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Design & Analysis of L-Shaped Fractal Antenna using Microstrip line feed and Inset Cut line feed technique

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Abstract –*This paper takes a research on the design of L-Shaped Fractal antenna for wireless communication. The proposed patch antenna can resonate at 5GHz Frequency. This paper describes the two types of feeding techniques: Microstrip line feed and inset cut line feed. To accomplish multiband Frequency, the proposed finite element method is employed to design the Fractal antenna. It is a fractal antenna, so that is why shapes are repeated the same in particular designs. The L- shapes slots are etched from the patch to improve the gain and return loss of the antenna. In the L-Shaped antenna design, firstly designed the antenna's shape and designed on FR4-epoxy substrate with dielectric constant 4.4 and thickness 1.6mm. The proposed antenna is designed to analyze the different antenna parameters such as Gain, Return loss, and VSWR. The proposed antenna is designed and simulated by using HFSS (High-Frequency Structure Simulator) V13 software. It is recommended to be useful in S, C, and X bands, respectively, along with that the proposed design has improved return loss, gain, and VSWR.*

Keywords —*Fractal Antenna, Microstrip line feed, Inset Cut line feed, Return loss, gain, and VSWR.*

I. INTRODUCTION

Antennas enable wireless communication between two or more stations by directing signals from one station to another by radio waves. A microstrip patch antenna (MPA) comprises of metallic patch radiator on an electrically thin dielectric substrate with the ground of metallic material such as copper, gold. Nowadays, the need for wireless communication has grown. Wireless systems must be low profile and small in size due to their characteristics to be mobile. The 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 centered at small-sized, increased gain, wide bandwidth, and multiple functionalities. With the widespread 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 has been proposed because of its low profile, less in cost, small size. Microstrip Patch Antenna consists of a rectangular patch which is a conductor in nature of length "L" and width "W" on one side of the dielectric substrate with the thickness of "h" and dielectric constant "ε_r" with the base named ground. Common microstrip antenna shapes are square, rectangular, circular, elliptical, but any shape is possible as 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 reflects signal power from a device's insertion in a transmission line or optical fiber. At the same time, antenna gain is the ratio of maximum radiation intensity at the peak of the main beam to the radiation intensity in the same direction produced by an isotropic radiator antenna having the same input power. Isotropic antenna is standardized 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 categorized into contacting and non-contacting techniques. Generally contacting methods are microstrip line feeding and co-axial plane feeding. On the other hand, non-contacting techniques are proximity coupled feeding, aperture coupled feed.

II. ANTENNA DESIGN

In the L-Shaped antenna design, firstly designed the antenna's shape and designed on FR4-epoxy substrate with dielectric constant 4.4 and thickness 1.6mm. The resonance frequency of 5 GHz is used to design the proposed antenna. The proposed antenna is designed to analyze the different antenna parameters such as Gain, Return loss, and VSWR. The proposed antenna is designed and simulated by using HFSS (High-Frequency Structure Simulator) V13 software. It is recommended to be useful in S, C, and X bands, respectively, along with that the proposed design has improved return loss, gain, and VSWR. The structural details of the proposed antenna are depicted in Figure 4.1, and its parametric values are shown in Table 1.1.

Table 4.1: Parametric values of the proposed antenna

S. No.	Parameters	Description	Values
1.	Ls	Length of substrate	54.36mm
2.	Ws	Width of substrate	46.72mm
3.	Lp	Length of patch	37 mm
4.	Wp	Width of patch	28 mm
5.	L_F	Length of the feed line	-10 mm
6.	W_F	Width of the feed line	5 mm

The 1st iteration of the proposed antenna has been designed by taking all the dimensions, but in 1st iteration L-Shaped slot is extracted from the center of the rectangular patch. The simulated structure of 1st iteration is shown in Figure 1.1

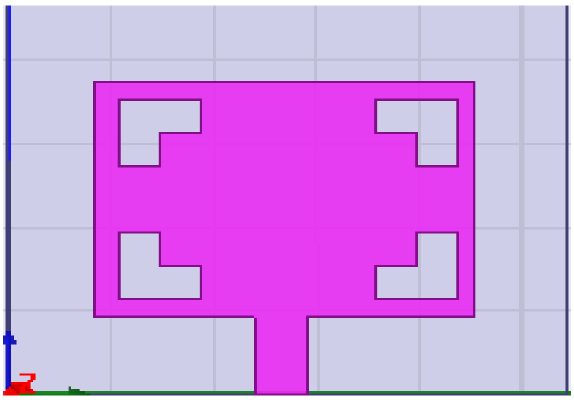

Figure 1.1 proposed antennas 1st iteration

III. Results and Discussions

The proposed antenna is designed and simulated 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 analyzed.

Return loss

The simulation results of antenna parameters like Return Loss, Gain, and VSWR are obtained using HFSS software. The designed antenna gives a return loss of -15dB, which shows that matching of antenna is good and losses are minimal. The simulated results of the antenna are shown in figure 1.2.

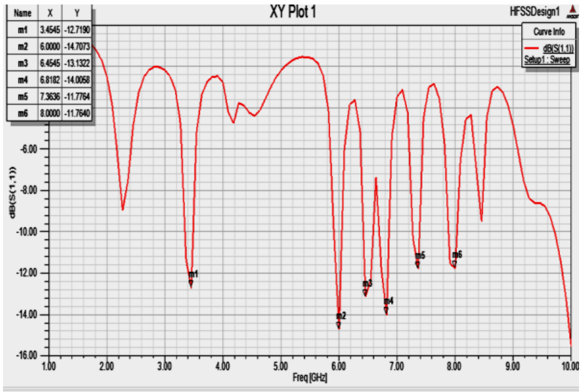

Figure 1.2 Return loss v/s frequency curve of 1st iteration of L-Shaped slot antenna

VSWR

The parameter VSWR (voltage standing wave ratio) is a figure of merit that mathematically describes the impedance matching between the transmission line and antenna. The ideal value of VSWR is 1, which means there is no reflection in the transmission line; however idealist nowhere exists in the world. In the practical scenarios, the optimum value for VSWR must be less than 2. Figure 1.3 shows the VSWR vs. frequency plot. From the plot, we can observe that the VSWR maintains a value of less than 2 at 5GHz resonant frequencies.

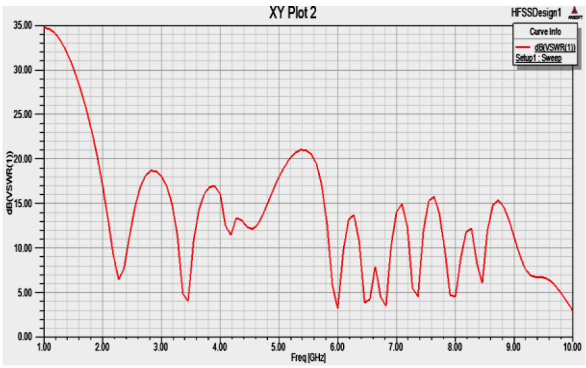

Figure 1.3 VSWR v/s frequency curve of 1st iteration of L-Shaped slot antenna

The 2nd iteration of proposed antenna has been designed by taking the 1st iteration as a base geometry and extracting the design is modified by cutting the four L-Shaped slots at the edges of the rectangular patch. The simulated structure of 2nd iteration of the proposed antenna is shown in Figure 1.4.

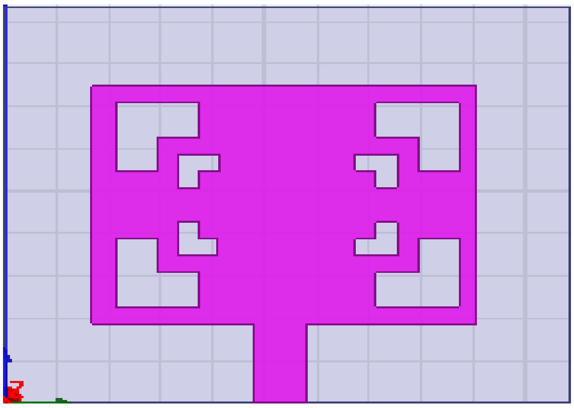

Figure 1.4 Proposed antennas 2nd iteration

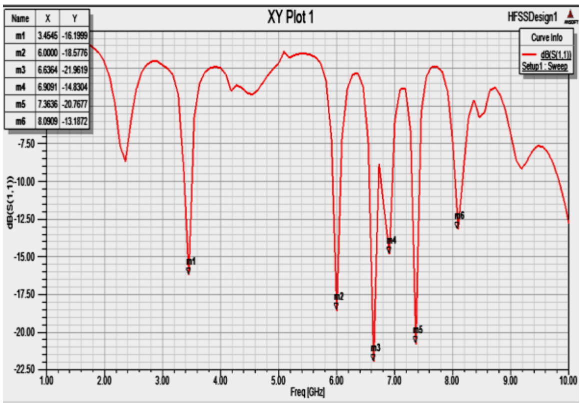

Figure 1.5 Return loss v/s frequency curve of 2nd iteration of L-Shaped slot antenna

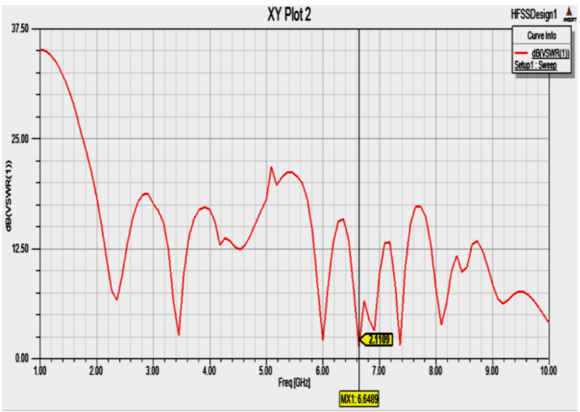

Figure 1.6 VSWR v/s frequency curve of 2nd iteration of L-Shaped slot antenna

The 3rd iteration of the proposed antenna has been designed by taking the 2nd iteration as a base geometry and extracting the design is modified by cutting the two Square Brackets Shaped slots at the edges of the rectangular patch. The simulated structure of 3rd iteration of the proposed antenna is shown in Figure 1.7

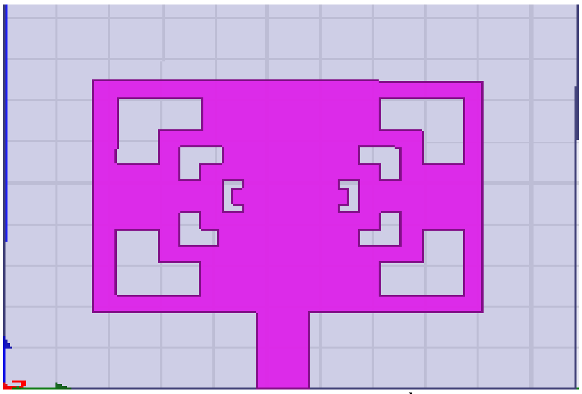

Figure 1.7 Proposed antennas 3rd iteration

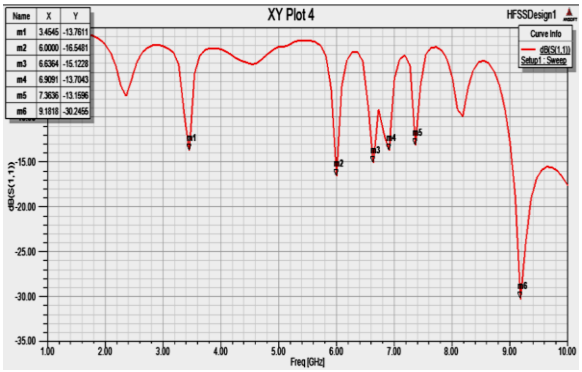

Figure 1.7 Return loss v/s frequency curve of 3rd iteration of L-Shaped slot antenna

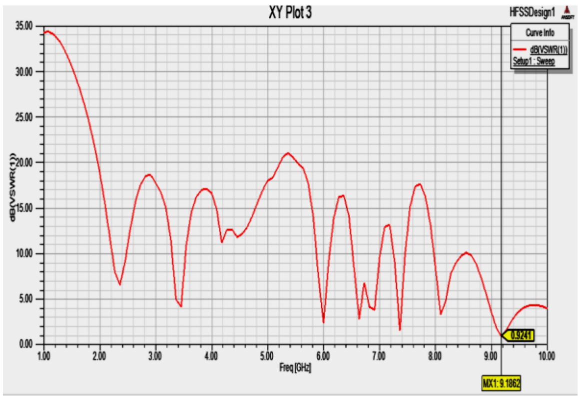

Figure 1.8 VSWR v/s frequency curve of 3rd iteration of L-Shaped slot antenna

The 3rd iteration of the proposed antenna has been designed using the inset cut feed line technique as a base geometry, and extracting the design is modified by cutting the two Square Brackets Shaped slots at the edges of the rectangular patch. The simulated structure of 3rd iteration of the Inset cut feed line antenna is shown in Figure 1.9

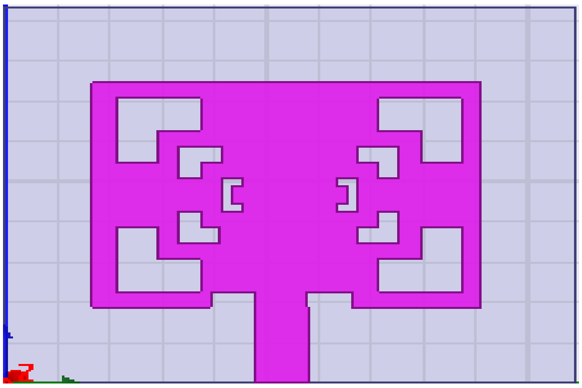

Figure 1.9 3rd iteration of proposed antennas by using inset cut feed line

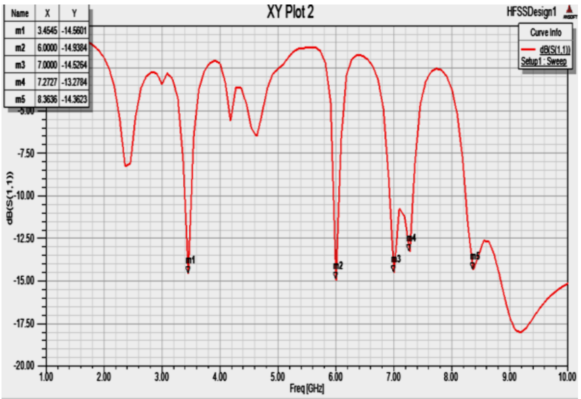

Figure 1.10 Return loss v/s frequency curve of 3rditeration of inset cut feed line

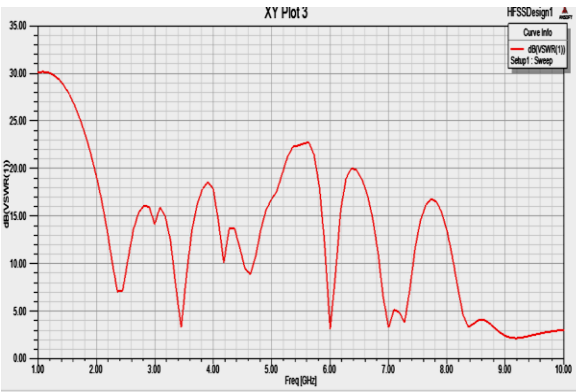

Figure 1.11 VSWR v/s frequency curve of 3rd iteration of inset cut feed line

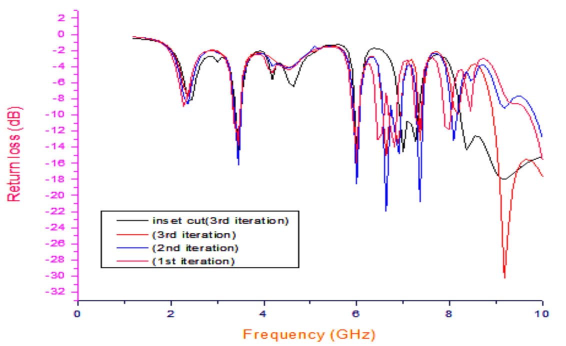

Figure 1.12: return loss v/s frequency plot of 1st, 2nd, and 3rditeration of microstrip line feed and inset cut feed

The Return loss v/s frequency plot of 1st, 2nd, and 3rditeration of microstrip line feed and Inset cut feed technique with the help of HFSS Software at resonant Frequency of 5GHz. In the case of 3rd iteration of the microstrip line feed technique, exhibit at a frequency of 9.18GHz, with the return loss -30.2dB compared to the Inset cut feed technique, which is an exhibit at a frequency of 6.00 GHz, with the return loss -14.9 dB. The return loss of different iteration of a fractal antenna is shown in figure 1.12 above.

Gain

Gain is defined as the ratio of power radiated in a particular direction to the power radiated by an isotropic antenna. The 3D plot of 1st, 2nd, and 3rd iteration of gain is shown in Figures 1.13 & 1.14, 1.15, and 1.16. This demonstrates that at resonating Frequency of 5GHz. The gain of the antenna comes out to be 9.5

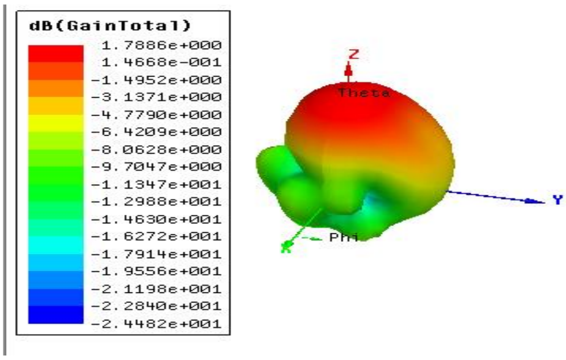

Figure 1.13 3D Polar Plot of 1st iteration of Gain

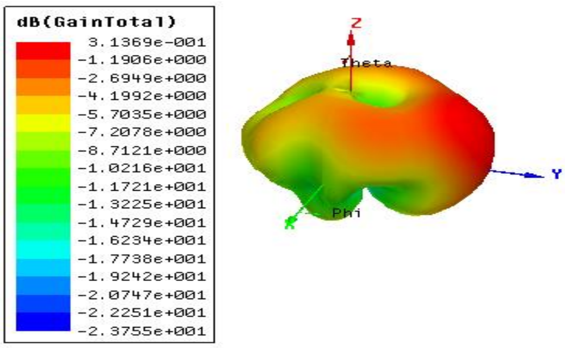

Figure 1.14 3D Polar Plot of 2nd Iteration of Gain

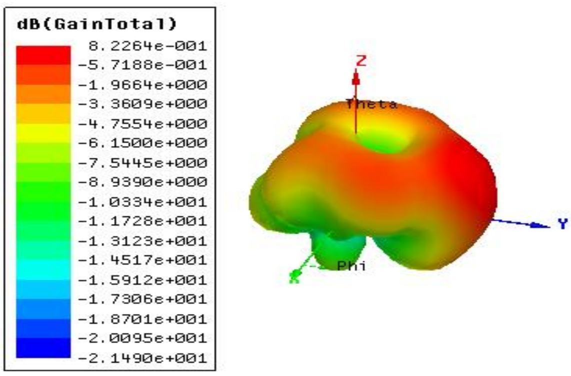

Figure 1.15 3D Polar Plot of 3rd Iteration of Gain

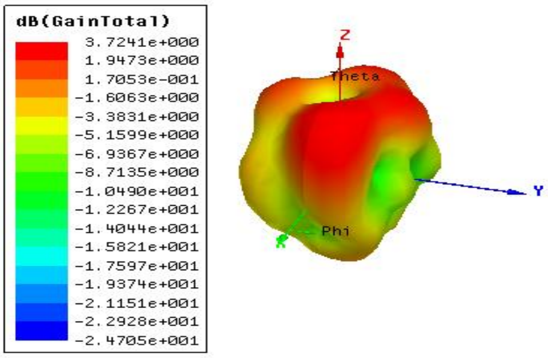

Figure 1.16 3D Polar Plot of inset cut feed line

Table 1.2: Comparison of simulated results of 1st, 2nd and 3rd iteration of microstrip line feed & inset cut feed line.

Iteration	Resonant Frequency in GHz	Return loss in dB	VSWR	Gain in dB	Bands
1st iteration	3.45	-12.71	1.17	-3.6	S
	6.00	-14.70	1.14	-5.4	C
	6.45	-13.13	1.16	-3.9	C
	6.81	-14.00	1.15	-9.2	C
	7.36	-11.77	1.18	1.7	C
	8.00	-11.76	1.18	8.6	X
2nd iteration	3.45	-16.1	1.13	-4.4	S
	6.00	-18.5	1.13	-3.2	C
	6.63	-21.9	1.09	3.1	C
	6.90	-14.8	1.14	-1.5	C
	7.36	-20.7	1.10	1.0	C
	8.09	-13.1	1.16	2.6	X
3rd iteration	3.45	-13.76	1.15	-3.7	S
	6.00	-16.54	1.12	-1.7	C
	6.63	-15.12	1.14	1.4	C
	6.90	-13.70	1.17	1.4	C
	7.36	-13.15	1.14	1.7	C
	9.18	-30.24	1.16	8.2	X
3rd iteration (inset cut feed line)	3.45	-14.56	1.00	-4.6	S
	6.00	-14.93	1.00	-2.5	C
	7.00	-14.52	1.14	-1.5	C
	7.27	-13.27	1.07	1.0	C
	8.36	-14.36	1.07	3.7	X

IV. CONCLUSION

In this paper, a design of an L-shaped fractal antenna is proposed, which covers the frequency range between 5GHz. The return loss for all resonant Frequencies is ≤ -10 dB. Gain is contemplated 8.2 dB at 9.18 GHz in L-shaped rectangular patch antenna using microstrip line feed and return loss in -30.2 at 9.18 GHz, and 1.16 VSWR. Hence we concluded that L- Shaped rectangular patch antenna with microstrip line feed is better than the inset cut line feed L- Shaped rectangular patch antenna. The proposed antenna can be used for many satellite communications transmissions, some Wi-Fi devices, some cordless telephones, and 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 S, C &X band.

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