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Design of Modified Sierpinski Gasket Fractal Antenna for Multiband Applications

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ABSTRACT:

With advancement in communication technology over the past decade, there is an increasing demand for miniaturization, cost effective, multiband and wideband antennas. Fractal antenna designs can support in meeting these requirements. This paper presents a novel design of Modified Sierpinski Gasket Fractal Antenna (MSGFA). Sierpinski Gasket is simply a Sierpinski Triangle having triangular slots using mid-point geometry of triangle. Sierpinski Gasket Geometry is modified using circular shape. In this project, Sierpinski Gasket Fractal Antenna geometry is modified in its 1st and 2nd iteration using circular part and 3rd iteration process applied. Equilateral triangular shape slots are cut on the patch to improve the return loss and gain of antenna.. The proposed antenna finds its application in Satellite navigation, Digital audio broadcasting, Mobile service, Aircraft surveillance, Astronomy

Key Words: Fractal antenna, Sierpinski Gasket, Fractal Geometry.

I.INTRODUCTION

For wireless communication system, antenna is one of the most critical components. A good design of the antenna can thus improve overall system performance. The rapid expansion of wireless technology over the recent years has led to increasing demand for small sized, low- cost and multiband operational antennas for use in commercial communications systems. Today's wireless, satellite and advanced military communication systems require antennas of higher performance, higher gain, wider bandwidth, multiband support, low cost and conventionally smaller design dimensions. These requirements are fulfilled by the fractal antennas. In the study of antennas, fractal antenna theory is a relatively new area.

The word fractal means fragmented or irregular, both meanings define fractal theory. It is a kind of geometric shape that has a property of similarity. Fractal antennas are used in broad range of applications from communication system to medical system, primarily due to their simplicity, inexpensive, conformability, light weight, low profile, reproducibility and ease of integration with solid state device. The concept of fractal antenna came from fractals existing in nature.Fractal antennas showed properties of self-similarity, space filling, and complexity in their structure. These properties are utilized in fractal antenna designs to achieve wideband/multiband behavior. The fractal theory had been seen as a size compression technique for all types of antennas such as dipoles, loops, patches and so on leading to the development of fractal antenna.

The most interesting example of a recent multiband antenna development is the incorporation of fractal geometry into radiator of the Sierpinski gasket antenna. The multi band and ultra wide band properties of the antenna are due to their self-similarity of fractal geometry while the space filling properties of antenna leads to the miniaturization of the antenna.

II.FEEDING TECHNIQUES

Coax feed or probe feed method is used for nourishing Micro strip patch antennas. It is shown in Figure 2.1 and found that the outer conductor is connected to the ground plane, meanwhile the inner conductor of the coaxial connector is integrated to radiating patch. The most important advantage of this method is that there is no need to match with its input impedance and the patch can be located inside a place of wanting to feed. The feed to make the process easier and less radiation is bogus.

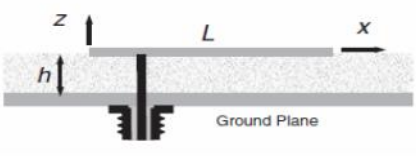

Fig:2.1.Probe Feed

The main disadvantage of modeling is the narrow bandwidth and a hole is drilled in to the substrate and the connector extends out of the ground plane. For the ground plane, the outer conductor of Coaxial cable is connected and the center will be extended up to patch antenna.

III.ANTENNA DESIGN APPROACH

For the design of proposed antenna resonant frequency (fr) is taken 4GHz. FR4 glass epoxy material with dielectric constant 4.4 and thickness 1.6 mm is used as substrate material. The side length (se) of proposed antenna is calculated by using following expression and side length is found equal to 0.0476 m.

$$f_r = \frac{2c}{3S_e\sqrt{\varepsilon_r}}$$

Where C= velocity of light and Se = side length of triangular patch.

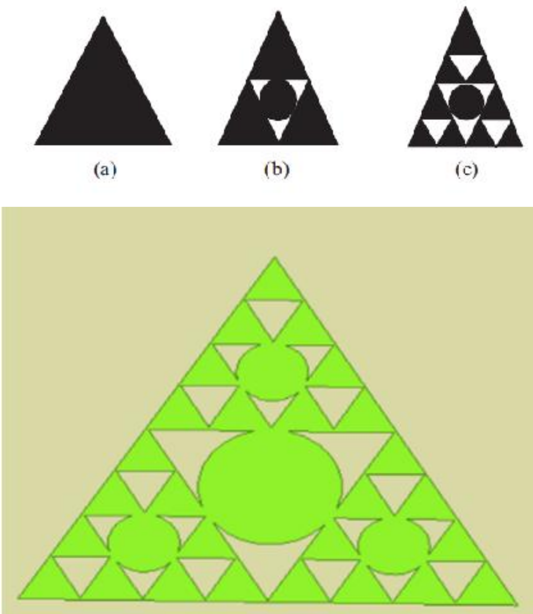

Fig 3.1: Stages of Iteration Process

Length and breadth of ground plane are 50.88 mm and 57.27 mm respectively. Length, breadth and height of substrate material are 50.88 mm, 57.27 mm and 1.6 mm respectively. When the fractal geometry is applied on the patch, discontinuity is generated and more current flows on the discontinuity part. To improve the results, triangles are introduced at the corner of triangular patch in 2^{nd} iteration and in 3^{rd} iteration.

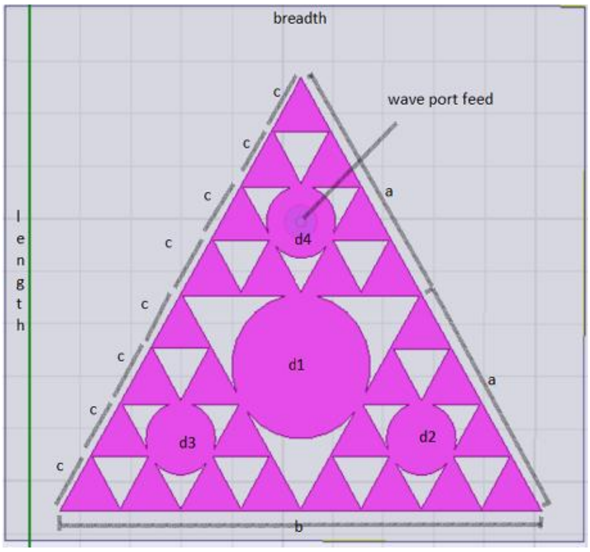

Fig.3.2: Geometry of Proposed Antenna

Antenna Parameters & Dimensions:

Antenna Parameter	**Designation**	**Dimensions (mm)**
Side Length of inner Triangular slots	A	23.835
Side Length of Triangular Patch	B	47.67
Side Length of inner Triangular slots	C	5.95
Diameter of Centre Circle	d1	13.76
Diameter of Inner Circle	d2	6.88
Diameter of Inner Circle	d3	6.88
Diameter of Inner Circle	d4	6.88

Table 3.1: Antenna Parameters &Dimensions

The wave port feed position is as shown in the figure 7.3 at the centre of circle with diameter indicated as d4. The inner cylinder radius of wave port feed is 0.5mm, outer cylinder radius is 1.6mm. The two cylinders are coaxial as shown in figure

7.3. The material used of outer cylinder is vacuum and that of inner cylinder is 'pec'.

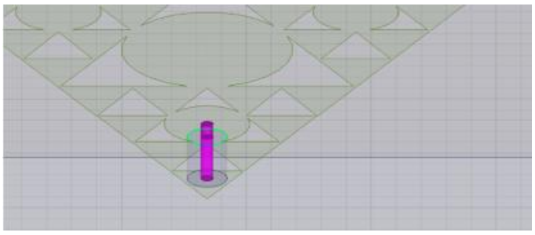

Fig.3.3: Probe Feed Bottom View

IV. SIMULATION RESULTS

Here wave port probe feeding is used to achieve accurate results for the proposed antenna. The feed point location is varied till a better results of return loss and VSWR were obtained at the desired resonant frequency.

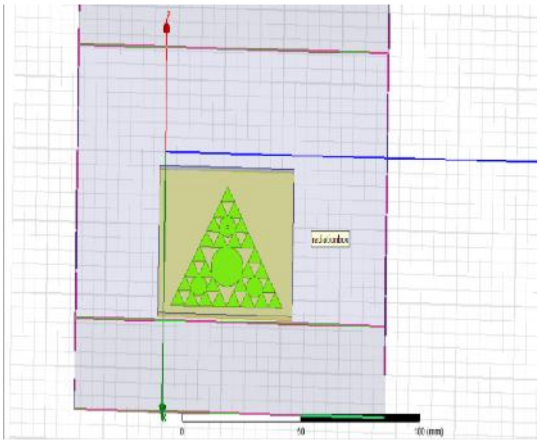

Fig.4.1: Simulated Antenna

The return loss and VSWR of the above simulated antenna are given below.

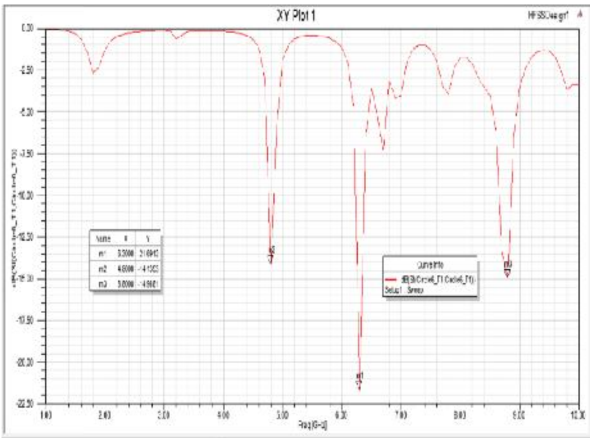

Fig.4.2: Return Loss

The response S(1,1) shows that antenna resonates at 6.3GHz, 4.8GHz, 8.8GHz with return losses of -21.6913 dB, -14.1393 dB, -14.9881 dB respectively. This shows that the antenna resonates at multiple frequencies in C band and X band.

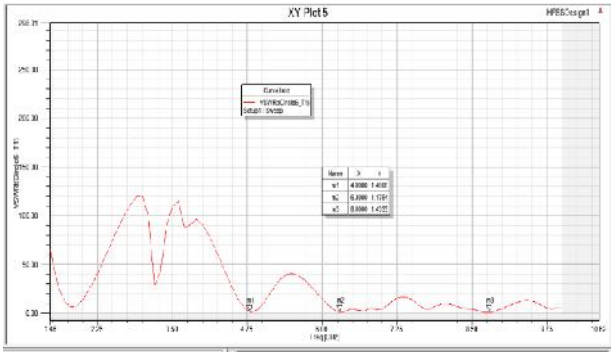

Fig.4.3: VSWR

The VSWR of the antenna at 4.8GHz, 6.3GHz, 8.8GHz frequencies are 1.4886, 1.1794, 1.4333 respectively. VSWR below the value 2 is desirable for any antenna.

V. FABRICATION RESULTS

The antenna is fabricated according to the simulated design and is shown in the fig.5.1. FR-4 epoxy material is used as substrate with thickness 1.6mm. coaxial wave-port feeding has been used and can be seen in the fig.5.2.

Fig.5.1: Front view of the fabricated antenna.

Fig.5.2: Back view of the fabricated antenna

The return loss and VSWR of the fabricated antenna are shown below.

Return Loss:

Fig.5.3: Return Loss of fabricated antenna

The above figure shows the variation of return loss of the fabricated antenna over the frequency range of 1 to 10 GHz. Here the fabricated antenna failed to satisfy the simulated result at 4.8 GHz. The return loss of the fabricated antenna were in the range of successful operation of an antenna at 6.29 GHz and 8.773 GHz with return loss values -19.49 dB and -12.20 dB respectively.

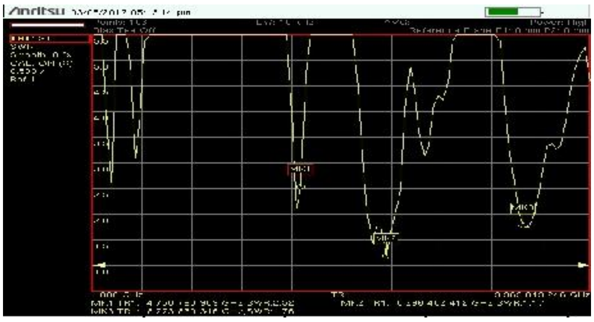

Fig.5.4: VSWR of fabricated antenna

The resonant frequencies obtained were 4.758 GHz, 6.296 GHz, 8.773 GHz with VSWR values of 2.52, 1.17, 1.76 respectively.

VI. Results Comparison

Resonant Frequencies	Simulation Results	Fabrication Results
4.8 GHz	1.488	2.52
6.3 GHz	1.1794	1.17
8.8 GHz	1.433	1.76

Table 6.1: Simulation and fabrication VSWR results comparison

Resonant Frequencies	Simulation Results	Fabrication Results
4.8 GHz	-14.1393	-7.32
6.3 GHz	-21.6913	-19.49
8.8 GHz	-14.9881	-12.20

Table 6.2: Simulation and fabrication Return loss results comparison

From the aboveit is observed that both the simulated and fabricated resultsmatched at two frequencies 6.3 GHz and 8.8 GHz. However, we found that fabricated result deviated from the simulated result at 4.8 GHz. This deviation may be due to the imperfect soldering of the coaxial probe feed to the micro strip patch antenna.

VII. CONCLUSION

A modified sierpinski gasket fractal antenna is designed upto third iteration for multiband applications and is simulated in HFSS Software. The simulated antenna resonates at 3 different frequencies i.e. at 4.8GHz, 6.3GHz, and 8.8GHz. having return loss of -21.6913 dB, -14.1393 dB, -14.9881 dB respectively and VSWR of 1.4886, 1.1794, 1.4333 respectively.

The antenna is fabricated and is tested for VSWR and RETURN LOSS. It is observed that the fabricated and simulated results are similar at 6.3 GHz, 8.8 GHz and are different at 4.8 GHz. This difference in results of fabrication and simulation at 4.8 GHz is due to the soldering of the coaxial probe feed to the antenna. The designed antenna finds its applications in short range medical sensors, radar technology and in WLAN, WIMAX.

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