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Design of Square Shape Multiband Sierpinski Carpet Fractal Antenna for X and Ku Band Applications

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***Abstract*—**In this paper a Square shape fractal antenna is proposed with resonant frequency is 11.3GHz and simulation result show it support multiband behavior.This antenna is fabricated on FR-4 dielectric substrate with dielectric constant 4.4 and height of substrate is 1.6mm. The proposed antenna fed by Coaxial Probe feed. The proposed antenna simulate from 0^{th} to 3^{rd} iteration using Simulation Zealand's IE3D software. The proposed antenna operates in X-band (8-12GHz) and Ku-band (12-18 GHz).The antenna resonates at 11.3GHz, 12.7GHz and 15.0 GHz. The execution of proposed receiving wire is measured regarding Return Loss (RL), VSWR, Gain, Directivity, Radiation Pattern, Smith chart, Bandwidth. Value of all these parameters is acceptable range, Return Loss< -10dB, VSWR< 2,and maximum Gain is 2.44dBi is obtained. It is found that proposed antenna works at three frequencies. It is Tri-Band Antenna. The proposed *antenna* useful for Satellite, RADAR, Space communication system application.

Keywords*-Sierpinski carpet; fractal Antenna;Multiband;X-badn;Ku-band;IE3D;VSWR;Radiation Pattern;Gain;Tri-Band*

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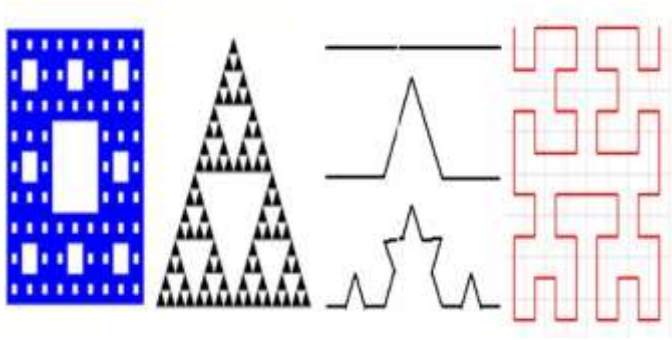
I. INTRODUCTION

One of the fundamental goals in wireless communication is the outline of wideband, or even multiband, low profile, little reception antenna. Utilizations of such receiving antenna incorporate, however are not constrained to, individual correspondence frameworks, little satellite communication terminals, unmanned airborne vehicles, and some more.[1].The term fractal implies unpredictable or broken sections [2]. It was characterized by Benoit Mandelbrot which was gotten from Latin word 'fractus' which implies cracked or broken [3].Fractal antenna are propelled by nature. Fractal antenna has two primary properties which are space-filling and self-similarity [4].The space filling property lessens the span of the reception apparatus and makes the radio wire electrically longer in little physical space [5].

Self-comparability property implies that fix of reception apparatus is sub-isolated into littler parts and each of these littler parts is the littlest bit or diminished size of the primary geometry [6].The multiband antenna is designed to operate at different frequency band By utilizing fractal geometry idea in to the fix of Microstrip antenna, we can outline multiband antenna. As of late, Sierpinski carpet fractal antenna, which was an augmentation of Sierpinski gasket, got much consideration by its multiband behavior [7],[8].The sierpinski carpet can be executed in two ways, a positive and negative design, with the positive being an organizer surface with square openings and negative being singular squares gathered together.[7][8].

A Sierpinski carpet fractal antenna result to multiple definite resonant frequency band along with superior radiation characteristics. As the no. of fractal iteration increases, the number of operational band also increases with matching of impedance for variety of wireless application [9].The performances of the Sierpinski fractal patch antenna for different iterations have been explored. The X- band and Ku-band, as expounded by an IEEE standard, ranges from 8-12 GHz and 12-18 GHz respectively [10-11].These applications involve various wireless applications such as long-distance radio telecommunications, satellite communications, space communications, radar, terrestrial broadband and amateur radio[12-13] Fig.1 show different geometry- Sierpinski Gasket [14], Sierpinski Carpet [15] , Koch Curve [16] and Minkowski Hilbert Curve [17].



(a) (b) (c) (d)

FIG. 1.(a) Sierpinski Carpet (b) Sierpinski Gasket (c) Koch Curve(d) Hilbert Curve

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II.ANTENNA DESIGN

In this paper a multiband sierpinski fractal antenna is designed with square shape patch. The design of proposed antenna from 0th to 3rd iteration is shown in figure 2.

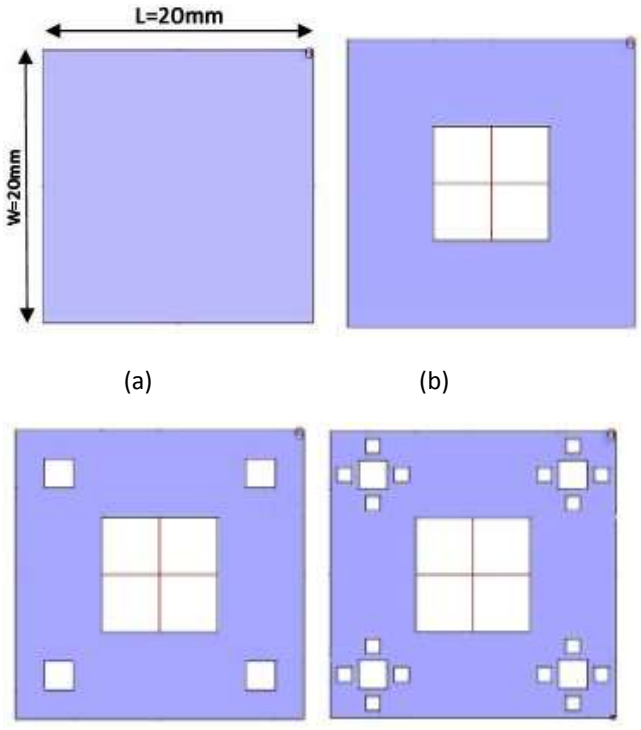

FIG. 2 Geometries of (a) 0th (b) 1st (c) 2nd (d) 3rd iteration of SSMSCFA

The Patch dimension is calculate by following formulas equation (1) to (4) of the transmission model line [19]

$$\text{Finally Patch width } (w) = \frac{c}{2 f_r \sqrt{\frac{(\epsilon_r + 1)}{2}}} \quad (1)$$

An effective dielectric constant of the propagation medium to account fringing effect is calculated as follows:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \quad (2)$$

The extended patch length ΔL due to fringing effect is calculated as follows:

$$\Delta L = 0.412h\frac{(\epsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)} \quad (3)$$

$$\text{Actual patch Length } L = \frac{c}{2 f_r \sqrt{\epsilon_{reff}}} - 2\Delta L \quad (4)$$

The proposed Antenna is composed and create on FR-4 glass epoxydielectric substrate with dielectric constant is 4.4.Frequency 11.3GHz is chosen for this antenna. Coaxial probe feed is used for feeding. The shape of designed antenna is square, in which a square patch is inserted.

Parameters of designed antenna is shown in Table 1

TABLE 1Parameters shown in table 1 of designed antenna

Parameter	Value
Patch Width (W)	20mm
Patch Length (L)	20mm
Dielectric Constant	4.4
Feed Location	9.6,9.8(mm)
Dimensions of Square shape Patchin 0th iteration	Width=20mm,Length=20mm Thickness=1.6
Dimensions of Square shape Patchin 1st iteration	Width=8mm,Length=8mm Thickness=1.6
Dimensions of Square shape Patchin 2nd iteration	Width=2mm,Length=2mm Thickness=1.6
Dimensions of Square shape Patchin 3rd iteration	Width=1mm,Length=1mm Thickness=1.6

III.RESULT AND DISCUSSION

Simulation of designed antenna using IE3D software we find result in terms of Return loss,VSWR, Radiation pattern, Gain, Directivity and Smit chart are calculated by using Simulation Zealand's IE3D software. Frequency range for 0th and 1st iteration is 8-12GHz ,8-14GHz for 2nd iteration and8-16GHz for 3rd iteration, so it exhibit multiband behaviour at frequency of 11.3Ghz ,12.7Ghz and 15.01GHz.

A. Return Loss –

Figure 3 to Figure 6 show return loss with frequency for 0th to 3rd iteration. It is noted that as the no.of iteration are increased that the number of frequency band over which antenna resonant also increased. For 0th and 1st iteration one band occurs at 11.3GHz which has return loss -18.65dB and -33.69dB.For 2nd iteration two band occurs at 11.3GHz and 12.7GHz which has return loss -18.68dB and -12.91dB.For 3rd iteration three band occurs at 11.3,12.7 and 15.01GHz which has return loss -26.4,-12.24,and-11.34dB.It is clearly from the figure 2 to figure 5,value of Return loss< -10dB at each resonant frequency.

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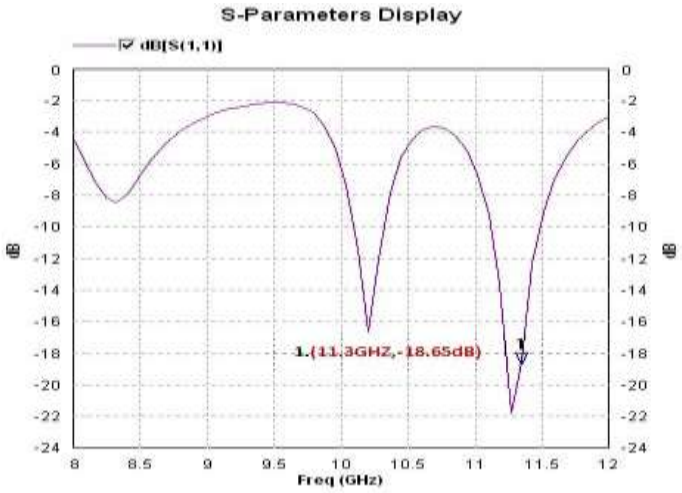

Fig.3 Return loss plot of 0th iteration

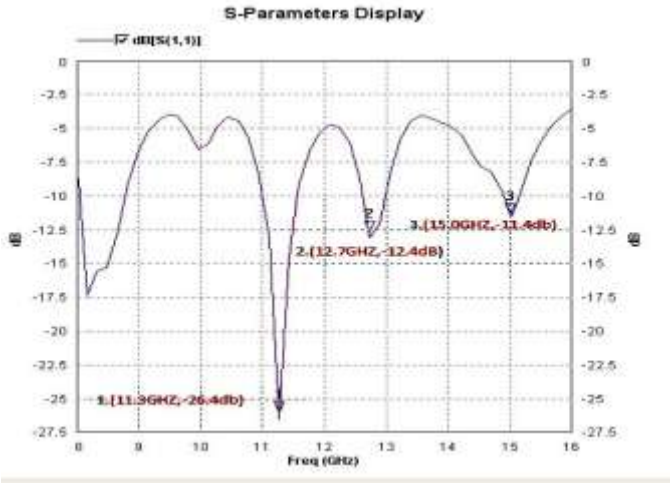

Fig.6 Return loss plot of 3rd iteration

Fig.4 Return loss plot of 1st iteration

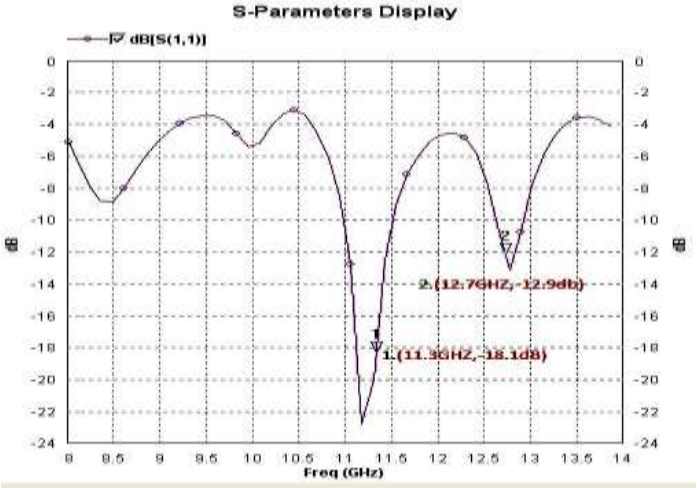

Fig.5 Return loss plot of 2nd iteration

B. VSWR –

Figure 7 to figure 10 show VSWR plot of designed antenna for 0th,1st,2nd and 3rd iteration. Value of VSWR is less than 2 for every iteration at all resonating frequency.For 0th and 1st iteration,VSWR is 1.26 and 1.049 at 11.3GHz.For 2nd iteration ,VSWR is 1.31 and 1.58 at 11.3GHz and 12.7GHz.For 3rd iteration ,VSWR is 1.09,1.57and 1.72 at 11.3GHz,12.7GHz and 15.01 GHz.

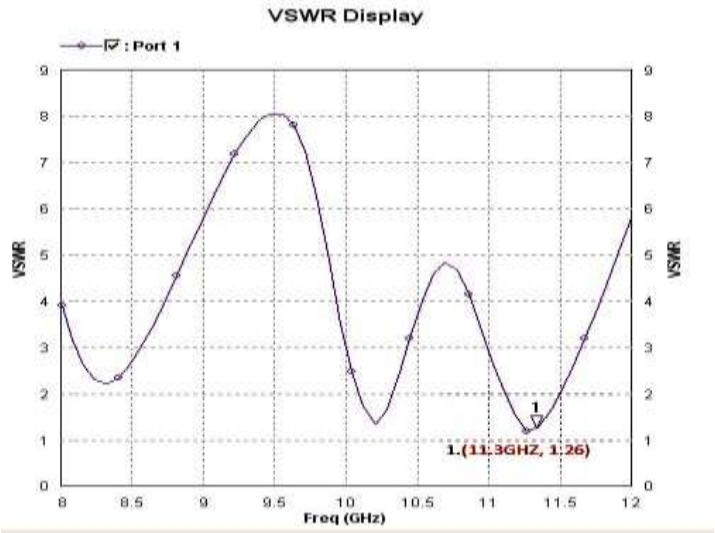

Fig.7 VSWR plot of 0th iteration

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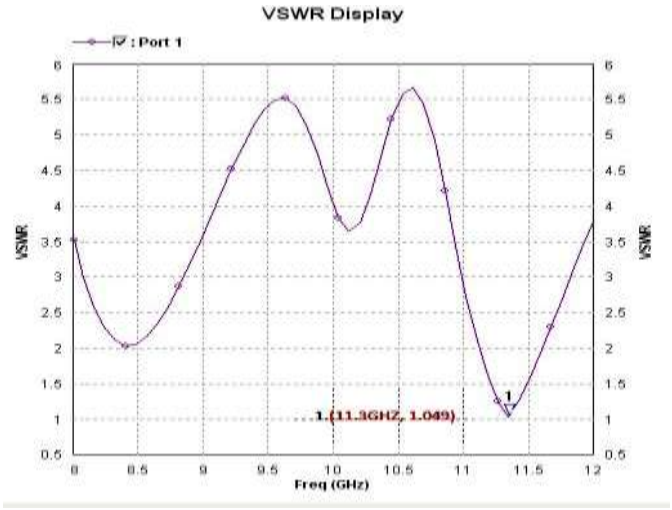


Fig.8 VSWR plot of 1st iteration

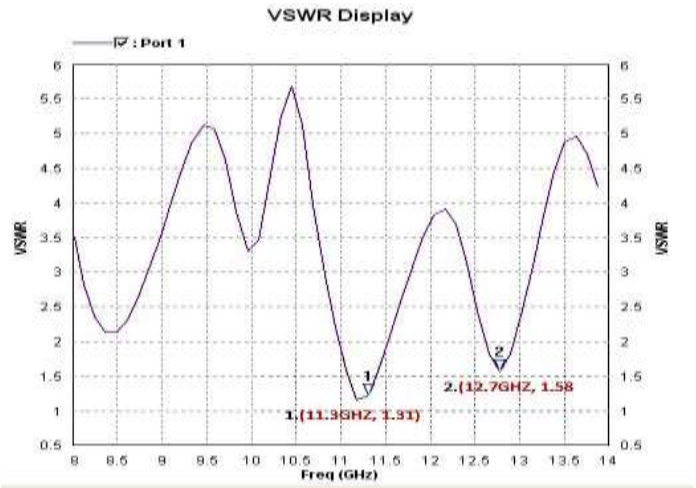


Fig.9 VSWR plot of 2nd iteration

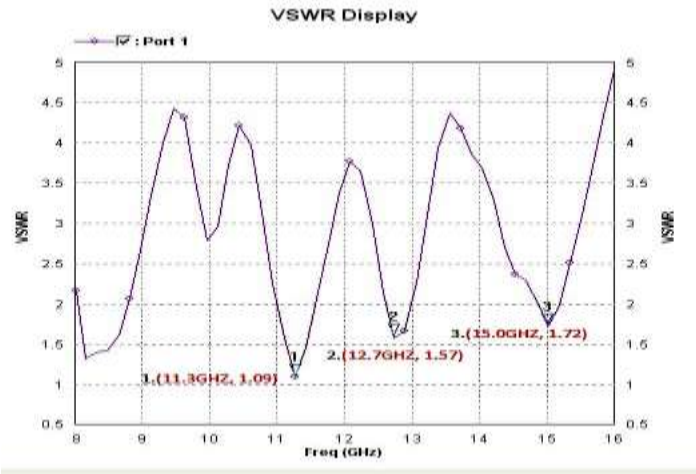


Fig.10 VSWR plot of 3rd iteration

C. Antenna Gain –

Figure 11 to figure 14 shows the Gain characteristics of proposed antenna as the no. of iteration increased gain of antenna also increases. For 0th and 1st iteration Gain is 1.29dBi and 2.01dBi at 11.3GHz and 12.7GHz.For 2nd iteration Gain is 1.22dBi and 1.37dBi at 11.3GHz and 12.7GHz.For 3rd iteration Gain is 2.41dBi, 1.22dBi and 0.40dBi.The maximum Gain occurs at 11.3 GHz which is 2.41dBi.

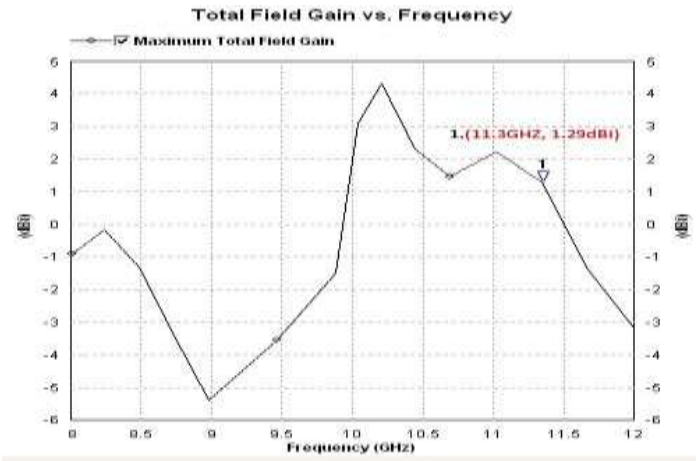


Fig.11 Gain plot of 0th iteration

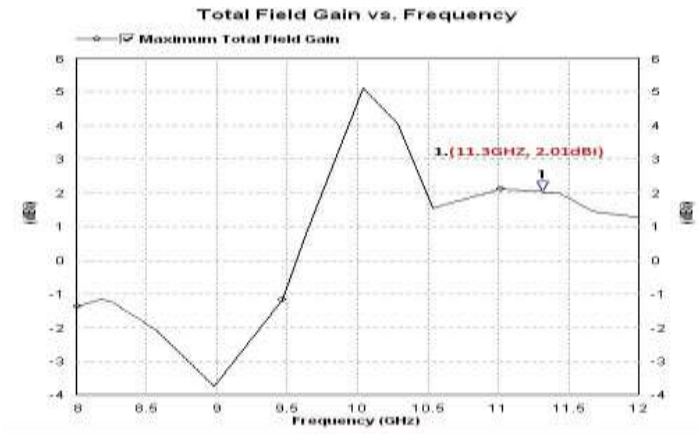


Fig.12 Gain plot of 1st iteration

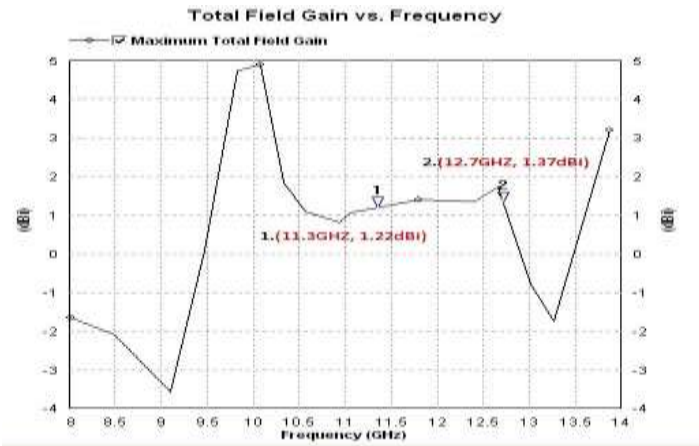


Fig.13 Gain plot of 2nd iteration

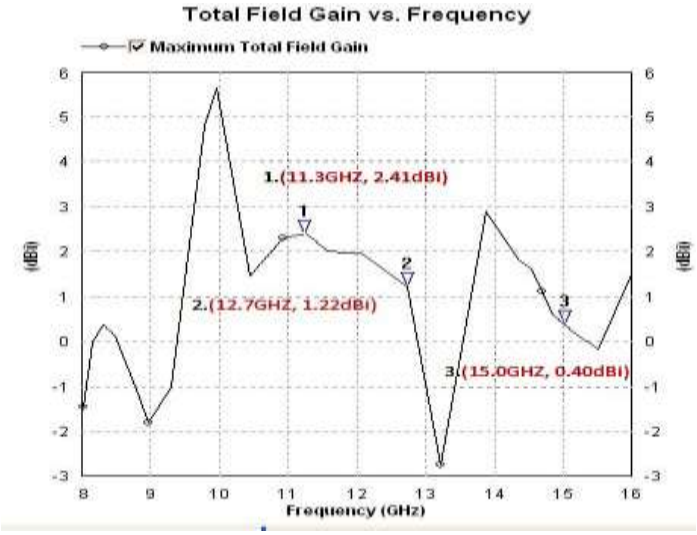
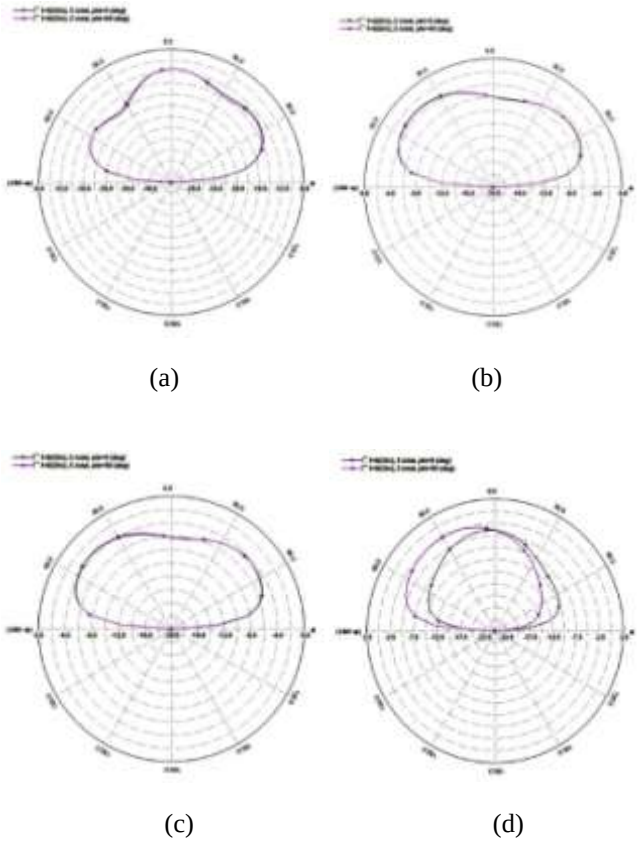


Fig.14 Gain plot of 3rditeration

D. Radiation Pattern-

This parameter gives that how the antenna transmits and coordinated vitality in favored ways [18]. Figure 15 indicates recreated radiation pattern from 0th to third iteration. It can be effectively seen from the radiation pattern that the planned antenna produces directional radiation and practically stable radiation pattern all through the entire working band.



(a) (b)

(c) (d)

Fig.15Radiation Pattern of (a) 0th (b) 1st(c) 2nd (d) 3rditeration of SSMSCFA

A comparative study of different performance parameter of the modified Sierpinski fractal patch antenna has been given in Table.2

Iteration No.	Freq. (GHz)	Return Loss (dB)	VSWR	Gain (dBi)	Directiv-ity(dBi)
Iteration 0	11.3	-18.65	1.26	1.29	8.02
Iteration 1	11.3	-33.69	1.04	2.01	7.69
Iteration 2	11.3	-18.68	1.31	1.22	7.66
	12.7	-12.91	1.58	1.3	8.3
Iteration 3	11.3	-26.4	1.09	2.41	8.56
	12.7	-12.24	1.57	1.22	8.67
	15.01	-11.34	1.72	0.4	10.35

IV. CONCLUSION

The proposed antenna has size 20x20x1.6 mm^3 .For impedance matching coaxial feeding is used. The proposed antenna is designed to execute X and Ku band range application with minimal antenna size and better impedance matching. The multiband ability of proposed antenna is achieved by fractal concept. Simulation result show that suggests antenna works on three resonant frequency having value in (in GHz) 11.3, 12.7 and 15.01.This is tri band antenna. Good result has been found at X-band and Ku band. The antenna is used for satellite, RADAR,space,terrestrial communication application like broadcasting satellite, service for maritime, aeronautical or land application. The different parameter of proposed antenna like return loss, VSWR ,gain ,directivity, radiation pattern, smith chart have acceptable value.

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