RESEARCH ARTICLE OPEN ACCESS

Novel Design of Star-Shaped Fractal Slot Antenna for Wlan and X-Band Applications

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Abstract
A wideband triangular microstrip antenna is proposed for wireless applications. The antenna has been modified into a star-shaped patch whose impedance bandwidth increases by using the fractal configuration. The design procedure is presented and characteristics of the antenna are analyzed. A 50-ohm Microstrip line is used to excite the star-shaped patch. The measured results demonstrate that the structure exhibits a wide impedance bandwidth of 56.67% ranging from 4.8 GHz to 7.1 GHz, which covers WLAN and X-band applications. Within the band, stable radiation characteristics are observed. The designed antenna has a gain ranging from 6.33dBi to 10.02dBi in impedance bandwidth range. The antenna has been simulated using HFSS'13.

I. INTRODUCTION

Microstrip antennas offer the advantages of thin profile, light weight, low cost, conformability with integrated circuitry (MMICs) [1]. They are extremely compatible for embedded antenna in handheld wireless devices such as cellular phones, pagers, etc. [2]. Over the years, we have seen growth in wireless communication applications. Multiband and wideband antennas are compatible for wireless communication systems. Recent advances in the designing method of multiband antenna are recognized using several methods. The development of the multiband antenna can be achieved by using thefractal concepts. Fractal antenna is an antenna that uses a fractal, self similar design to maximize the length that can receive or transmit electromagnetic radiation within a given total surface area or volume [3]. The fractal geometry is a space-filling curve, since with a larger iteration depth, it tries to fill the area [4-5]. Iteration depth refers to the number of iterations that should be carried out to get the higher order structure. The self-similarity properties of certain fractals result in a multiband behaviour.In this paper, we present a gain enhancement for a multi band fractal antenna. A triangular patch is modified as a star-shaped patch and fractal configuration is applied to it. The patch is fed using 50Ω Microstrip line. The antenna has been simulated using HFSS'13 and antenna performance is studied for 1 iteration of patch.

II. ANTENNA GEOMETRY

The basic geometry is the star patch antenna, which is shown in Fig. 1. The star-shaped patch microstrip antenna which is designed at operating frequency 7.1 GHz, having roger substrate with height of 3.2 mm, dielectric constant 2.2 is presented here. The size of patch is 50mm and the ground plane has dimensions 110x120mm. The antenna has two layers of substrate both using the same material.

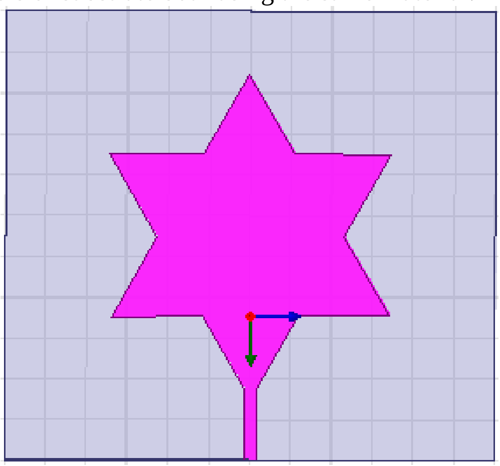

Figure 1: Basic antenna geometry

The two iterated fractal geometries are as shown in figure 2 and 3. Initially a star-shaped patch having a length of 50 mm is taken as shown in figure 1 above and microstrip feed has been applied to it. Feed point (35, 1.5, 0) is chosen in such a way that impedance matching take place. The 1st iteration of star-shaped patch has been obtained by adding stars of reduced length by 50% that are added at the corners of the patch. Hence self-similar shape as shown in figure 2 has been obtained.

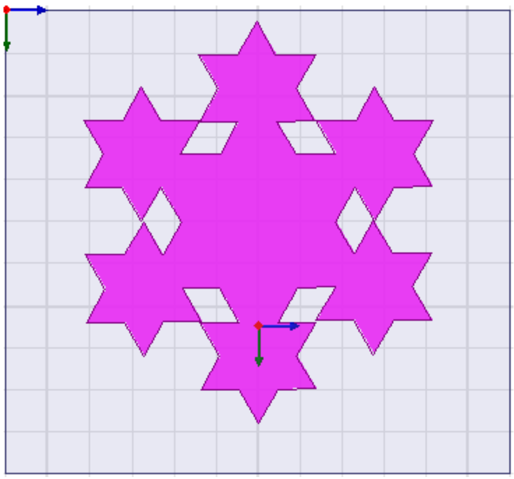

Figure 2: I[st] iteration of patch

III. PARAMETRIC STUDY AND RESULT DISCUSSION

To access the best performance of the proposed antenna, it was simulated using Ansoft HFSS (ver. 13). To analyze the antenna bandwidth coverage, the effect of adjusting the antenna parameters are investigated. The analysis of the antenna for different parameter values has been carried out by changing one of the parameters without modifying others. The final optimal values of the parameters of the antenna are depicted in Table I.

Table 1

Description	Optimal value(mm)
Length of substrate	120
Width of substrate	110
Height of substrate	3.2
Dielectric constant of substrate	2.2
Length of ground	120
Width of ground	110
Feed location	35x1.5x3.2
Length of feed	20
Width of feed	3

A. Zeroth iteration

Figure 1 shows the basic geometry of star-shaped patch antenna. The simulated results of gain, return loss and VWSR for zeroth iteration are shown in figures 4, 5 and 6. Tha gain of antenna is 6.33 dB with the return loss of -39.5372 dB at center frequency 7.1 GHz. The impedance bandwidth at this frequency is 390 MHz. VSWR corresponding to 7.1 GHz is 1.12. At this frequency, stable radiation pattern results.

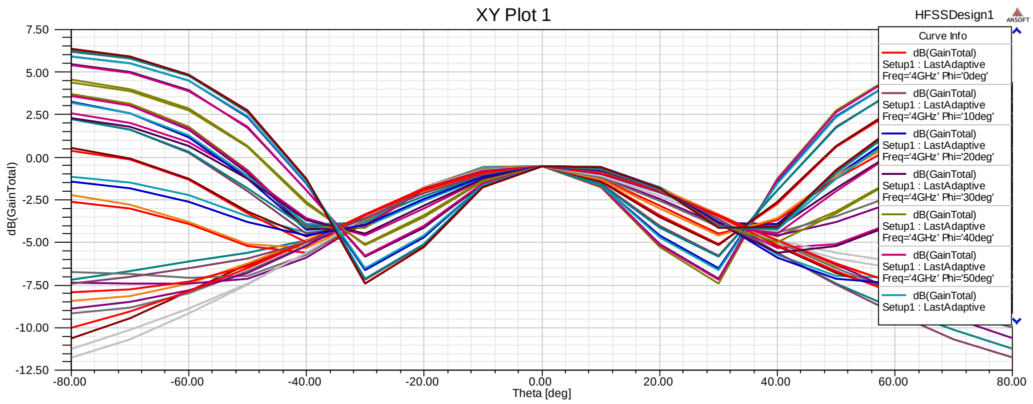

Figure 4: Gain for zeroth iteration

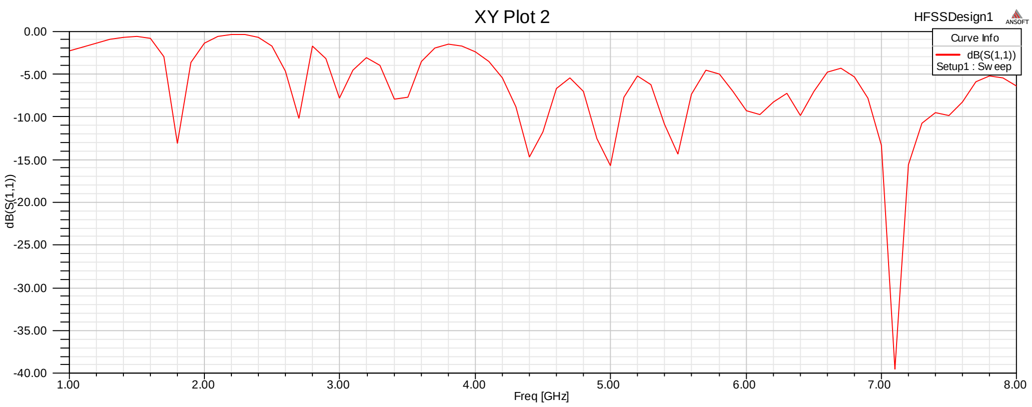

Figure 5: Return loss for zeroth iteration

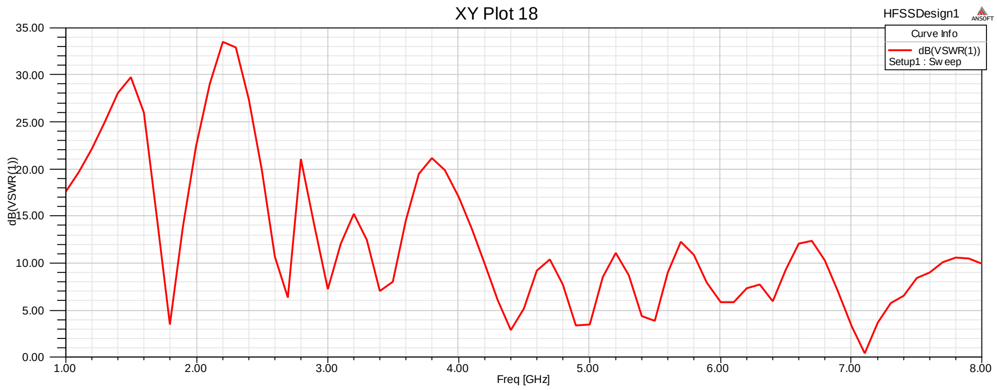

Figure 6: VSWR for zeroth iteration

B. *First iteration*

The first iteration of the star-shaped patch antenna is performed and its simulated results of gain, return loss and VSWR are shown in figure 7, 8 and 9. After first iteration, the proposed antenna resonates at frequencies namely 4.8 GHz and 6.3 GHz, with a return loss of -20.0711 dB and -23.4379dB respectively. The gain of antenna has improved to 10.02 dB. The corresponding VSWRs at frequency 4.8 GHz is 1.7 and at 6.3 GHz is 1.1. This antenna utilizes the application of both WLAN and X-band simulataneously.

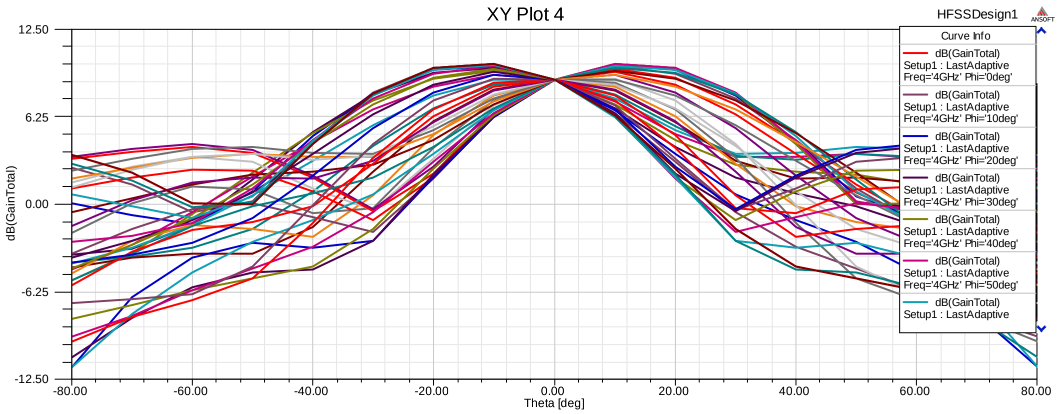

Figure 7: Gain for first iteration

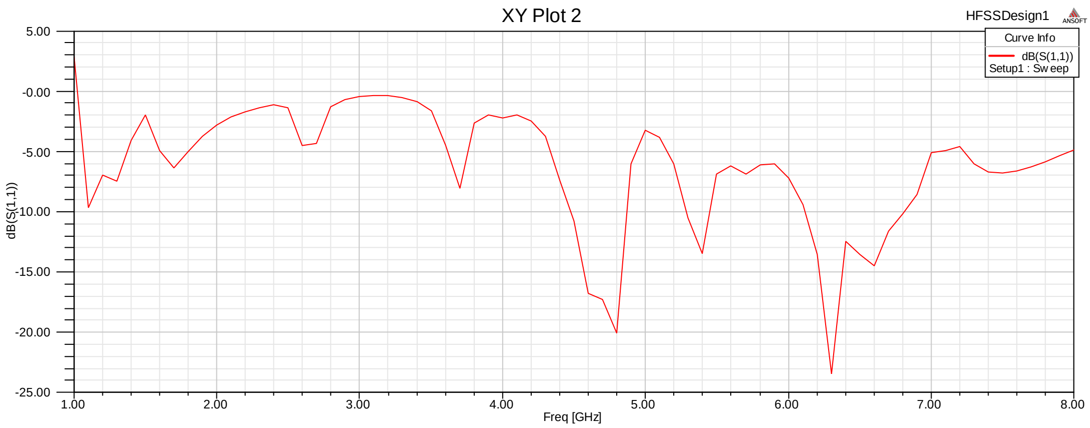

Figure 8: Return loss for first iteration

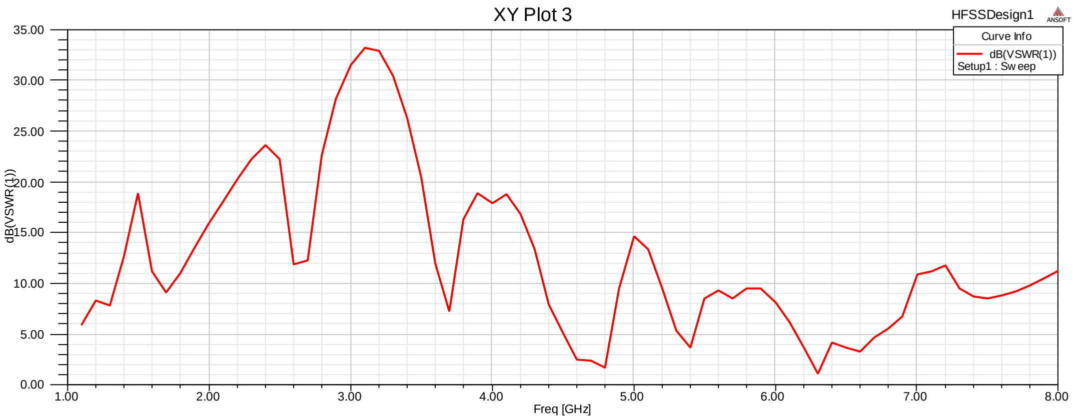

Figure 9: VSWR for first iteration

The Characteristics of the proposed antenna is summarized in the Table 2. It reveals that the antenna behaves with good multiband characteristics after 1st iteration.

Table 2

Iteration	Frequency(GHz)	Return loss(dB)	VSWR	Bandwidth(MHz)	Gain(dB)
0^{th}	7.1	-31.61	1.3	390	6.12
1^{st}	4.8 6.3	-20.07 -23.43	1.7 1.1	370 700	10.02

IV. CONCLUSION

The fractal geometry effect on star-shaped patch antenna has been analyzed. This antenna is a good example of the properties of fractal boundary patch antennas. As the fractal iteration increases, perimeter of patch increases and effective area of antenna decreases [6]. The gain of the final antenna is 10.02 dB with the antenna covering the WLAN as well as X-band applications. The radiator is now resonant at more frequencies. It gives multiband properties to fractal geometry antenna with increased gain. The designed antenna used for Navigation & Collision Avoidance, Acquisition & Tracking, Missile and Radar Navigation as well as for WiFi application. This behaviour is obtained with a simple feeding scheme which keeps the antenna geometry planar. So, fractal boundary patch antennas are an interesting replacement in the multiband antenna. This geometry offers numerous variations in dimension and design, hence gives wide scope for various commercial applications.

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