Characteristics of I Shape Fractal Antenna for UWB Applications

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Abstract : **In this paper, I shaped fractal antenna is proposed which is operating in C band (4GHz to 8GHz) and X band (8GHz to 12 GHz) Ultra Wide Band (UWB) applications. The proposed antenna was designed using FR-4 Substrate in Computer Simulation Technology 2014 (CST) software. The simulation and parameters shows that the proposed antenna has better radiation characteristics such as Gain of the order of 4dB to 6dB, good return loss and VSWR of 1.41 to 1.47 is achieved when the I shaped antenna is iterated with 32 parts by the length and width which is more suitable for the UWB applications.**

IndexTerms **- C Band, X Band, UWB, CST, VSWR**

I. INTRODUCTION

Due to enormous development and application in wireless communication systems, multiband antennas with different antenna characteristic become a great demand. Fractal antenna elements are preferred for various applications due to low profile structure, less fabrication cost, multiband operations, easy feeding techniques and their shape can be modified for better optimization. Various structures are preferred for the fractal antenna technique such as Sierpinski, Gasket, Minskowsi, Hilbert curve; Koch Curve, Tree Structure, etc. [1]. Two important properties of fractal geometries are self-similarity and space filling properties. To reduce the antenna size for different resonant frequency Self-similarity properties are used. Based on the number of iteration is increased space filling property fill the area occupied by the fractal antenna. These two properties make the fractal antennas with multiband for various microwave applications [2].

A novel triple-frequency micro strip-fed planar monopole antenna for multiband operation is sketched and examined in [3]. A rectangular patch with dual inverted L-shaped strips with cross-shaped strip line fed in order to achieve additional resonances and bandwidth enhancements. The sketched antenna is of 20x30mm, and excites over the frequency ranges of 2.14–2.52 GHz, 2.82–3.74 GHz, and 5.15–6.02 GHz suitable for WLAN2.4/5.2/5.8GHz and WiMAX3.5/5.5GHz applications. By the combination of two fractal geometries fractal monopole antenna is proposed in [4] for the application in the UWB frequency range. The presented antenna has an Omni directional radiation pattern, a good gain, and high efficiency. The fabrication and measurement data attest to the satisfaction of the design specifications.

A novel modified micro strip-fed ultra wide band (UWB) printed Pythagorean tree fractal monopole antenna is presented in [5]. Wider impedance bandwidth has been produced using modified Pythagorean tree fractal in the conventional T-patch. New resonance frequency was obtained by increasing the tree fractal iterations.

Multilayer substrate with proximity coupled in microstrip patch antenna was proposed in [6] to overcome the harmonic radiation. The main aim of this design is to avoid the radiation of harmonic signals (2nd and 3rd harmonic) generated by non-linear devices at the amplifying stage. The study shows, length of the feeding line can control the second harmonic resonance matching.

A wide band vertical patch antenna (VPA) [7] is depicted, which is devised from fractal antenna technology. By using a dual Koch loop structure, a wideband VPA with 42% bandwidth and 8 dBi gain at the centre frequency is designed and tested.

In this paper I shaped fractal antenna with single, Patch with 8 parts by the length and width cut and 32 parts by the length and width cut are designed and their analytical parameters such as Gain, VSWR, and return loss and radiation pattern are calculated using CST simulation software and compared. The design and Simulation results are presented in following sections.

II. ANTENNA DESIGN CALCULATION

The geometry of an I shaped fractal antenna is derived from the following formulas [8]. The dimensions of the antenna are referred from [9].

Operating frequency (f0) = 3GHz-10GHz.

Velocity of light(c) = 3x108 m/sec.

Substrate Flame Retardant 4 with relative permittivity (εr) =4.4

Substrate thickness (h) = 2.4mm

Width W of patch is given as:

$$W = \frac{c}{2f_0}\sqrt{\frac{2}{\epsilon r+1}} \quad \text{-----} \quad 1$$

$$W = \frac{(3*10^8)}{2*2.4*10^9}\sqrt{\frac{2}{4.4+1}} \quad W \approx 38 \text{ mm}$$

Effective dielectric:

$$\epsilon reff = \frac{\epsilon r+1}{2}+\frac{\epsilon r-1}{2}[1+12\frac{h}{w}]^{\wedge -1/2} \quad \text{-----} \quad 2$$

$$\epsilon reff = \frac{4.4+1}{2}+\frac{4.4-1}{2}[1+12\frac{1.6}{3.2}]^{\wedge -1/2} = 3.34$$

The effective length of the patch Leff:

$$Leff = \frac{c}{2f_0\sqrt{\epsilon reff}} \quad \text{------} \quad 3$$

$$Leff = \frac{(3x10^8)}{2(2.4x10^9)\sqrt{3.34}} = 0.0341$$

Extension Length ΔL

$$\Delta L = 0.412h\left[\frac{(\epsilon reff+0.3)(\frac{w}{h}+0.264)}{(\epsilon reff-0.258)(\frac{w}{h}+0.8)}\right] \quad \text{------} \quad 4$$

$$\Delta L = (0.412*1.6)\left[\frac{(3.34+0.3)(\frac{3.2}{1.6}+0.264)}{(3.34-0.258)(\frac{3.2}{1.6}+0.8)}\right]$$

$$\Delta L \approx 0.6295 \text{ mm}$$

The length L of patch:

$$L = Leff - 2\Delta L \quad \text{------} \quad 5$$

$$= 2.93 - 2(0.6295)$$

$$L \approx 1.67\text{mm}$$

III. DESIGN AND SIMULATION RESULTS USING CST 2014

In this section pictorial representation of proposed antenna with the CST Simulator 2014 were discussed.

3.1 Square shaped patch antenna-Basic Iteration

Initially the square shaped patch antenna shown in Fig .1 is taken as reference. The S-parameters, VSWR and radiation pattern of the deign are given below.

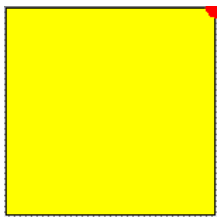

Fig.1 Geometry of the square shaped patch antenna-Basic Iteration

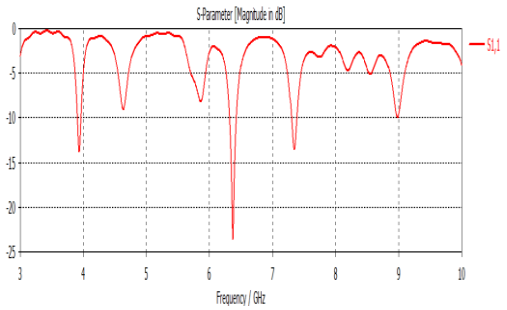

Fig.2 S- parameter of Square shaped patch antenna-Basic Iteration

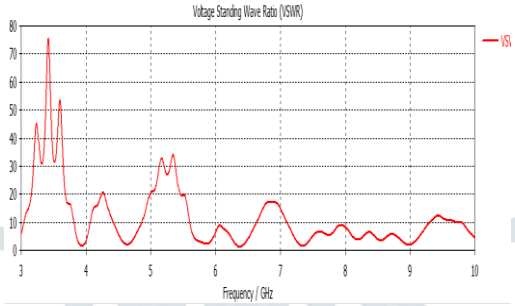

Fig.3 VSWR- Square shaped patch antenna-Basic Iteration

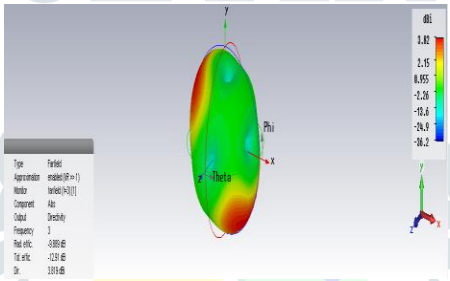

Fig.4 Radiation Pattern - Square shaped patch antenna-Basic Iteration

3.2. I shaped fractal Antenna- Iteration 1:

I shaped geometry is applied on that to reduce overall size of the antenna. This is done by removing two squares of size 6.1*6.1 mm from the basic iteration and given in Fig .5.

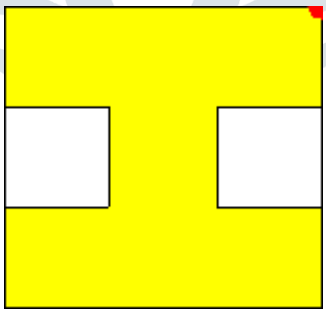

Fig. 5 Geometry of the I shaped antenna- First Iteration.

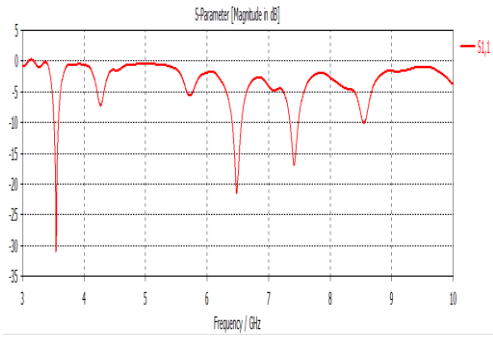

Fig.6 S- parameter of Square shaped patch antenna- First Iteration

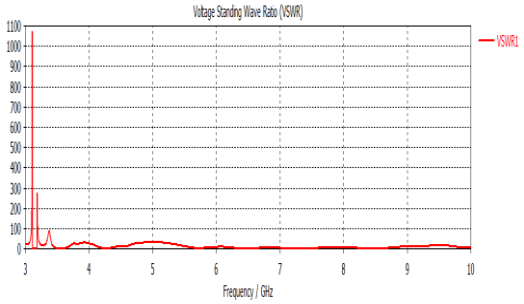

Fig.7 VSWR- Square shaped patch antenna- First Iteration

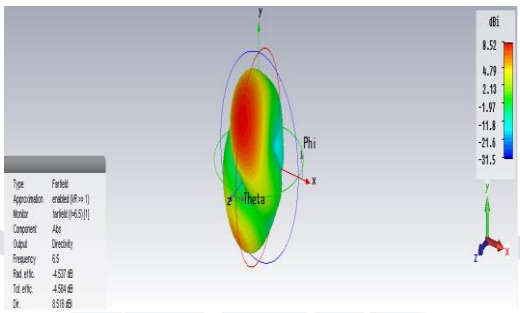

Fig.8 Radiation Pattern - Square shaped patch antenna- First Iteration

3.3. I shaped fractal Antenna- Iteration 2:

Similarly the design of the Second Iteration is obtained by cutting the patch design of first iteration into 8 parts by the length(l) and width(w) of 2.09x2.09mm shown in the Fig 9.

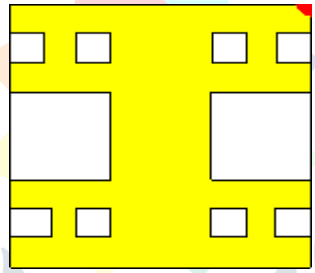

Fig. 9 Geometry of the I shaped antenna- Second Iteration.

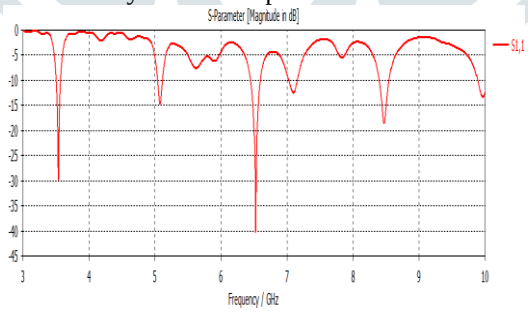

Fig.10 S- parameter of Square shaped patch antenna- Second Iteration

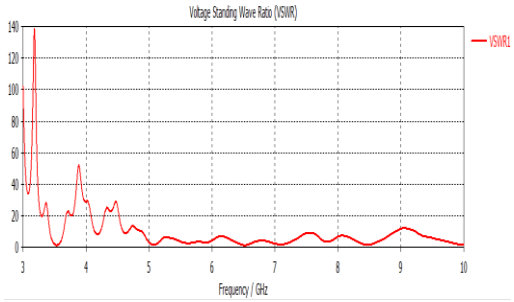

Fig.11 VSWR- Square shaped patch antenna - Second Iteration

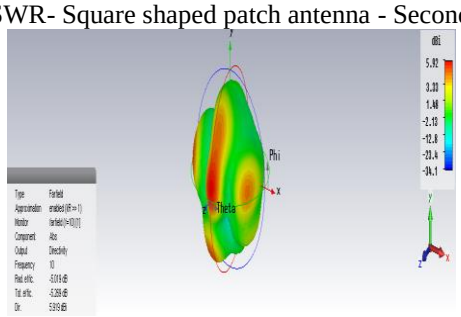

Fig.12 Radiation Pattern - Square shaped patch antenna- Second Iteration

3.4. I shaped fractal Antenna- Final Iteration:

Finally the design of Third Iteration (Final) is obtained by by cutting the patch design of second iteration into 32 parts by the length(l) and width(w) of 0.65x0.65mm shown in the Fig 13.

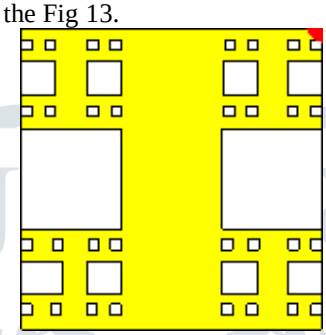

Fig. 13 Geometry of the I shaped antenna- Final Iteration.

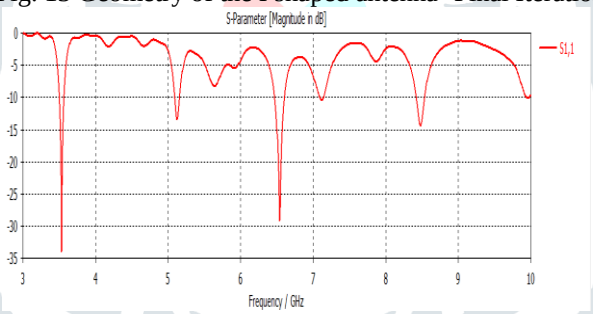

Fig.14 S- parameter of Square shaped patch antenna - Final Iteration

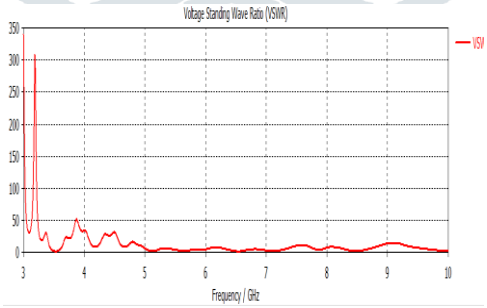

Fig.15 VSWR- Square shaped patch antenna - Final Iteration

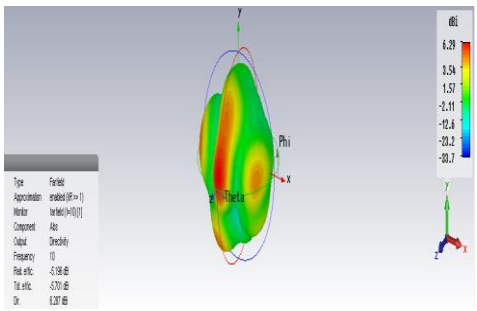

Fig.16 Radiation Pattern - Square shaped patch antenna- Final Iteration

Table1 Comparison results of proposed I shaped fractal antenna using CST

ITERATION	FREQUENCY	RETURN LOSS	VSWR	GAIN	BANDWIDTH (MHz)
0	3.93	-13.7	1.51	3.82	50
	6.38	-21.92	1.17	6.5	110
	7.34	-13.47	1.53	6.38	80
1	3.53	-28.50	1.07	4.69	70
	6.48	-21.52	1.18	4.69	160
	7.41	-16.89	1.33	7.2	140
2	3.53	-29.89	1.06	4.6	60
	5.95	-32.39	1.04	5.7	140
	8.47	-18.56	1.26	5.92	160
3	3.53	-23.62	1.41	4.69	60
	6.54	-27.13	1.09	3.36	130
	8.48	-14.37	1.47	6.29	120

In table.1, the proposed antennas simulated with CST parameters are compared.

IV. CONCLUSION

The I-Shaped Fractal antenna design is simulated using CST Microwave Studio Suite 2014. Designs are made using FR4 substrate having value ε_r 4.4 and height of 1.6mm which is a low-cost material and easily available in the market. Both the characteristics i.e. Wideband and Multiband behaviour of the antenna using fractals in fractal geometry have been successfully achieved. Significant improvement in bandwidth is achieved by creating iterated fractals to increase the total perimeter (electrical length) of patch antenna to have wideband behaviour. Fractional bandwidth greater than 90% is achieved for wideband antenna. A controlled band notch is created in wideband characteristics to avoid interference at desired frequency. The small frequency drift seen in measurement results is produced by the error in the manufacturing and measurement.

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