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Design of Square Curve Fractal Patch Antenna using Coaxial Feeding

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ABSTRACT: Here in this paper we are designing square curve fractal antenna from our conventional micro strip patch antenna having resonating frequency at 1.9GHz with length and width as 50.1mm and feed point at (0,10.21)mm in length and width side respectively . Measured and calculated results in various tables shows return loss, bandwidth, gain, directivity, and radiation efficiency of each micro strip fractal antenna. From results it is found that a fractal antenna provides better bandwidth, gain, and directivity and radiation efficiency over conventional patch antennas. Various measured and calculated results with figures are shown in respective tables. The purposed antenna is multiband antenna and small in size. The designs of antenna have been modelled, designed and simulated using high frequency structural simulator (HFSS 15.0) finite element electromagnetic solver software, HFSS Antenna Design Kit and MATLAB. Here coaxial feed is used for feeding the excitation port of square curve fractal antenna.

KEYWORDS: Square Curve Fractal, Micro strip patch Antenna, Gain, Bandwidth, HFSS

I.INTRODUCTION

An antenna is electromagnetic radiating device which converts guided waves into free space waves or radio waves and vice-versa. Antennas are used in radar, satellite communication, aeronautical and metrological departments, and mobile communication among others. An antenna design engineer is faced with the task of optimizing the design for meeting the varied requirements of the application at hand. In many cases the criteria that need to be satisfied which are in conflict to each other. Some of the common requirements are small size, high gain, wide bandwidth, high radiation efficiency, high directivity etc.

Micro strip patch antenna [1] is an antenna consisting of a rectangular or square metallic patch over a substrate having a ground plane. Micro strip patch antennas are very popular due to their low weight and low profile. But due to the narrow bandwidth, low efficiency and low gain, these antennas are not suitable for many communication systems. As, each antenna element resonates at a single or dual frequency. Different antennas are required for different applications of the same device.

The demand for antennas which provide wide and multiband characteristics with high gain is increasing for both civilians and military applications. This drives the research in field of antennas in many different directions; one such emerging field is the design of a micro strip antenna element using fractals.

A technique which shows potential to address many of the limitations of the currently used antenna designs is an application of the theory of fractals in antenna design. This area of research is known as fractal antenna engineering [2-5]. Mandelbrot [2] in 1983 gave the term Fractal which defines a class of complex geometrical shapes that can be subdivided in parts, where each part will be similar to the original shape. In nature many examples of fractal can be found in the form of trees, plants, ferns, leaves etc. It is found that fractal antenna provides multibandandbroadband characteristics with small antenna size [6-10].

This paper consists of design of square curve fractal antenna [11, 12] using the dimensions of micro strip patch antenna for 1.9GHz resonating frequency.

Fractal square curve antenna is designed using Roger RT/duroid 5880(tm) with relative permittivity ε 2.2 and substrate thickness 62 mil using conventional micro strip patch antenna.

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II.GENERAL DESIGN OF SQUARE MICROSTRIP ANTENNA

The step for design of rectangular microstrip antenna is illustrated in the following flow chart.

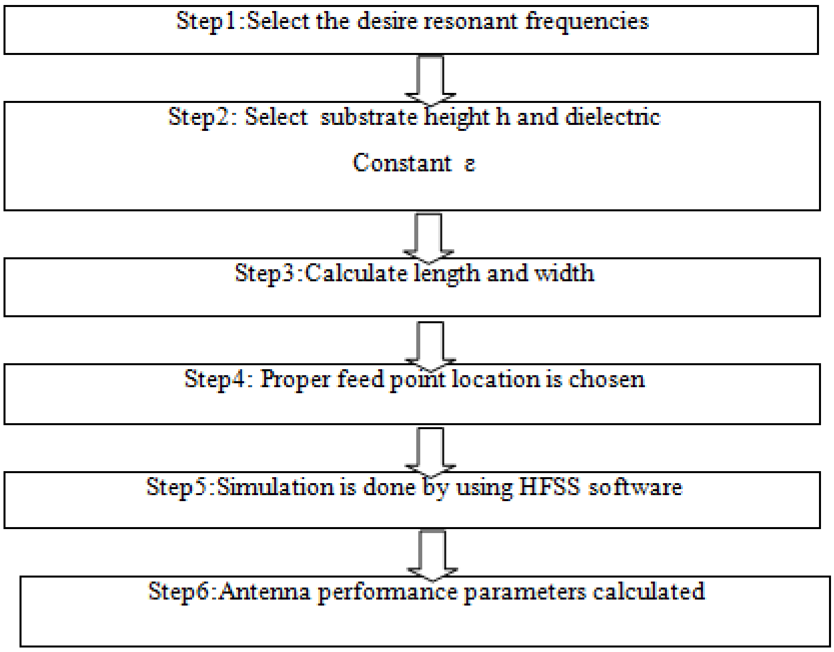

Fig.1: Flow diagram for design steps of a microstrip antenna

III.FORMULATION OF DESIGN PAPRAMETERS

- Calculation of Width

$$W = \frac{c}{2f}\sqrt{\frac{2}{\epsilon_r + 1}}$$

- Calculate ϵ_{reff}

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

For W/h>1

- CalculateΔL i.e normalized length

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}$$

- Calculate L

$$L = \frac{v_0}{2f_{r\sqrt{\epsilon_{reff}}}} - 2\Delta L$$

- Calculation of input impedance

$$Z_o = R_{in}cos^2(\frac{\pi}{L} - L)$$

With the help of above mentioned procedure, the length, width, input resistance, and feed point location also can be calculated for the microstrip antenna which can be resonant at desired frequencies.

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IV. DESIGN STEP OF SQUARE CURVE FRACTAL ANTENNA

Stage0: The shape of the 0th stage is a conventional square patch as shown in fig.2
Stage 1: The shape of the 1st stage is a cut out of four ¼ of length and width of a rectangular or squares conventional microstrip patch in the middle of the sides as shown in fig. 4
Stage 2: The shape of the ^{2nd} stage is a cut out of previous stage fractal. Here just take four edges as individual square or rectangle and cut out its ¼ part of it as shown in fig. 6
Stage 3: The shape of the 3rd stage is a cut out of previous stage fractal. Here just take three edges as individual square or rectangle and cut out its ¼ part of it.

V. RESULT AND DISCUSSION

Fig.2 shows the initial step i.e. 0th stage for design of conventional microstrip patch antenna having resonating frequency of 1.9GHz.

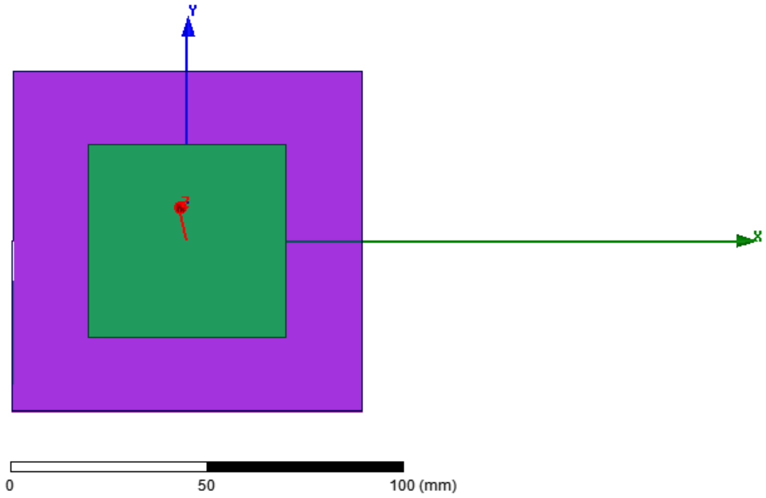

Fig.2: 0th stage of 1.9 GHz Microstrip antenna

Fig.3 shows return loss v/s Frequency plot of 0th stage conventional patch antenna which is resonating at 1.9GHz.

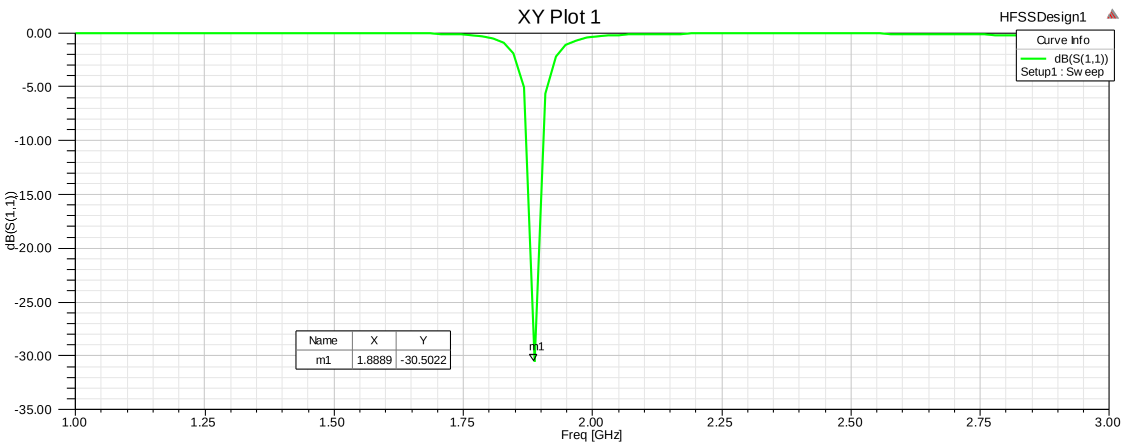

Fig.3: Return loss for 0th stage of 1.9GHz microstrip patch antenna

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1st stage of Square curve fractal antenna is shown in Fig.4 feeded with inset microstrip line feeding technique.

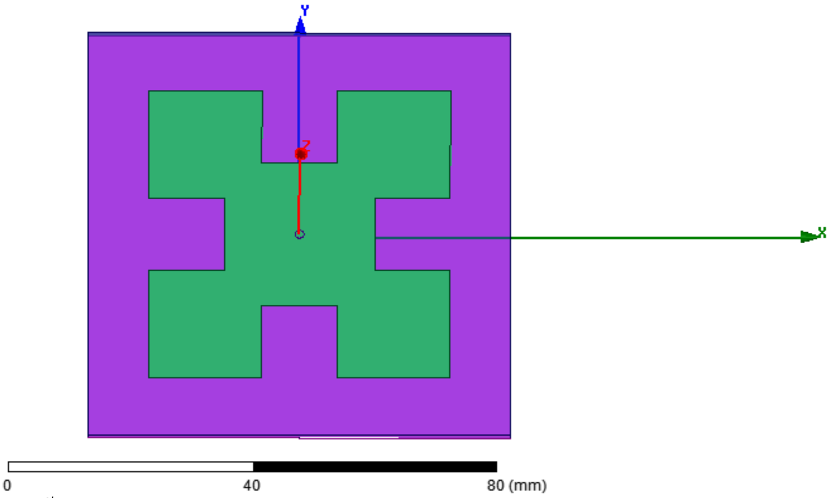

Fig.4: 1ststage of 1.9GHz Square curve fractal antenna

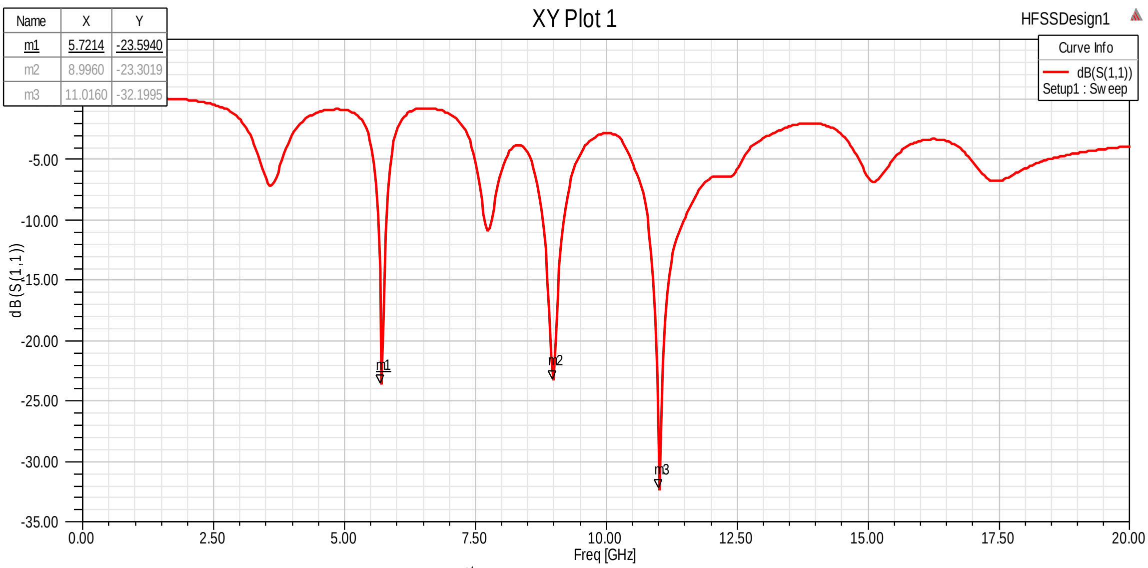

Fig.5: Return loss for 1ststage 1.9GHz Square curve fractal antenna

Return loss v/s Frequency graph for 1st stage Square curve fractal antenna is shown in fig.5 which shows the multiband characteristics of fractal antenna. Whereas Table 1 is showing measured and calculated values of various parameters i.e. return loss, bandwidth, gain, directivity and radiation efficiency.

Resonating frequencies (GHz)	Return loss	Bandwidth (MHz)	Gain dB	Directivity dB	Radiation Efficiency
5.7415	-23.0553	164	3.3214	3.3963	0.97795
8.9960	-23.6139	418	3.9933	3.8932	0.9853
11.0140	-32.2169	690.2	3.2618	3.1781	0.9901

Table 1: Measured and calculated results at different resonating frequencies for 1st stage 1.9GHz Square curve fractal antenna with various parameters i.e. return loss, bandwidth, gain, directivity and radiation efficiency.

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Design of 2nd stage Square curve fractal antenna using HFSS is illustrated in fig.6.

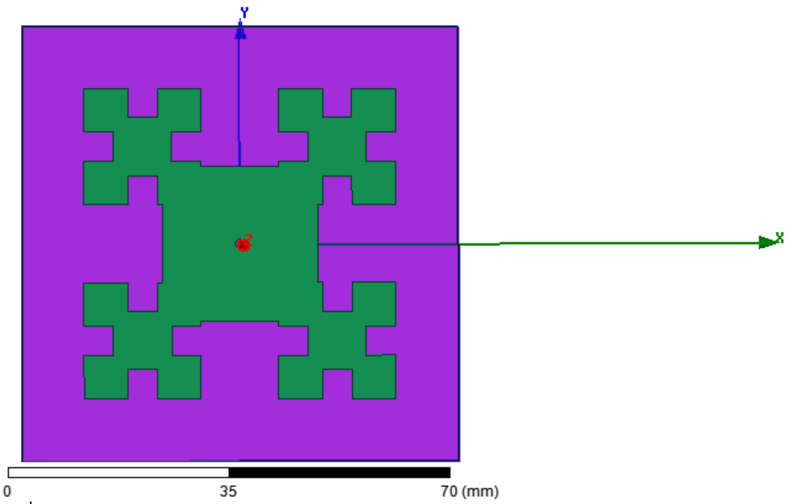

Fig.6: 2nd stage of 1.9GHz Square curve fractal antenna

Return loss v/s frequency graph for 2nd stage Square curve fractal antenna is shown in fig.7, which shows that it is resonating at three frequencies below -10dB.

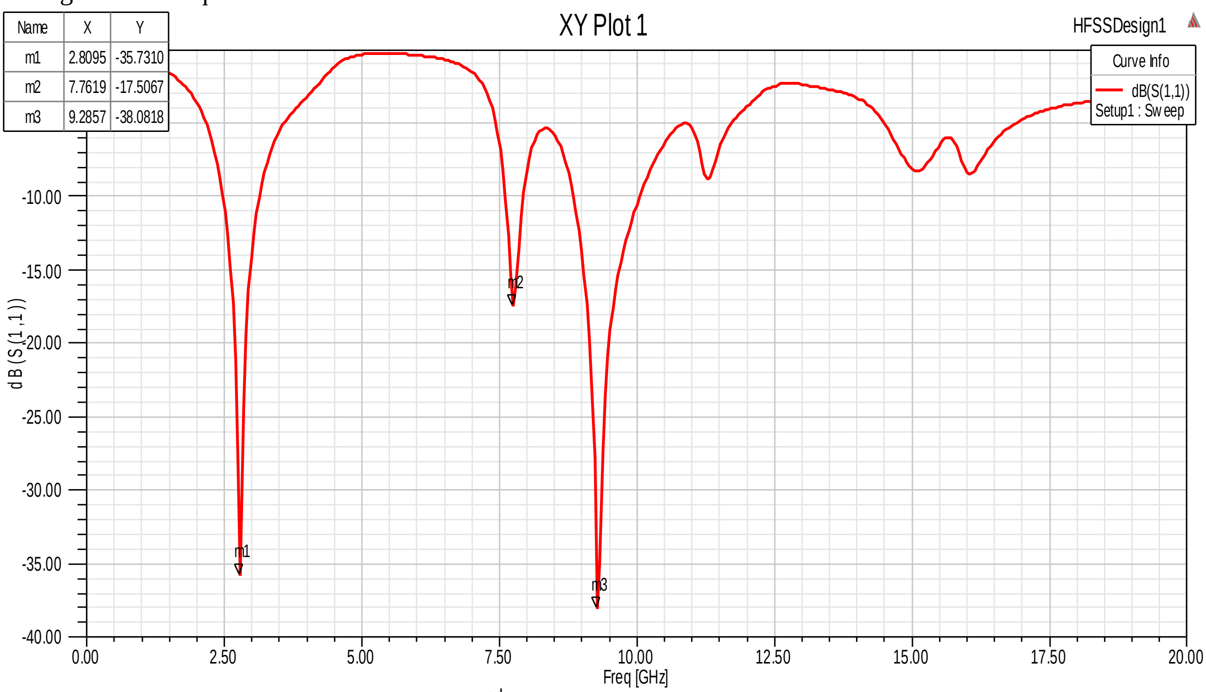

Fig.7: Return loss for 2nd stage 1.9GHz Square curve fractal antenna

The various measured and calculated parameters i.e.return loss, bandwidth, gain, directivity and radiation efficiency for 2nd stage resonating frequencies are shown in the Table 2

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Resonating frequencies (GHz)	Return loss (dB)	Bandwidth (MHz)	Gain (dB)	Directivity (dB)	Radiation efficiency
2.8095	-35.7310	654.9	1.113	1.1667	0.95399
7.7619	-17.5067	323.8	3.7149	3.6235	0.9745
9.2857	-38.0818	1195.1	2.127	2.0807	0.9805

Table 2: Measured and calculated results at different resonating frequencies for 2^{nd} stage 1.9GHz square curve fractal antenna with various parameters i.e. return loss, bandwidth, gain, directivity and radiation efficiency.

Using above stages of fractal antenna 3^{rd} stage Square curve fractal antenna is designed using HFSS, which is shown in fig.8

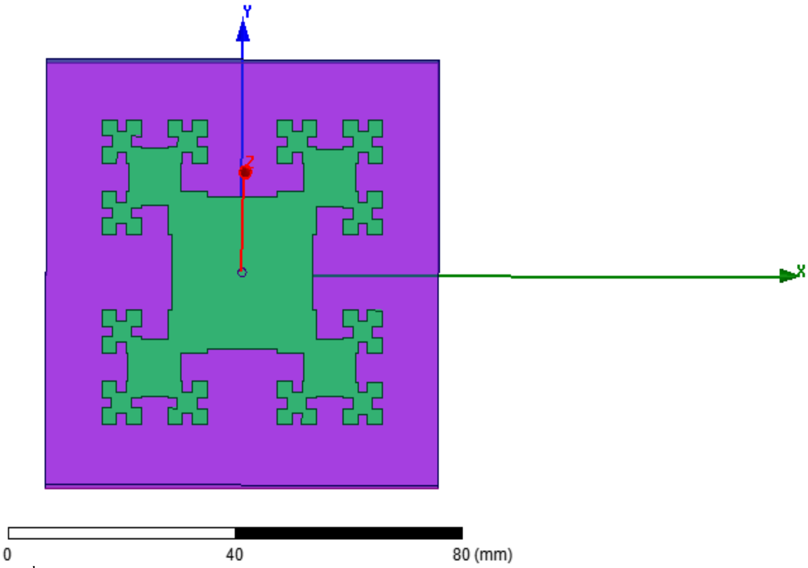

Fig.8: 3^{rd} stage of 1.9GHz Square curve fractal antenna

3^{rd} stage Square curve fractal antenna return loss v/s frequency plot is shown in fig.9.it is showing various frequencies which are resonating below -10dB.

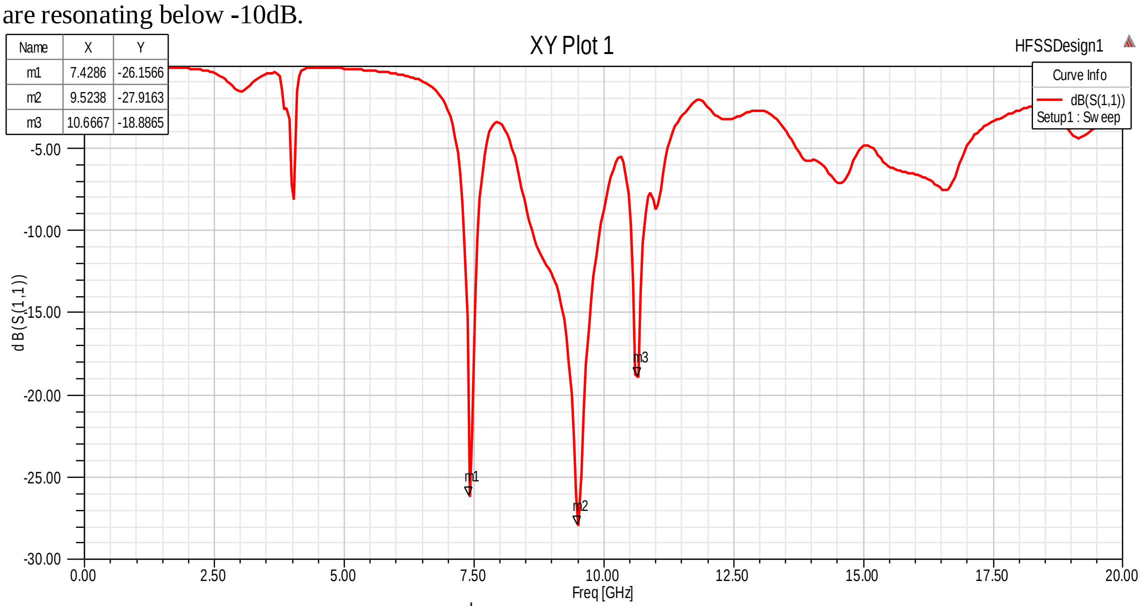

Fig.9: Return loss for 3^{rd}stage 1.9GHz Square curve fractal antenna

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The various parameters i.e. return loss, bandwidth, gain, directivity and radiation efficiencywhich are calculated for 3rd stage Square curve fractal antenna resonating frequencies are shown in table 3.

Resonating frequencies (GHz)	Return loss (dB)	Bandwidth (MHz)	Gain (dB)	Directivity (dB)	Radiation efficiency
7.4286	-26.1566	275	3.4365	3.365	0.9895
9.5238	-27.9163	1300.2	3.2261	3.1902	0.9907
10.6667	-18.8865	251.2	11.523	11.284	0.9732

Table 3: Measured and calculated results at different resonating frequencies for 3rd stage 1.9GHz Square curve fractal antenna with various parameters i.e. return loss, bandwidth, gain, directivity and radiation efficiency.

VI. CONCLUSION

Square curve fractal antenna is designed and simulated using dimensions of 1.9GHz microstrip patch antenna using coaxial feeding technique.
1st iteration 1.9GHz patch dimension square curve fractal antenna resonates at three frequencies out of which at 11.01GHz frequency it gives highest bandwidth of 690.2MHz with 3.26dB gain and 0.990 radiation efficiency whereas 2nd iteration resonates at three frequencies and gives highest bandwidth of 1195.1MHz with 2.12dB of gain and 0.980 radiation efficiency at 9.28GHz. 3rd iteration fractal antenna also resonates at three frequencies and gives bandwidth of 1300.2MHz which is highest bandwidth among all three iterations of this fractal antenna with gain 3.22dB and 0.990 radiation efficiency.
It is found that fractal antenna provides multiband and broadband characteristics with better return loss, bandwidth, gain, directivity, and radiation efficiency at different resonating frequencies.
Designed fractal antennas can be used for commercial and military applications. It can work effectively in S, C and X bands. It is found that fractal antenna provides multiband and broadband characteristics with better return loss, bandwidth, gain, directivity, and radiation efficiency at different resonating frequencies.
Designed fractal antennas can be used for commercial and military applications. It can work effectively in S, C and X bands.

VII. SCOPE OF FUTURE WORK

Though, this paper presented the study of multiband fractal antenna design. But still there is an enough scope of improvement and further research. In future, researchers can concentrate on following area of fractal for further research.

- Design of multiband and wide broadband fractal antenna using other fractal geometric shapes.
- Optimization for miniaturization of fractal antenna size using different types of optimization techniques using MATLAB or HFSS.
- Study the effective behavior on fractal antenna parameters due to change in substrate relative permittivity ε and substrate thickness *h*.
- Use of different types of feeding techniques for ultra wide band fractal antenna design.

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