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Design of Hybrid Fractal Antenna for Multiband Applications

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Abstract: This paper takes research on design of multiband microstrip patch antenna. The proposed patch antenna can resonate at four unique frequencies between 2 GHz and 9GHz out of which two are considered to be useful bands. To accomplish multiband frequency, proposed finite element method is employed to design the rectangular Microstrip Patch Antenna (MPA). The circular patch is designed and then united with more circles to make a new design. The proposed antenna is designed on FR4 Epoxy substrate with specifications: relative permittivity = 4.4, relative permeability = 1, di-electric loss tangent =0.02 and thickness = 1.6 mm .The return loss for all the resonant frequencies is less than -10dB. The proposed design exhibits the overall gain of 9.5 dB On other hand, individual gain of antenna is 9.3 dB and 1.9 dB at 5.09 GHz and 9.36 GHz respectively in the final iteration, and is used for many satellite communications transmissions, some Wi-Fi devices, some cordless telephones as well as some surveillance and weather radar systems.
Index Terms: MPA, Fractal techniques, Return loss and Gain

I. INTRODUCTION

Antennas enables wireless communication between two or more stations by directing signals from one station to another by radio waves [1]. A microstrip patch antenna (MPA) comprise of metallic patch radiator on an electrically thin di-electric substrate with the ground of metallic material such as copper, gold. Now-a-days the need of wireless communication has grown [2]. Wireless systems are required to be low profile and small in size due to its characteristics to be mobile. Microstrip patch antenna is the major attraction for researchers over the past work. The microstrip patch structures are probably easy to fabricate. Research on microstrip antenna in the 21st century centred at small sized, increased gain, wide bandwidth, multiple functionality [3-4]. With the wide spread proliferation of wireless communication technology in recent years, the demand for compact, low profile and broadband antennas has increased significantly. To meet such features and requirements, the microstrip patch antenna have been proposed because of its low profile, less in cost, small in size.[1] Microstrip Patch Antenna consists of rectangular patch which is conductor in nature of length "L" and width "W" on one side of dielectric substrate with the thickness of "h" and dielectric constant "ε_r" with the base named ground. Common microstrip antenna shapes are circular , elliptical , square, rectangular, but any shape is possible like introduced in this paper by using regular shapes. Parameters like return losses, gain and VSWR are calculated in this paper. Return loss or reflection loss is the reflection of signal power from the insertion of a device in a transmission line or optical fibre. Whereas , antenna gain is the ratio of maximum radiation intensity at the peak of main beam to the radiation intensity in the same direction produced by an isotropic radiator or omni - directional antenna having the same input power. Isotropic antenna is standardised to have a gain of unity. The gain function can be described as : G $\theta,\phi = \frac{p(\theta,\phi)}{\frac{Wt}{4\pi}}$. Various feeding mechanisms are used to supply Microstrip patch antennas. These methods are categorised into contacting and non-contacting technique. Generally contacting methods are microstrip line feeding and co-axial plane feeding. On other hand, non- contacting techniques are proximity coupled feeding, aperture coupled feed. We are using inset microstrip line feed technique because microstrip line feed gives less return losses, is reliable and easy to fabricate.

II. ANTENNA DESIGN

Designing an antenna in wireless application meant that the antenna dimension couldn't be bulky. With this regard objective is to design a reduced sized multi band micro strip patch antenna, design idea was taken from broadband antennas with feed line technique. This is a type of microstrip line feeding technique, in which the width of conducting strip is kept small as compared to the patch and has the advantage that the feed can provide a planar structure [2].
The structure of proposed multiband microstrip patch antenna is shown in figure 1, which is designed with di-electric constant 4.4 and loss tangent of 0.02. The total volume of proposed antenna is about (20×22×1.6) mm^3 and it resonates for various frequencies discussed further. The dimension of microstrip patch antenna is displayed in Table 1 below:

S.No	PARAMETERS	VALUES (mm)
1.	Feed Width (F_W)	1.3
2.	Feed Length (F_L)	3.6
3.	Ground length(G_L)	20
4.	Ground width(G_W)	22
5.	Height (H)	1.6

TABLE 1: Dimensions of proposed microstrip patch antenna.

The circular patch with the new design is comprised of eight circles united together which are different in size but similar in shape same as fractal. Geometry of 0^{th} Iteration of proposed antenna is show in figure 1.

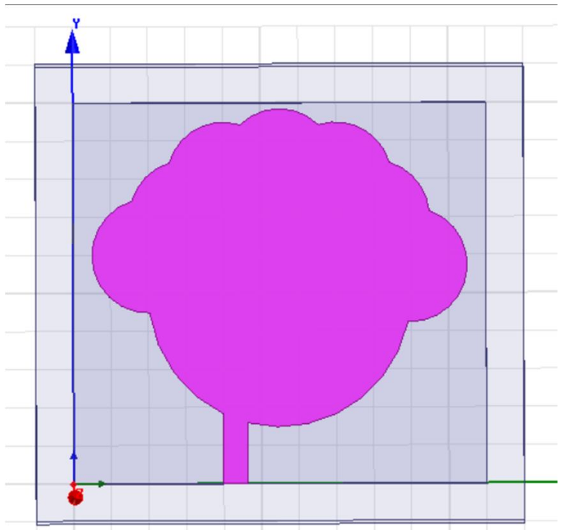

Figure 1: 0^{th} Iteration of Proposed Antenna

Now in order to improve its parameters we have etched circular slots from the patch as shown in figure 2. Here we observed the overall gain is raised to 9.7 dB by introducing this slot in patch. Further results will be discussed in this paper.

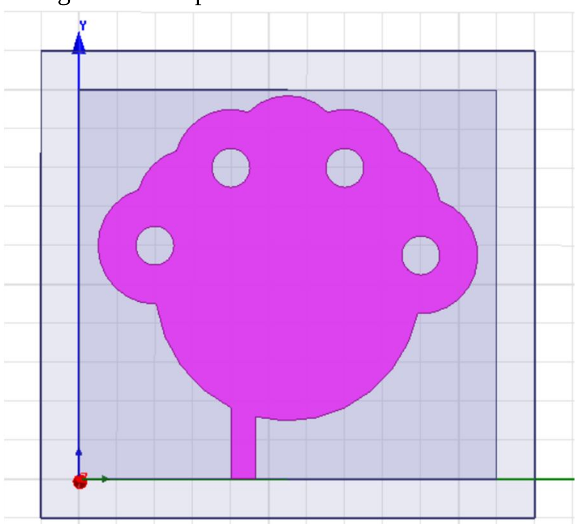

Figure 2: 1^{st} Iteration of Proposed Antenna

In second iteration rectangular slots are etched to introduce different shapes like circular and rectangular both in one antenna which are inspired from seirpinsiki carpet which is shown in figure 3.

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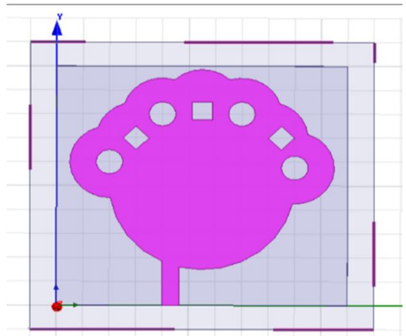

Figure 3: 2nd Iteration of Proposed Antenna

In the final iteration seirpinsiki carpet and gasket which are two types of fractal shapes of antenna are combined to make hybrid fractal antenna as shown in the figure 4.

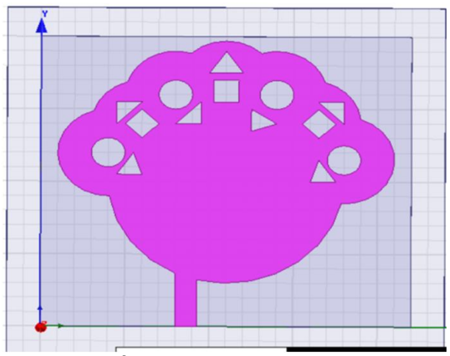

Figure 4: 3rd Iteration of Proposed Antenna

III. RESULTS AND DISCUSSIONS

The proposed antenna is designed and simulated by using HFSS V13 (High Frequency Structure Simulator Software) version 13 Software. The different parameters such as return loss, VSWR, gain and radiation pattern has been observed and analysed.

A. Return Loss and VSWR

Return loss is an important parameter of antenna. It is the difference between forward and reflected power in dB. The return loss is the ratio of reflected power over transmitted power. The acceptable value of return loss is below -10dB for the antenna to work efficiently. The return v/s frequency curve of 0th, 1st and 2nd and 3rd iteration are shown in Figure 5, 6, 7 and 8 respectively. It is observed that in 0th Iteration best result is at 9.46 GHz is -26.61 and in 1st Iteration at 9.27 GHz is -24.31, in 2nd Iteration at 9.36 GHz is -21.35 and in 3rd Iteration at 9.36 GHz is -30.34 of Proposed Antenna. Moreover return loss and gain for various resonant frequencies is given in Table 2. A very low return loss can be achieved at frequency of 9.36GHz.

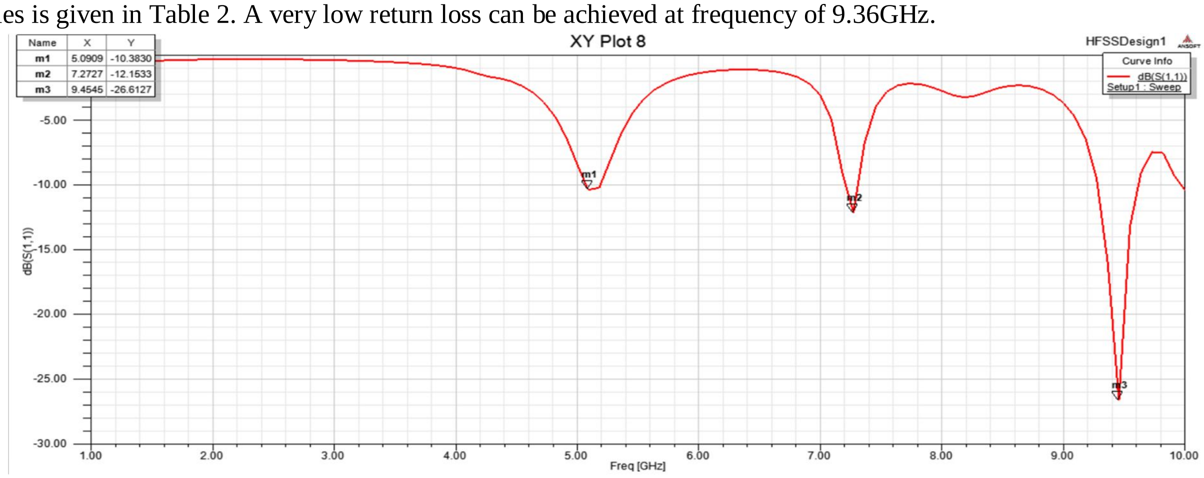

Figure 5: Return loss of 0th iteration

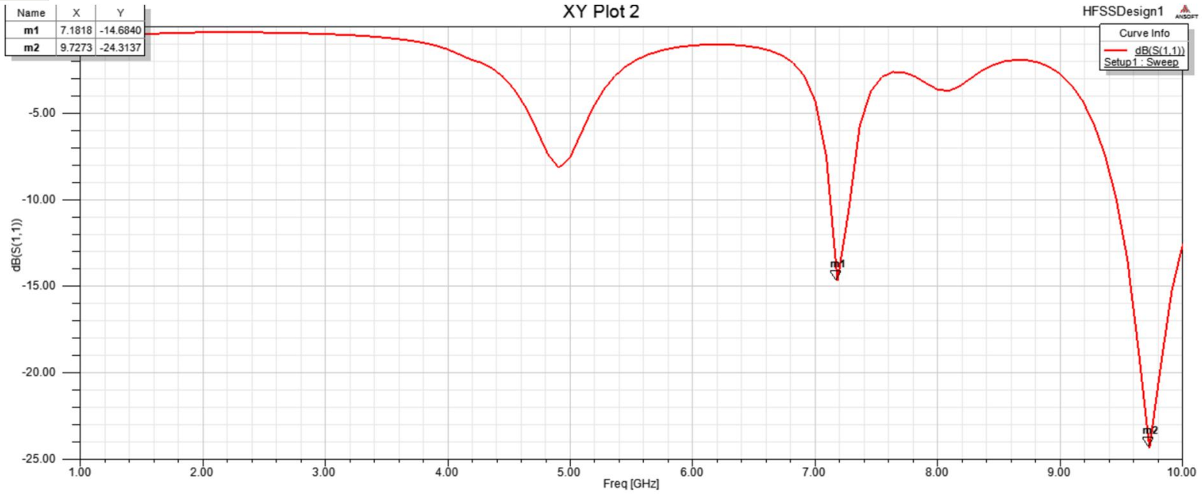

Figure 6: Return loss of 1st iteration

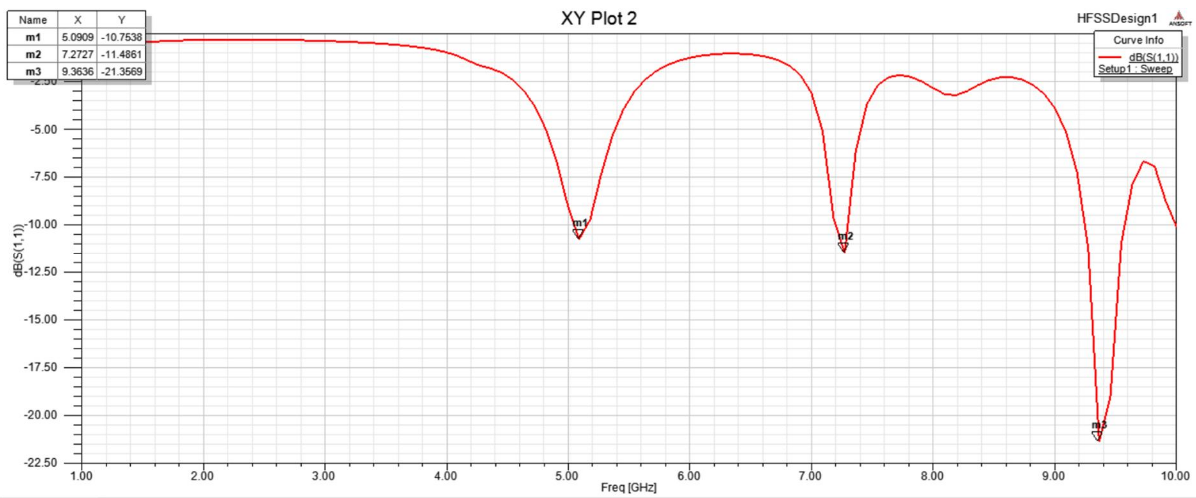

Figure 7: Return loss of 2nd iteration

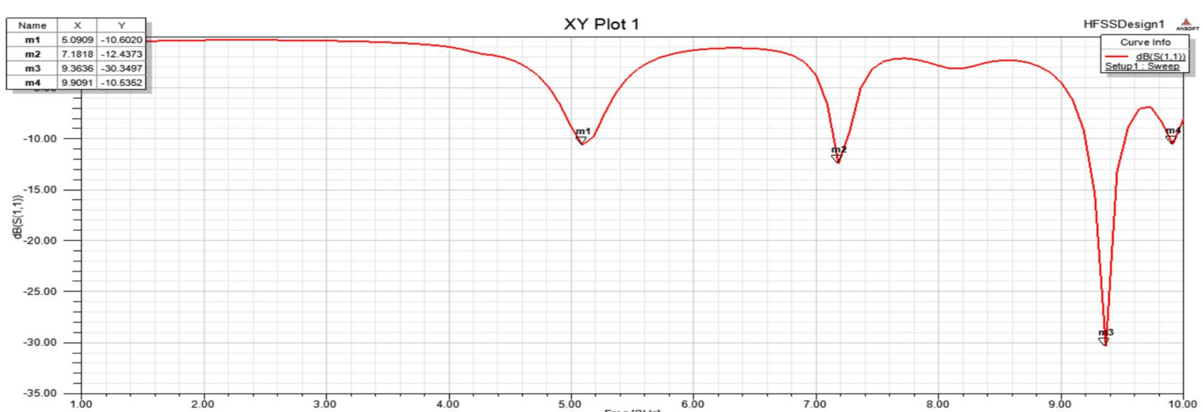

Figure 8: Return loss of 3rd iteration

VSWR is Voltage Standing Wave Ratio it shows the impedance mismatch between the feeding system and antenna. Higher VSWR means higher mismatch. The acceptable value of VSWR is less than 2 and it is a dimension less quantity. The VSWR v/s frequency curve of 0th, 1st and 2nd and 3rd iteration of proposed antenna are shown in Figure 9, 10, 11 and 12 respectively. The comparisons of simulated results are shown in Table 2.

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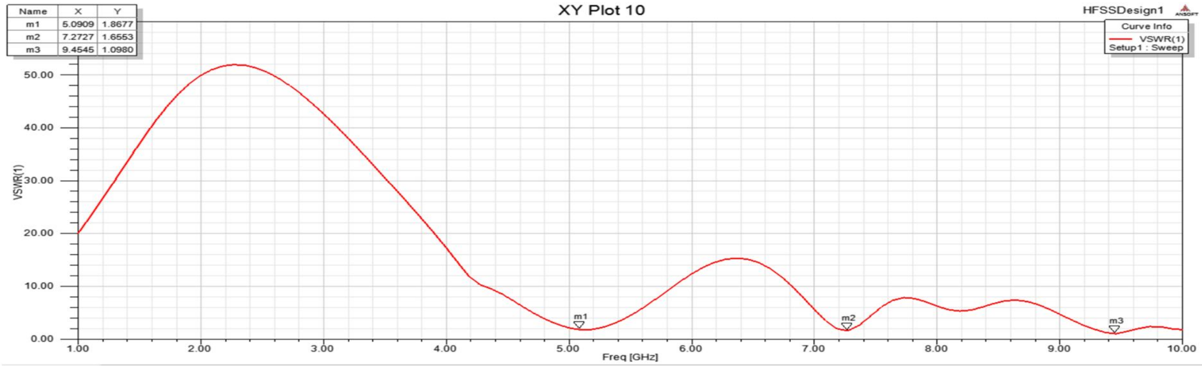

Figure 9: VSWR v/s frequency curve of 0^{th} iteration of proposed antenna

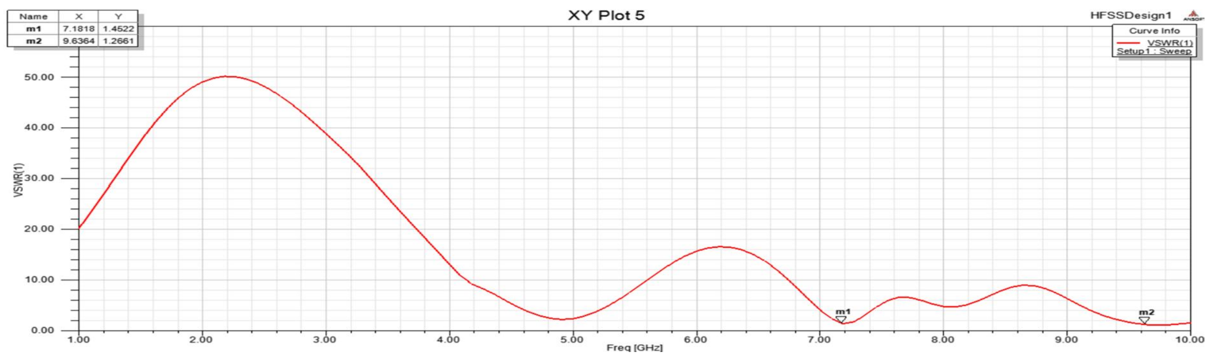

Figure 10: VSWR v/s frequency curve of 1^{st} iteration of proposed antenna

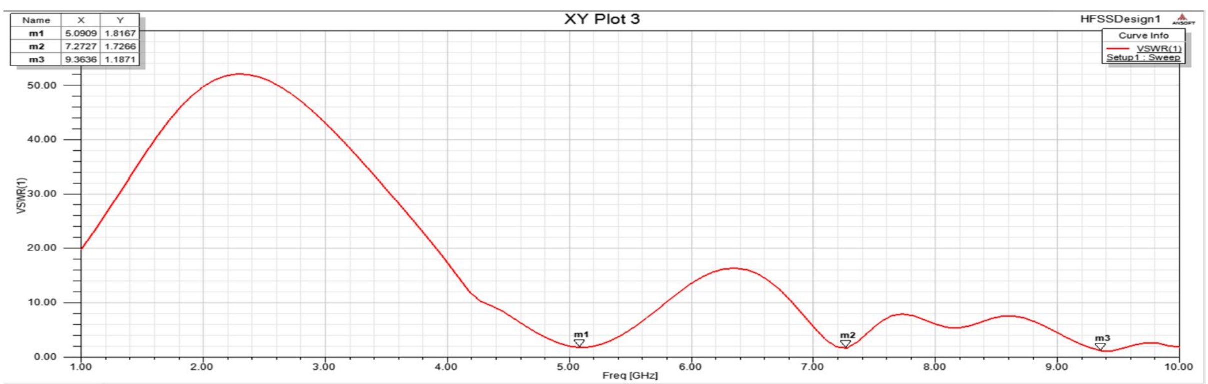

Figure 11: VSWR v/s frequency curve of 2^{nd} iteration of proposed antenna

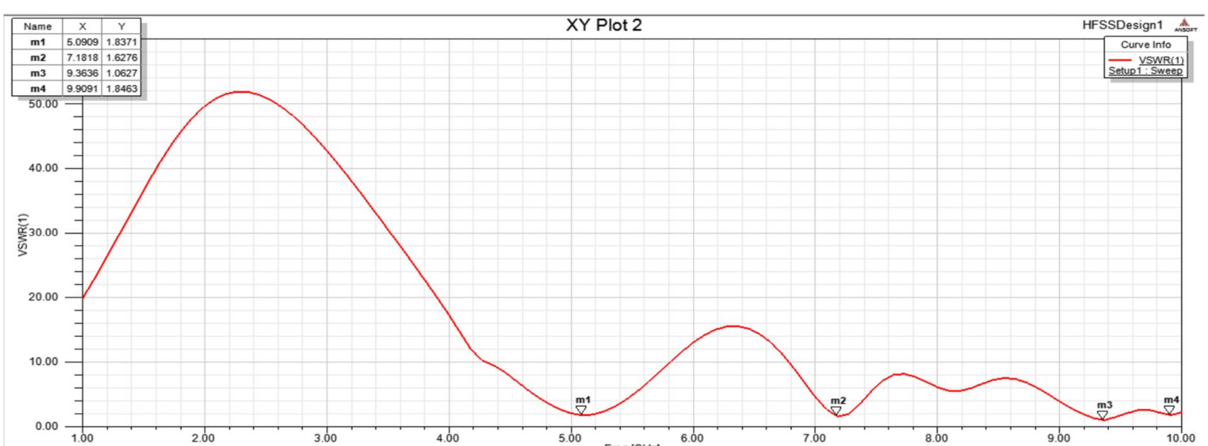

Figure 12: VSWR v/s frequency curve of 3^{rd} iteration of proposed antenna

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IV. GAIN

The outcome of simulated results of return loss and gain confirms the good performance for proposed design of microstrip patch antenna. It can be seen from figure 1.3(a), 7dB is maximum gain obtained at 6.1GHz in 0th iteration, 9.8 dB is maximum gain obtained at 6.2 GHz in 1st iteration and 9.04 dB is maximum gain obtained at 8.8 GHz in 2nd iteration. Gain shows the directional capability and efficiency of antenna. The acceptable value of antenna gain is 3dB or more. The 3-D overall gain plot of proposed antenna for 0th, 1st and 2nditeration is shown in Figure 10, 11 and 12.

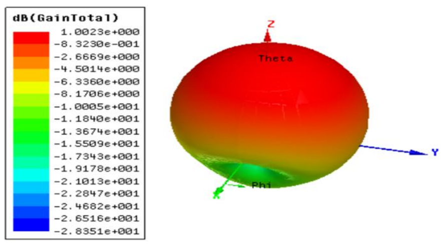

Figure 13 : Gain of 0th iteration of proposed antenna

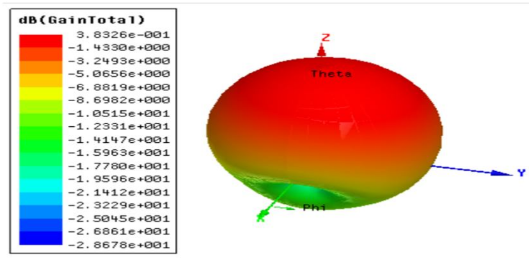

Figure 14 : Gain of 1st iteration of proposed antenna

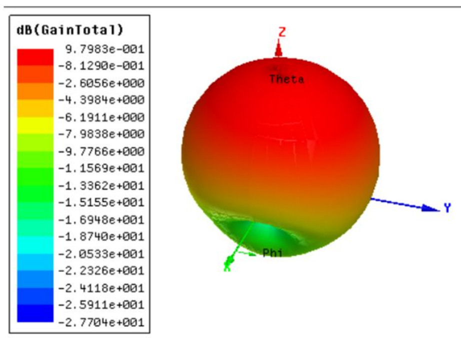

Figure 15: Gain of 2nd iteration of proposed antenna

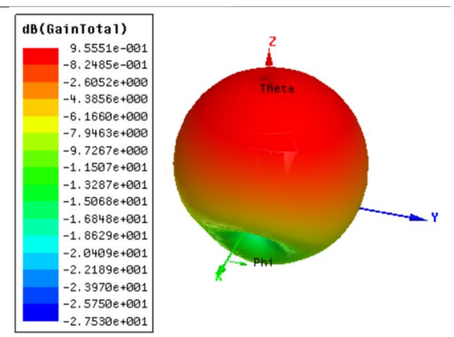

Figure 16: Gain of 3rd iteration of proposed antenna

Table 2: Comparison of Various Iterations of Proposed Antenna

ANTENNA	ITERATIONS	FREQUENCY in (GHz)	RETURN LOSS (dB)	OVERALL GAIN (dB)	GAIN AT VARIOUS FREQUENCIES (dB)	VSWR
PROPOSED ANTENNA (20*22)	ITERATION 0	5.09	-10.38	1	9.9	1.8
		7.2	-12.15		-1.8	1.6
		9.4	-26.61		2.1	1
	ITERATION 1	7.18	-14.68	3.8	-2.5	1.4
		9.27	-24.31		9.3	1.2
	ITERATION 2	5.09	-10.75	9.7	9.6	1.8
		7.27	-11.48		-1.8	1.7
		9.36	-21.35		1.9	1.1
	ITERATION 3	5.09	-10.6	9.5	9.3	1.8
		7.18	-12.43		-2.4	1.6
		9.36	-30.34		1.9	1
		9.9	-10.53		-2.02	1.8
EXISTING ANTENNA (21*25)	ITERATION 0	3.5	NA	3	NA	1
		5.5				1
		9				1.5

V. CONCLUSION

In this paper, a design of multiband hybrid microstrip patch antenna is proposed, which covers the frequency range between 2GHz and 9GHz. The return loss for all resonant frequency is ≤ -10 dB . The maximum gain is 9.5 dB in final iteration. Third iteration possess this is a dual band hybrid fractal antenna. The proposed antenna can be used for many satellite communications transmissions, some Wi-Fi devices, some cordless telephones as well as some surveillance and weather radar systems. Moreover the simulation results of return loss and gain show that this antenna can be used for various civil, military & government institutions applications of X band

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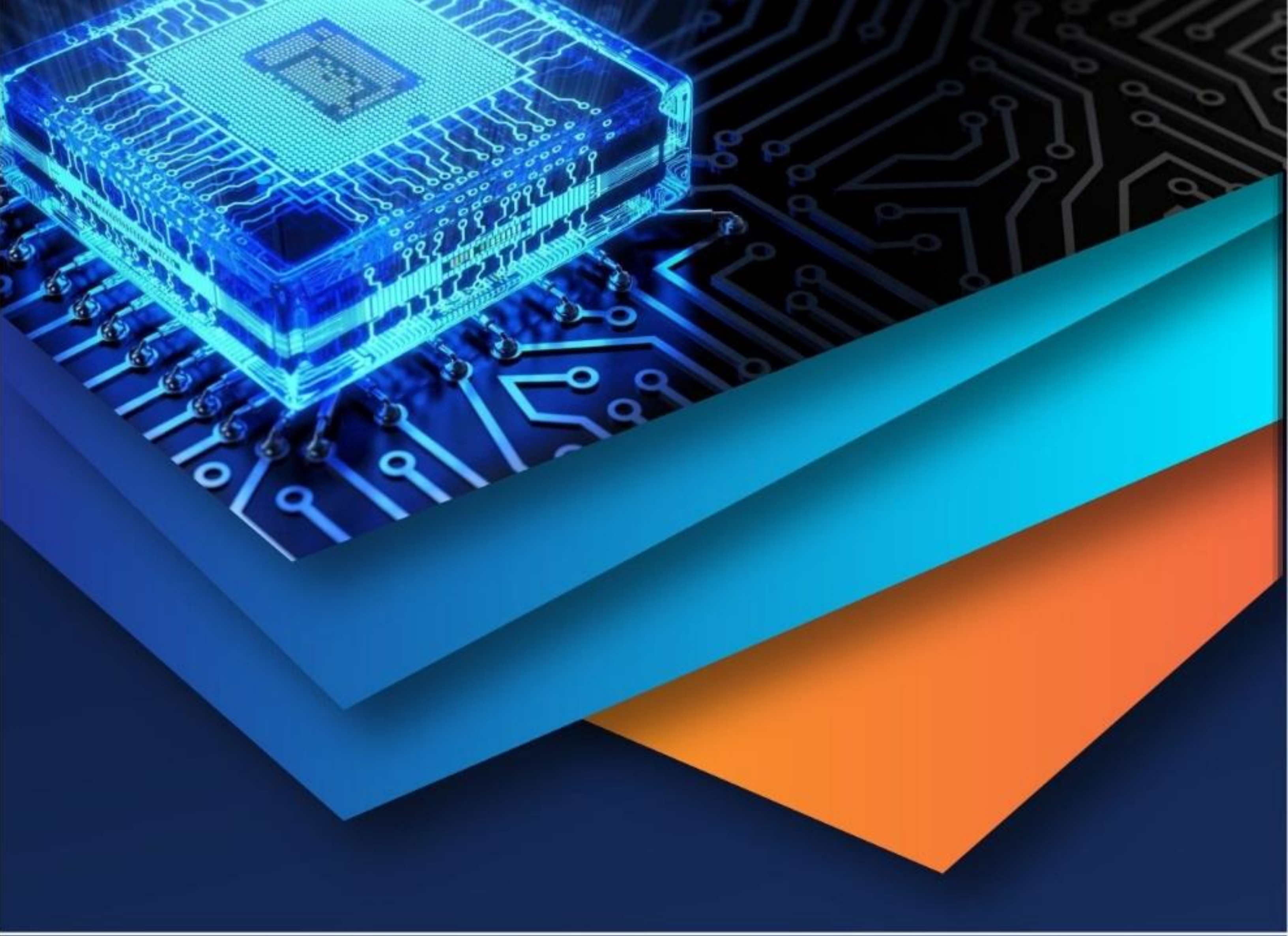

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