.Mandelbort, describes the complex geometries and it was generated with iterative procedure in 1975 [4]. Fractals are made of union of several copies of itself each reproduction being transformed by a function system called iterated function system (IFS), IFS is a method of creating fractals resulting structure is always self- similar [5], [9].

A very good miniaturization ability is achieved due toitself similarity without affecting the bandwidth & accuracy of IPTF antenna, New resonance is obtained as iteration increases but radiation patterns just like Euclidean-shape patches unchanged & it also having several degree of freedom over conventional type patches [1].

II.ANTENNA DESIGN

The Iterated Pythagorean fractal multiband tree (IPFT) is 2-D planar antenna, constructed by squares [6], [7] and named after Greek mathematician Pythagoras because each triple of touching of squares enclose a right triangle based on configuration traditionally used to depict the Pythagoras theorem. If the basic patch of having dimensions of L*L mm^2 then entire structure is fit into the structure of dimension 6L*4L mm^2, Further squares are iterated on the base patch and each square is further scaled down by the factor of (1/2)*$\sqrt{2}$, the meshing of the scale down structure can be merged for the proper flow of current supplied from the base patch through SMA connector having impedance of 50Ω [1].

If n= iteration factor
No. of squares in each iterations =2^n
Size of patch scale down after n iteration= $[1/\sqrt{2}]^n$

The basic patch is chosen from the microstrip rectangular patch antenna at frequency of 2.4 GHz.Antenna is feeded by the microstrip feeding of 13 mm length & 3 mm width, it is 0.5 mm inserted in square patch for the activation. Antenna is fabricated on the dielectric substrate having dielectric constant $\varepsilon = 2.2$ and loss tangent tanδ=.001 and thickness of substrate h=1.57 mm, separation between the ground plane & base patch= 1 mm.
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, each iteration depends on size of base shape patch but angle remain constant don't depends on any factor.
The designing of antenna consists of Wp= 41.08 mm, Lp=41.08 mm, Wf= 3 mm, t= 1mm, a=4.375 mm, b=8.745, c=5.9 mm & h1=h2=1,57 mm

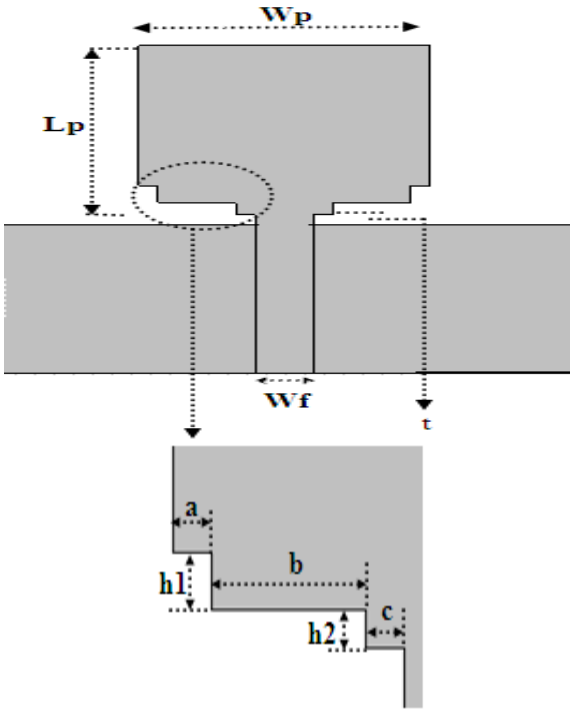

Fig 1: Existing antenna design with impedance steps& finite ground plane[2].

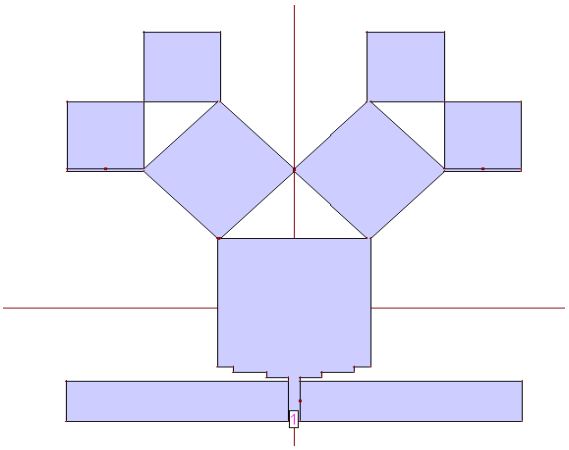

Fig 2: proposed Pythagorean tree antenna design with impedance steps & finite ground plane.

By varying steps in impedance we can tune the impedance matching for better signal transmission.

III.RESULT AND DISCUSSION

The proposed antenna is simulated over integral equation in 3 dimension (IE3D) software as simulation tool, characteristics of iterated Pythagorean fractal multiband tree antenna (IPTFA) have been analyzed in term of return loss, impedance bandwidth & radiation characteristics.

Multiband behavior is achieved at frequency of 3.39 GHz with return loss (RL) =-12.38dB, second band is at 4.82 GHz frequency with RL=-12.35 dB, third band of return loss is obtained at 5.05 GHz frequency with RL=-14.47 dB and fourth band is dictated at 5.61 GHz frequency having minimum value of RL=-15.76dB.

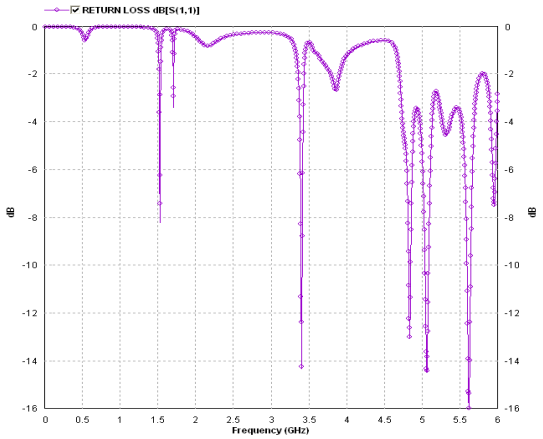

Fig 3: simulated IPTF antenna Return loss (RL) plot

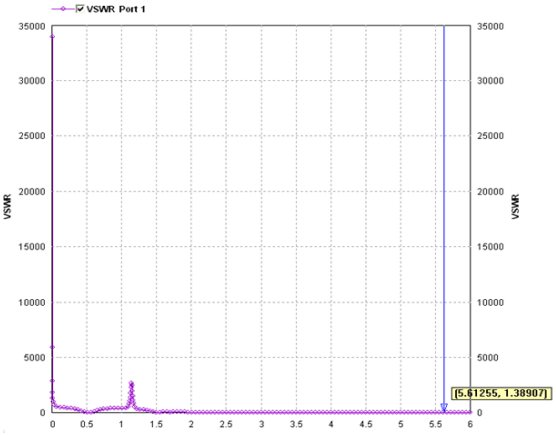

Fig 4: VSWR pattern plot

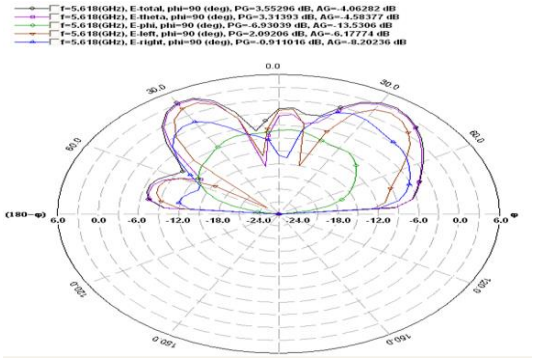

Fig 5: Radiation pattern (Polar plot) of proposed IPTF antenna at different elevation & azimuthal angle.

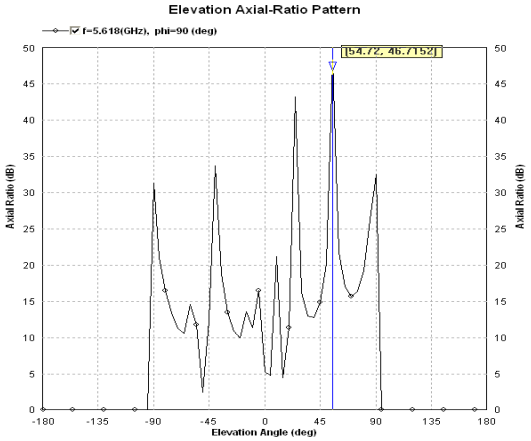

Fig 6: Elevation axial ratio pattern plot at phi= 90 (deg) for proposed IPTF antenna

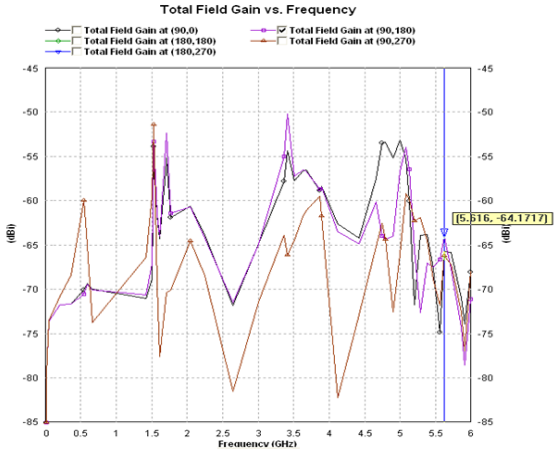

Fig 7:Total Field gain Vs. Frequency at phi=90(deg) & theta= 180(deg)

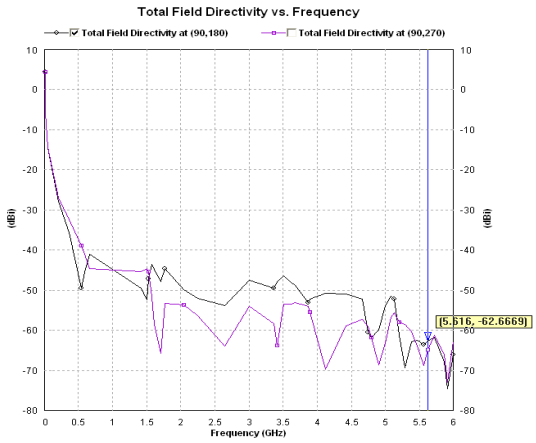

Fig 8: Total field directivity Vs. Frequency at phi= 90 (deg)& theta= 180(deg)

Impedance steps enhance current distribution path, which improves the bandwidth and multiband characteristics under VSWR=1.38 at frequency of 5.61 GHz, total gain=-64.17 dBi and total directivity=-62.66 dBi at phi=90 (deg) and theta= 180 (deg) is obtained

Table: 1 Summary of measured parameter characteristics of IPTF antenna

Frequency	5.61 GHz
Incident Power	.01 w
Input Power	0.00974179 (w)
Radiated Power	0.00715859 (w)
Average radiated power	0.000569662 (w/s)
Radiated efficiency	73.483%
Antenna efficiency	71.5859%

IV. CONCLUSIONS

A planar Iterated Pythagorean tree (IPTF) antenna with impedance steps are investigated, by using impedance steps in base patch better impedance matching is obtained.First bandappears between 3-3.5 GHz with return loss RL=-12.38 dBi, 2nd band appears between 4.5-5 GHz with RL value=-12.35 dBi, 3rd band appears between 5-5.5 GHz with RL value=-14.28 dBi and finally 4th band appears between 5.5-6 GHz with minimum value of RL=-15.76 dBiso this particular IPTF antenna is capable to operate for the mobile wi-max(2-6 GHz) and also usable for the IEEE802.11a radio utilizes(5.180-5.825 GHz.

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