Automated Sierpinski Gasket Model using Mathematical Formulations for Ku and K Band Applications

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Abstract: Fractal Antenna are embeds the different scenario of the antenna structures such M, C, O, Triangle, Step, star, and hexagonal etc. in practical application choice of interest. The design scenario improvised with frequency of operation of the different bands ensuring the correct size of the patch, and substrate with design criteria from the mathematical formulations. The proposed Antenna utilizes the Sierpiński gasket with the iteration varying from 0, 1, 2, 3 and 4. The design factor for the size of the antenna is calculated using the mathematical formulations with cut-off frequency at 15, and 17 GHz. This antenna improvised with two set of transmission line with the iteration from 0-1, 3-4 as step induced transmission line, and M shaped transmission line patch as generalist view. The novelty of design model utilizes the python as automated model for each set of iteration criteria and gaps from each subset of Sierpiński gasket. Each set of the antenna parametric values are observed with antenna design lying the Ku and Ka respectively

Keywords: Fractal Antenna (FA), Sierpinski gasket, Ku and K Band, Voltage Standing Wave Ratio (VSWR), Gain (G).

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1 Introduction

Long-range and adaptable interchanges provide wideband and conservative capabilities. Hand-scaled media are better suited for modern approaches. Fractals have the properties that obey all the preceding them, and appear in order to exhibit the new innovation. Utilizing pre-calculated geometrical shapes as radiators increases pre-utility. Analysts have been investigating and demonstrating how fractal wires can be applied in various applications over the years. A large percentage of the proceeds went into receiving wires with unique characteristics. Radiators with simpler settings and less pressure now appear to receive desired attributes two different methods have been suggested to attain the goal of wider band operation: This innovation can be applied to antenna apparatus with varying forms, as well as those having openings, in several different ways to help solve reception problems, including the shape of ground or antenna shapes. Mandal and Sarkar Pritam have developed a hi-band implementation using different ground structure and extruded base for the additional antennas [1]. A “U” shaped opening to the antenna with ground plane for multi-band operation have proposed an open-space transmission upgrade that keeps super wideband signal execution in pace with changing technology[2], [3]. For data capacity and wire scale reduction multiple fractal forms are utilized. To get high levels of transfer speed, the self-closeness and transferability of fractal geometry are essential [4], [5]. One may consider self-similitude to be a form that is divided into duplicate sections, as well as each of the parts representing the whole. Widespread and multiband reception is possible with this adapter. The capacity of the space used by objects diminishes as they have extended electrical duration, but is entirely filled and uses no additional space. Due to tangled and powerful data transmission, people are interacting with the fractal results, creating discontinuities in the process.

2 Literature Survey

The scenario for achieving wide band applications for an antenna with concentric circular structure and quad model is iterated with phase 2.The equilateral section is implemented with quad patch which has the size of 50*50 mm ^{2} with the FR4 substrate thickness of 1.2 mm and dielectric constant of 4.4. The bandwidth observed is more than 8GHz hence utilized with different applications such as 3G, 4G etc. [6].

The receptacle is created using the Fire-resistant evaluation 4 dielectric material (twelve by twenty-micron and with a thickness of one and sixteenth of a millimeter) on the Relative-permittivity 4.4 dielectric substrate. This substance, also known as fractal fixed side, incorporates multifractal formulas on its face, while single ring-meta surfcaster puts on the posterior surface. 2.45GHz and 3.17 GHz on S channel, 5.46 GHz on C band, 6.51 GHz on X band, 10.37 GHz on WLAN and other wireless systems. The functional characteristics are estimated with the features considered from the above bands of frequencies [7].

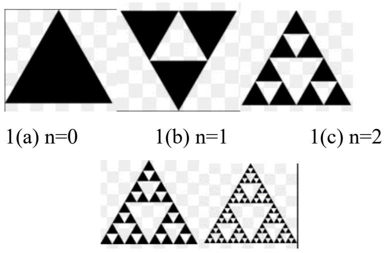
This paper shows how to design a smaller receiving wire that can be effective using any reception strategy and has three reverb frequencies in the S-band. One way to enhance the Minsky fractal system is to provide a DGS (deflected ground system) the receiving wire was built on Rogers RT/duroid ground with a 2.2mm dielectric. components of the last receiving wire has decreased by around 67% whereas square connector applications suffer by means of a reduction in 21X19mm to 67% 75-ohm input impedance on the S11 = 15.0 dB, 2.44 GHz influences the return [8].

Author describes about the fractal antenna design using quad band circular patch model which are operated at S and C band range of applications. With the current operated frequencies 2.86GHz, 4.76GHz, 6.50GHz and 7.42GHz and bandwidth observed of 110MHz and 90GHz for the performance parametric such as S11, VSWR and gain with four frequencies for the designed antenna to be acceptable level. With other factors considerations we have utilized an insert line feeding technique and other substrate parameters such as FR4 with designed dimensions calculated with frequencies of operations as 35X44.92X1.6 mm^2 and relative permittivity of 4.4[9].

Represents a novel model for the Murkowski and Meander curves based hybrid fractals which are utilized in current mobile applications for delay tolerant sensor networks and ADHOC networks. These curves contribute different frequencies of operations as mentioned as 1.98 GHz, 5.94 GHz, 10.61 GHz, 12.73 GHz, 14.85 GHz. These designs provide a better relational aspects on the performance for the parametric criteria as return loss, radiation pattern, current distribution, VSWR and gain are modelled and observed. The maximum bandwidth of the designed antenna are 2.83 GHz and 2.4 GHz at gain of 9dB. With current design of gain range of frequency at 2.4 GHz with 9dB would provide a different application scenario such as WI-MAX, WI-FI, WLAN 80211b/g [10].

3 Sierpinski Gasket Antenna Design

The proposed antenna design structures aims to follow the design consideration on sierpinski gasket where each triangle and its sub-triangles are estimated with the binomial equations as $(x+y)^{n-1}$ where n is the iterations for which triangles are generated at every stage. Assuming the triangle with n = 0 represents plain triangle and for n=1 it represents a triangle as shown in figure 1(a), for n=2 figure 1(b) and for n=3 figure 1(d).



1(a) n=0 1(b) n=1 1(c) n=2

1(d) n =3 1(e) n=4

Fig. 1. Representing the Sierpinski Gasket with iterations from n=0 to 4.

These sections of the triangular model is implemented using python code for specific values of gaps observed for each triangle on each iterations.

3.1 Algorithm for sierpinsiki gasket

- Create a triangle with the vertices and length of the each side as “a” since equilateral.
- For the iteration at each section value we need to choose the design model with angle of rotation at 60, 120 and 240 which will be iterated based on n=0, 1, 2, 3 and 4.

- *Mathematical fomulations are :*

$$Main_{SG} = ET_r(x, y, -r)$$

$$SubSG = ET_r(n, x, y, r)$$

$$ET_r(n, x, y, r) = ET_0\ (n-1, x - rcos\left(0 * \frac{pi}{3}\right), y - rsin\left(0 * \frac{pi}{3}\right), 0.39 * r) \quad (1)$$

$$ET_r(n, x, y, r) = ET_1\ (n-1, x - rcos\left(0 * \frac{2pi}{3}\right), y - rsin\left(0 * \frac{2pi}{3}\right), 0.39 * r) \quad (2)$$

$$ET_r(n, x, y, r) = ET_2\ (n-1, x - rcos\left(0 * \frac{4pi}{3}\right), y - rsin\left(0 * \frac{4pi}{3}\right), 0.39 * r) \quad (3)$$

- *Calling functions:*

$$ET_r(0,0, -r)$$

$$ET_r(n, 0,0, -0.45 * r)$$

To maintain certain gap with value of 0.39 radius and 0.45 as whole number which either contracts or increase the size.

4 Antenna Design Parametric Formulations

4.1 Antenna Design

1. For each set of iteration phase we need to calculate the side of the equilateral triangle and its substrate size.
2. We initiate the design cut off frequency at 17 and 15 GHz and calculate the side and substrate length and width.

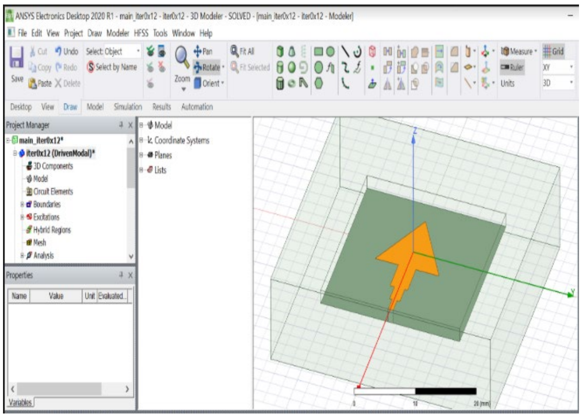


Fig.2.Representing the Structure of Stepped Triangular antenna.

Formulations for Equilateral Triangle:

1. $Side\ of\ equilateral = 2 * \frac{c}{3 * f_r * \sqrt{e_r}}$
2. $L = 4 * (a)$
3. $W = 4 * (a)$
4. $H = 1.6$ *for FR4_epoxy (consideration for this antenna).*
5. *Radiation box size :* $6 * (a)$

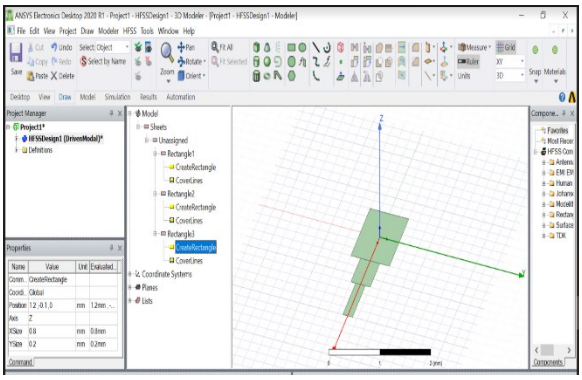


Fig. 3. Represents the design of the step induced line based on rectangular elements.

The values 4 and 6 are observed from the figure 2 representing the antenna structure where its dimensions with ¼ quarter of the substrate is estimated using the area formula. Assuming the dimensions of the substrate be s as for the square the area becomes s^2 and for equilateral becomes$\approx \frac{1}{4} * s^2$. Hence the length would be 2*a and width would 2*a. With factor of transmission line L = 2*a. we have the total lengths would be 4*a, and 4*a.

4.2Transmission Line Design

The size of the transmission line is calculated with the rectangular model and its equivalent reduction with powers of 2. As the rectangular size for the step assumed to 12mm, for step1 the length is 6mm and step2 the length of 4mm as a rectangular cut is positioned with the origin as mentioned figure 3 and 4.

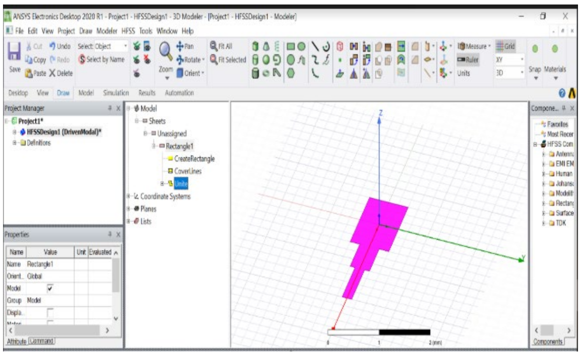


Fig. 4. Represents the design of the united step induced line based on rectangular elements.

5 Results andDiscussion

ITER 0:

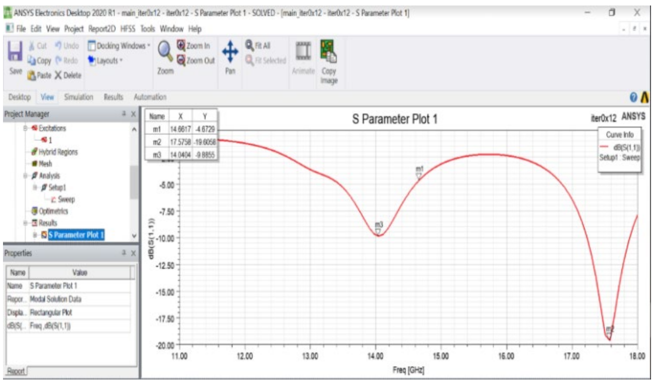


Fig. 5. Representing the reflection coefficient S_{11} value of -19.6056 with the frequency value at 17.578GHz.

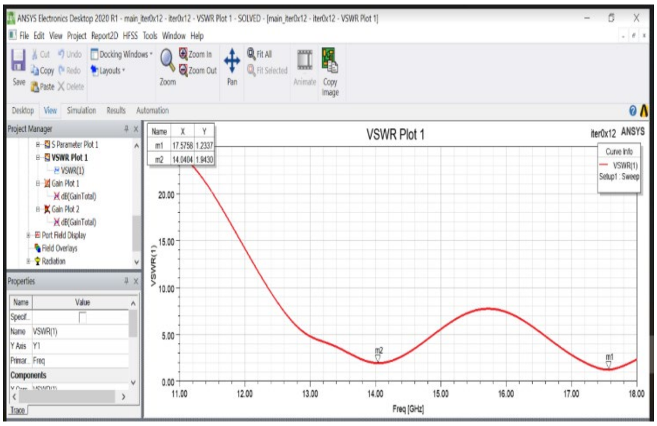


Fig. 6. Representing the VSWR value at 17.56GHz as 1.207.

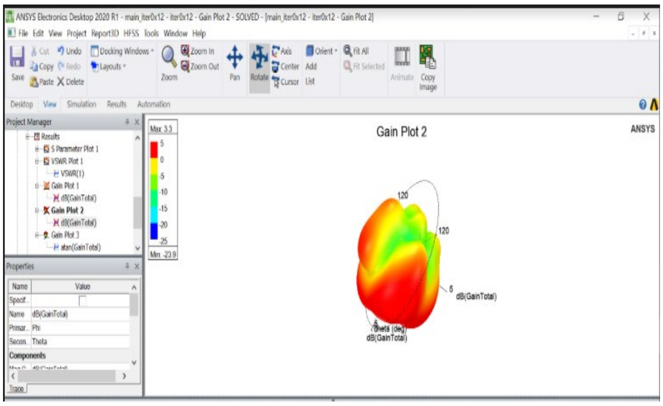


Fig. 7. Representing the GAIN 3-D plot for each frequency sweep.

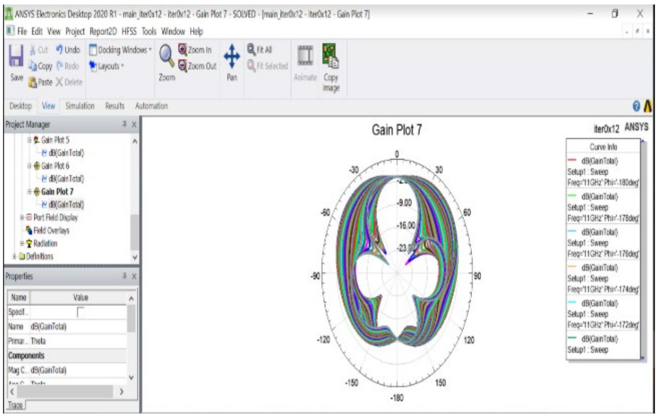


Fig. 8. Representing the Gain 2-D plot for each frequency sweep.

ITER 1:

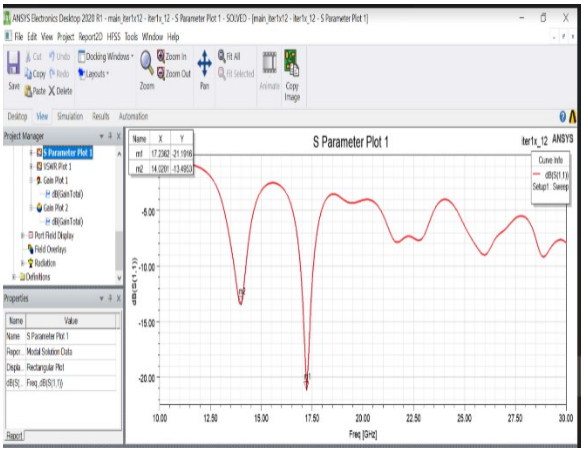


Fig. 9. Representing the reflection coefficient S_{11} value of -21.1916 with the frequency value at 17.206GHz.

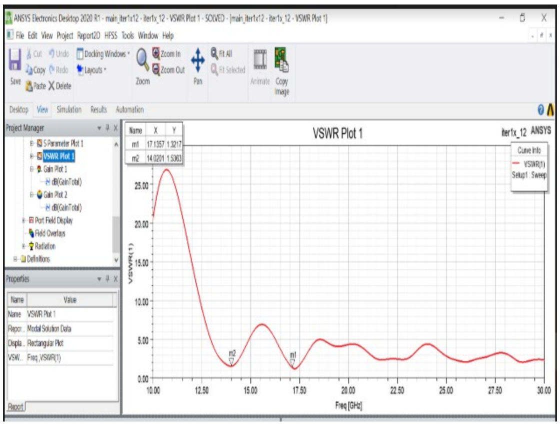


Fig. 10. Representing the VSWR value at 17.206GHz as 1.327.

This design model for the antenna at size of 6.358 mm for equilateral triangle at n=1 iteration. The variation of 0.2362GHz and 1GHz is observed from the fractal antenna for a value of -21.1916 dB and -13.4953 dB with the frequency sweep of 100 iterations. The overall gain of the antenna is observed with 26.7 dB in total as (max-(-min)). Maximum gain with 4.5dB is observed from the figure 8-11.

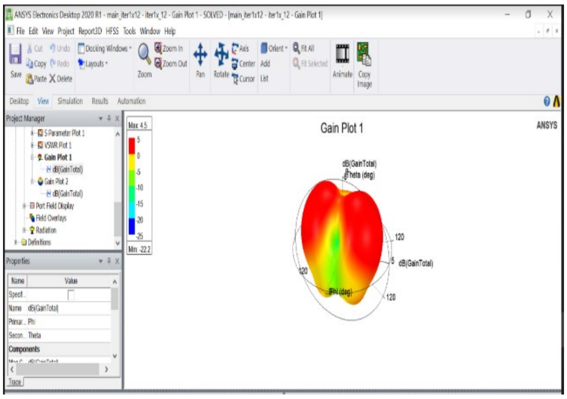


Fig. 11. Representing the Gain 3-D plot for each frequency sweep.

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ITER 2:

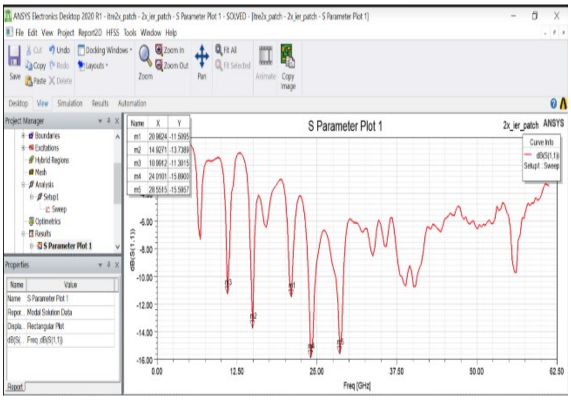

Fig. 12. Representing the reflection coefficient S_{11} value of -13.7389 with the frequency value at 14.9271 GHz and 24.0101 GHz S_{11} value is -15.89 dB.

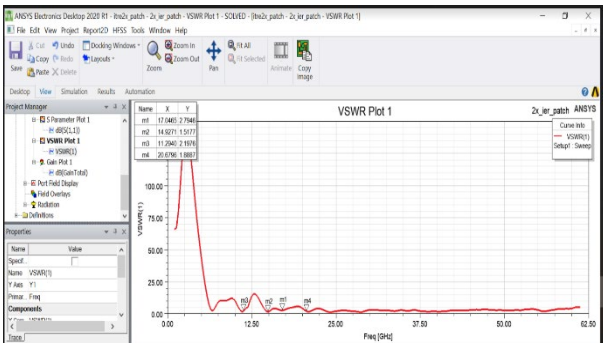

Fig. 13. Representing the VSWR value at 14.9271 GHz as 1.517.

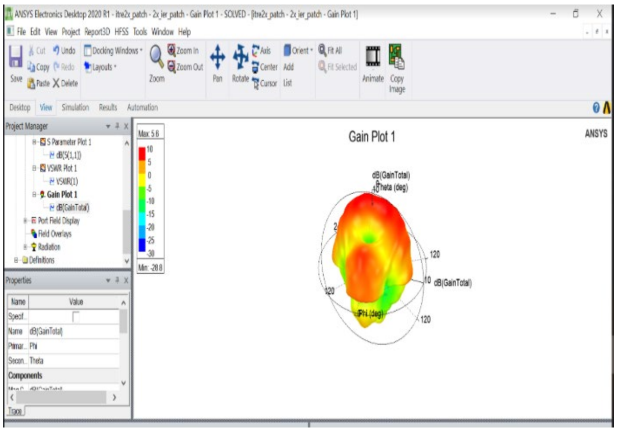

Fig. 14. Representing the Gain 3-D plot for each frequency sweep.

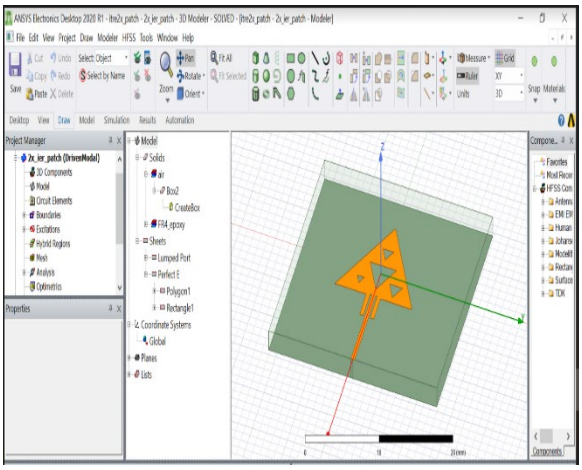

Fig. 15. Representing the M shaped transmission line designed for iteration 2.

This design model for the antenna at size of 6.358 mm for equilateral triangle at n=2 iteration. The variation of 0.0729 GHz from 15GHz, at 20.9824 GHz, 10.9912 GHz is observed from the fractal antenna for a value of -13.739 dB, 11.3015, and -11.5095 with the frequency sweep of 300 iterations. The overall gain of the antenna is observed with 34.4 dB in total as (max-(-min)). Maximum gain with 5.6dB is observed from the figure 12-14.Only for the iteration two a step induced has been changes from the M shaped transmission line as depicted in figure 15.

ITER 3:

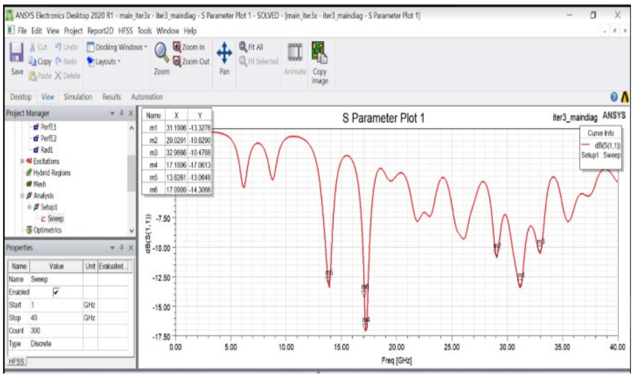

Fig. 16. Representing the reflection coefficient S_{11} value of -17.06 with the frequency value at 17.1806 GHz.

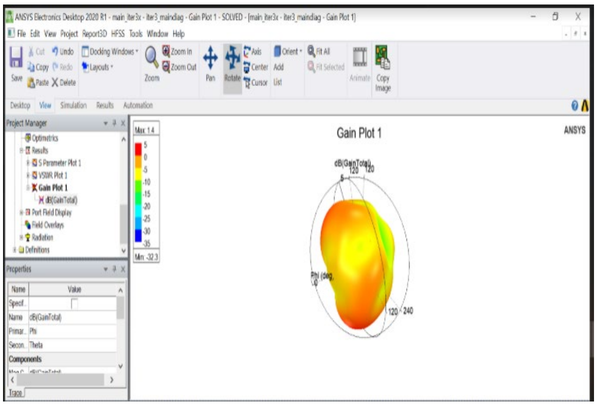

Fig. 17. Representing the Gain 3-D plot for each frequency sweep.

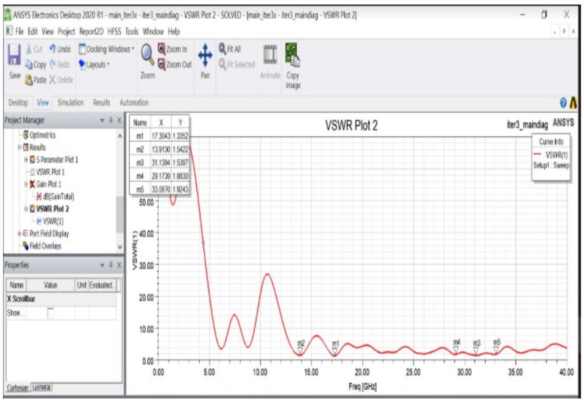

Fig. 18. Representing the VSWR value at 17.206GHz as 1.327.

This design model for the antenna at size of 6.358 mm for equilateral triangle at n=3 iteration. The variation of 0.1806 GHz from 17GHz, at 13.8261GHz with variation of 1.1739GHz from

15 GHz, 31.1906 GHz, 29.0201 GHz, and 32.9666GHz is observed from the fractal antenna for a value of -17.06dB, -13.0646 dB, -10.829dB, -13.3227dB and -10.4768dB with the frequency sweep of 300 iterations. The overall gain of the antenna is observed with 33.7 dB in total as (max-(-min)). Maximum gain with 1.4dB is observed.

ITER 4:

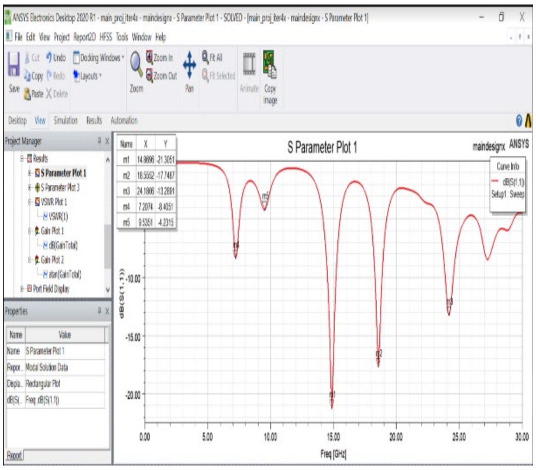

Fig. 19. Representing the reflection coefficient S_{11} value of -21.305 with the frequency value at 14.8696GHz.

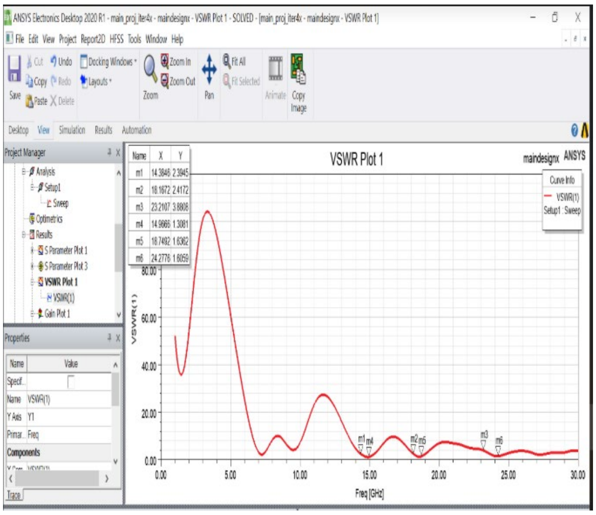

Fig. 20. Representing the VSWR value at 17.206GHz as 1.327.

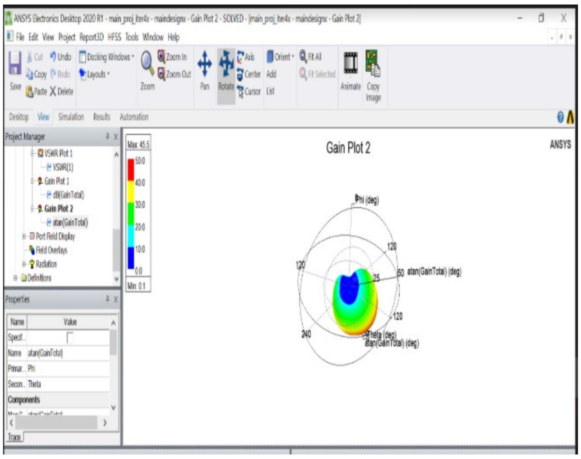

Fig. 21. Representing the tan-1-Gain 3-D plot for each frequency sweep.

This design model for the antenna at size of 6.358 mm for equilateral triangle at n=4 iteration. The variation of 0.1304 GHz from 15GHz, at 18.5552 GHz, 24.1806 GHz is observed from the fractal antenna for a value of -21.3051 dB, -17.7487, and -13.2891 with the frequency sweep of 300 iterations. The overall gain of the antenna is observed with 29.7 dB in total as (max-(-min)). Maximum gain with 0.2 dB is observed.

Table 1. Representing the observed Tabulated Results for Sierpiniski Triangle gasket.

Parameters	S11 in dB max	VSWR (minimum)	Gain in dB total
ITER 0	-19.608	1.2337	27.2
ITER 1	-21.19	1.3217	26.8
ITER 2	-15.36	1.3867	34.8
ITER 3	17.6	1.3352	33.7
ITER 4	-21.30	1.3081	29.7

The proposed SA gasket with each iteration is tabulated with the performance factors of S11, VSWR and Total Gain. The designed antenna with the iterations are observed with different gaps at each section of the fractals which are estimated on the simulation environment. Since the Gap and other features can be remodeled with a script tool. We improvise a multiple solutions to ensure better performance characteristics as mentioned in Table1. As per the designed iterations we could observe that overall gain and VSWR are at maximum for the iteration 2 while similar case on S11 would be the minimum. These iterations improvises to create different Ku, K band features on the frequencies ensuring the different performance characteristics as mentioned via formulation in section 3.

6. Conclusion

The design aims to improvise the improved factors each iteration levels depending upon the design characteristics for the bands Ku and K as mentioned in section 5. VSWR seems to vary between from 1.2 to 1.4 at max which improvises the design antenna accuracy with the transmission line matching criteria. The Gain factor and S11 values are depends on the frequency of operations where each set of the variations at gap of 0.39*0.45 is estimated with each iterations except for iteration 2. The size of the equilateral triangles are changed for only for iteration 2 since as of at least 3 drops of frequencies are observed between 10-20 GHz. Hence the design changes of transmission line from step induced to M shape have been implemented to provide the correct response outputs.

7. Future Scope

The prime scenarios for mathematical modelling and structure representing the different designs are explained and implemented successfully. This scenario on the low-profile, cheaper, less weight antennas are prime aspects of the design criteria even for fractal models which are discussed with sierpinski model only with the iteration of 0 to 4. Based on the geometry of the ground plane is estimated with deflected ground surface (DGS) modelling for improved gain values and its S11 characteristics.

8. References

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