DESIGN OF FRACTAL WIDEBAND ANTENNA BY USING WIND DRIVEN OPTIMIZATION

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Abstract— Antennas with these qualities are in high demand these days: they must be compact, low profile, multiband, or broad band. Since communication technology has advanced over the past 10 years, there has been a rise in the need for wideband, multiband, affordable, and compact antennas. These specifications can be met with the use of fractal antenna designs. Patch antennas in the current world use fractal shapes to obtain huge bandwidth and various other beneficial properties. In wireless communication, Ultra-Wideband Patch antennas are in high demand. This paper presents a low profile Sierpinski fractal antenna for wide band applications. The suggested antenna's design increases its impedance band width and radiation efficiency by enclosing Sierpinski Fractals within a 1 mm-wide circular ring. A micro-strip feed line supplies the suggested antenna, which has dimensions of 29 x 28 x 1.6 and a radiation efficiency of 92%. The antenna operates in the frequency range of 2.0 to 14.3 GHz. Over the working WB range, the radiation pattern remains constant. High Frequency Structure Simulator (HFSS) is used for the design and simulation of the Sierpinski fractal Wideband antenna. FR-4 Substrate is used for fabrication, and Vector Network Analyzer is used for testing. Ultimately, Wind-Driven Optimization (WDO) was to be used in order to create this proposed Sierpinski Fractal Wideband Antenna.

Index Terms—Fractal Antenna, Ultra Wide Band (UWB), Sierpenski Fractals, Wind Driven Optimization

I. Introduction

Using radio transmission, broadband technology uses very little power to send large volumes of digital data over short distances over a wide band width of 7.5 GHz, which varies from 3.1 GHz to 10.6 GHz. It meets the requirements for wireless applications, including high-speed data transfer and short-range radars. For a Wideband antenna to provide excellent impedance matching and generate high gain radiation in the desired direction, a broad operational band width is required. Many resonances are available with a self-similar fractal antenna. The characteristics of fractal WB antennas are low resonance, unidirectional radiation pattern, and wide band phenomena. Fractal Wideband antennas are utilized extensively for ultra wide band applications because of their appealing properties. The narrow band width operation is first provided by designing a circular ring with a width of 1 mm. Radiation is created when fractals are added to antennas, allowing for the existence of unique current distributions. Consequently, the presented fractal antenna will have an extremely wide band width. Utilizing Sierpinski Fractals within the circular ring yields an exceptionally broad band. Improved radiation properties are also obtained by including sierpinski fractals within the ring. The core region of the patch has fractals etched into it, which may not have a significant impact on the radiation properties. More fractals are incorporated to achieve good radiation properties and a wide band width.

An antenna that increases the perimeter, or the length of material that can receive or transmit electromagnetic radiation, within a given total surface area or volume is known as a fractal antenna. This type of antenna uses a fractal, self-similar design. These fractal antennas, also called multilevel and space-filled curves, are characterized primarily by their capacity to repeat a motif over two or more scale sizes, or "iterations." For this reason, fractal antennas are incredibly small, multiband or wideband, and helpful in microwave and cellular communications.

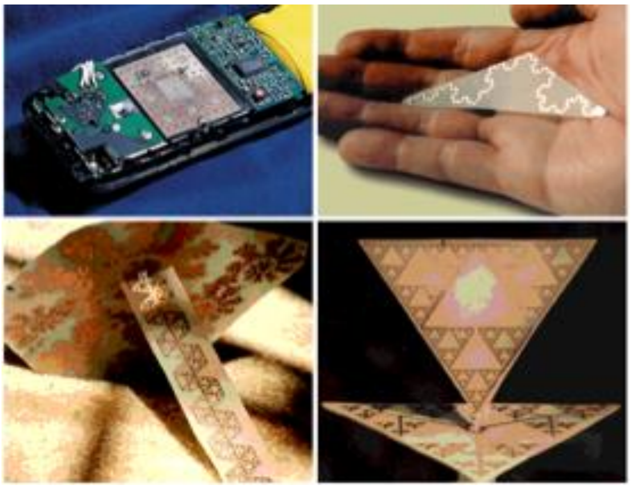


Figure 1: Fractal Antennas

One effective example of a fractal antenna used as a space filler curve is a shrunken fractal helix. In this case, a copper line is merely a small fraction of a wavelength. Because fractal antennas can operate at multiple separate frequencies simultaneously with good to exceptional performance, their response differs greatly from that of traditional antenna designs. Because standard antennas must be "cut" for a certain frequency, they are typically only effective at that frequency. The fractal antenna is therefore a great design for multiband and wideband applications. Furthermore, the antenna's fractal nature reduces its size without the need for any external parts, such as capacitors or inductors.

II. Wind Driven Optimization

Based on wind movement in the surrounding environment, Wind Driven Optimization (WDO) is a revolutionary bio-inspired global optimization technique. This method's initial concept, which entailed simulating wind flowing from high pressure zones to low pressure areas, was developed by Z. Bayraktar. It mimics the travel of a group of tiny air packets following Newton's second law of motion throughout a search space. The movement of air through the earth's atmosphere is comparable to this. It is comparable to the optimization process, in which moving from poorly performing to good performing combinations within a search area is the aim. When compared to other particle-based methods, WDO is robust and provides more process optimization degrees of freedom. The WDO method has also been used to the electromagnetic field. It has been used to design dual resonance, high gain microstrip fractal antennas.

III. Antenna Design

The proposed Sierpenski Fractal Wide-band antenna is created on a FR4 substrate with a relative permittivity of 4.4 and a thickness of 1.6 mm (h). Circular patch antenna with a resonance frequency of 6 GHz is intended for wideband applications due to its appealing radiation properties. Equation (1) is used to compute the circular path's radius.

$$f_r = \frac{1.8412\, c}{2\pi r_{eff}\sqrt{\varepsilon_{reff}}} \qquad (1)$$

The radius of the patch is **r**, the speed of light is **c**, and the resonance frequency is **fr**.

The circular patch's radius of 8.5 mm can be found using equation (1).The micro-strip feed line with an impedance of 50 ohms feeds the circular patch antenna. Eqn (2) is used to calculate the micro-strip feed line width.

$$\frac{w}{h} = \frac{8e^{A}}{e^{2A} - 2}$$

Where

$$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$$

The width (w) of the micro-strip feed line, which is 3 mm, may be found using equation (2). As a result, by etching a circle patch with a radius of 7.5 mm from a circular patch with an 8.5 mm radius, a circular ring with a width of 1 mm is created. In order to enhance radiation properties and band width, The introduction of three order Sierpinski Fractals inside the circular ring is demonstrated in Figure 2. The first order Sierpinski Fractal measures 10.6 mm, the second order measures 7.6 mm, and the third order measures 4.5 mm. The substrate is fed through a micro-strip feed line that measures 11.1 x 3 mm2, and is situated beneath a partial ground plane with length and width (Lg x Wg) of 10 x 28 mm2.

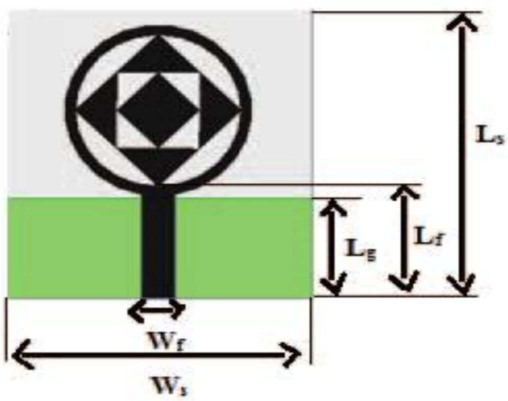
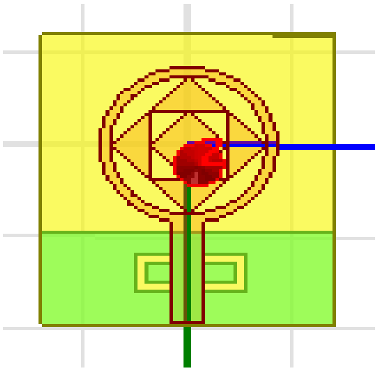


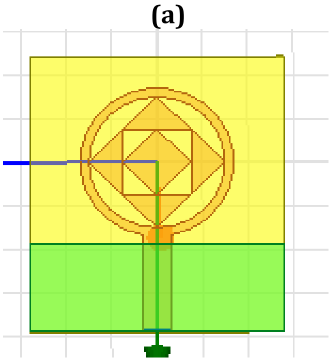
Figure 2: The geometry of Sierpenski Fractal Antenna design

a) Simulation Using HFSS:

HFSS (High-Frequency Simulation Software) version 13.0 is used to model and analyze the aforementioned antenna design, as illustrated in Fig. 3 below.



(a)



(b)

Figure 3: HFSS Design of Sierpenski Fractal Antenna
(a) Front View **(b)** Back view

IV. Simulation Results of Sierpenski Fractal Antenna using HFSS

a) S11

Figure 4 displays the S11 for the Sierpinski Fractal antenna that corresponds to Figure 3. This chart shows that the 10.93GHz band width, which is between 2.4GHz and 13.34GHz, has a return loss of -28 at 3.3GHz and falls below -10dB.

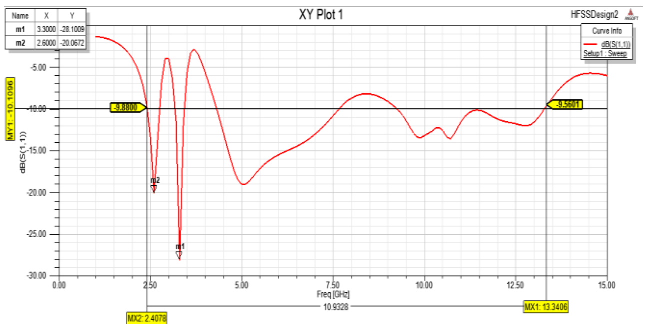


Figure 4: S11 of Sierpenski Wideband Antenna

b) VSWR

A perfect match requires a VSWR of at least unity. picture 5 displays the VSWR of the Sierpenski Fractal Antenna with an integrated HFSS, which corresponds to picture 3. An antenna's VSWR ranges from 1 to infinity. In real-world applications, it ought to be in the range of 0 and 2. This graph shows that the appropriate bandwidth is less than -10dB and that the VSWR at 3.3 GHz is 1.08.

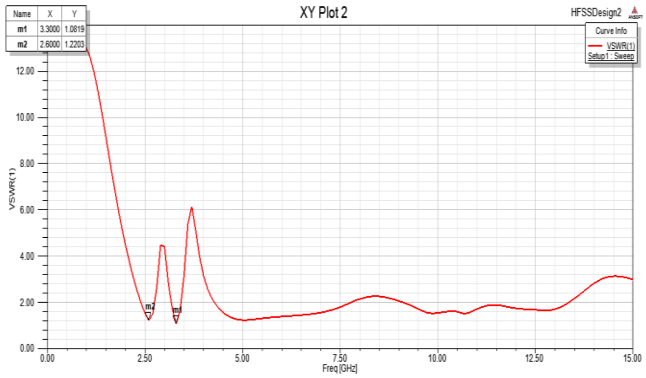


Figure 5: VSWR of Sierpenski Fractal Antenna

c) Gain

The power transmitted per unit solid angle is all that constitutes gain. The 3-D gain of the Sierpenski Fractal Antenna integrated into the HFSS is shown in Figure 6 in comparison to Figure 3. Any antenna has a gain of greater than 3dB for all uses. This antenna has been observed to have a 5.14 dB gain.

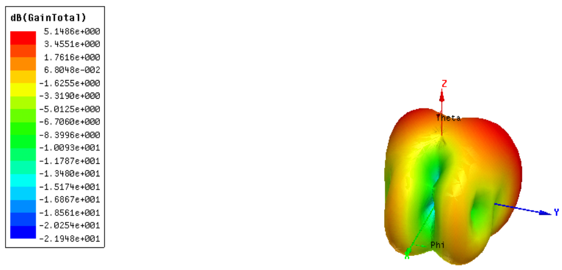


Figure 6: Gain for Sierpenski Fractal Antenna

d) Radiation Pattern

A radiation pattern is the fluctuation in power of an antenna with respect to direction away from the antenna. This power change as a function of arrival angle is observed in the antenna's far field. The radiation pattern of the Sierpenski Fractal Antenna is shown in Figure 7, which correlates to Figure 3 and plots gain against theta and phi.

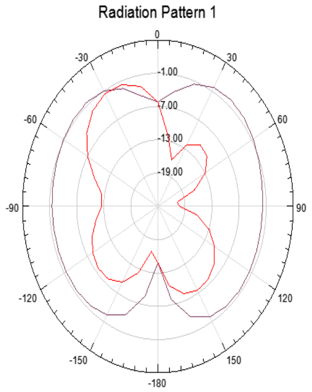
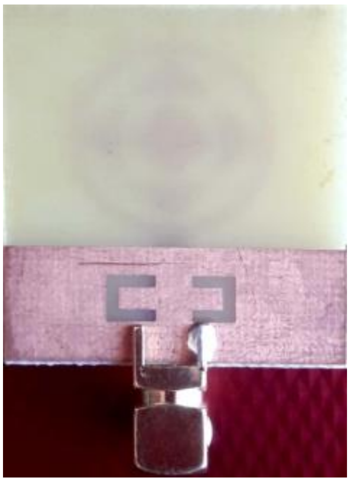


Figure 7: Radiation pattern of Sierpenski Fractal Antenna

V. Fabrication Model of Proposed Antenna

(a) Front view



(b) Back view

Figure 8: Fabricated Sierpenski Fractal Antenna

Figure 9: Experimental Setup of Sierpenski Fractal Antenna

V Fabricated Results of DGS Antenna

The graphic depiction below compares the theoretically achieved results from the constructed model, such as return loss and VSWR of the Sierpenski Fractal Antenna, with the simulated results of the planned antenna in HFSS (High-frequency Simulation Software).

I) Practical Results

a) S11

Figure 10: S11 of Fabricated Fractal Antenna

b)VSWR

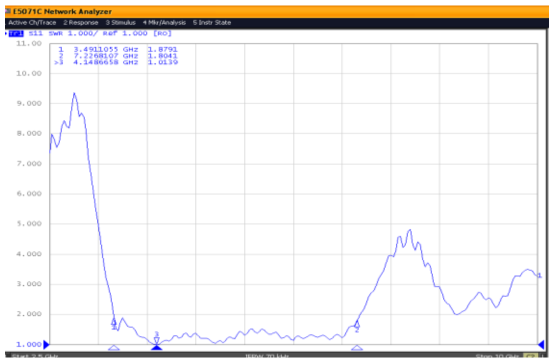


Figure 11: VSWR of Fabricated Fractal Antenna

II) Comparison Results

c) S11

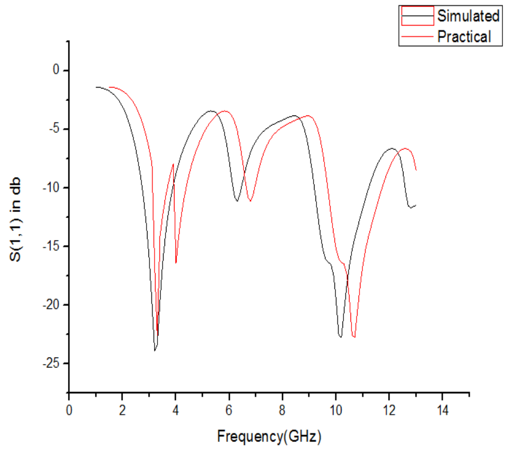


Figure 12: Comparison of S11

d) VSWR

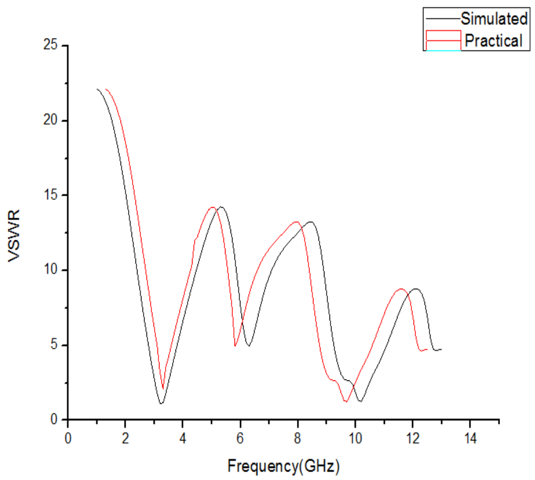


Figure 13: Comparison of VSWR

Using a network analyzer, the Sierpenski Fractal Antenna's practical results are achieved, and the parameters of return loss and VSWR are checked.

V RESULT ANALYSIS

Ref	S11 (dB)	VSWR	Gain (dB)
1	-13	<2	2.5
2	-15.77	<2	2.8
3	-13.9	<2	3.34
4	-10	-<2	3.3
5	-27.77	<2	4.24
*****	**-28**	**1.08**	**5.14**

* Proposed Work

The reference papers compare return loss, VSWR, and antenna gain in relation to fractal antennas for wideband applications and above result analysis. When comparing the suggested work's antenna gain to Fractal Antennas, which served as the model, it is higher.

VI CONCLUSION

Due to the device's restricted area, nearly all contemporary wireless communication devices require the integration of multiple wireless communication protocols into a single unit. Multi-band antennas are therefore desperately needed for WLAN, Wi-Pro, Bluetooth, PCS/LTE, WiMaX, UWB, and US Public Safety Band applications. This is because these antennas can be used in nearly all commercial communication devices, including medical devices, tablets, smart phones, portable laptops, digital cameras, and medical equipment. The proposed 10.6 GHz Sierpinski Fractal Wideband Antenna has a radiation efficiency of 92% and a bandwidth that spans from 2.0 GHz to 14.3 GHz. The volume of the suggested antenna is rather small, measuring only 29 x 28 x 1.6 mm3, in contrast to other fractal antennas that are currently in use. You can add more sierpinski fractals to improve radiation efficiency and band width

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