DECAGON FRACTAL ANTENNA FOR WIRELESS APPLICATIONS

S. Malathi, A. Sudheera, K. Lakshmi Durga, G.G.V.M. Parvathi, B. Prashanti

Department of Electronics and Communication Engineering

Vignan's Institute of Engineering for women

ABSTRACT: The demand for wireless wideband applications is rapidly increasing due to the need to support more users and to provide more information with a higher data rate. UWB is a radio technology that can use a very low energy level for transmitting information across wider bandwidth(>500Mhz). The antenna presents a newly inscribed triangle decagon fractal antenna for wireless applications. The antenna resonates from 3.8GHZ to 8.1GHZ frequency. The designed antenna parameters are validated by using simulation as an Ansoft High-Frequency structure simulator (HFSS). It has advantages of compact size, low manufacturing cost, easy fabrication, a wide bandwidth of frequency, and low profile.

Keywords: Fractals, Fr-4 epoxy, UWB applications, HFSS software, return loss, S11, gain.

INTRODUCTION:

Over the past decade, there has been a tremendous development in the wireless communication network. With the introduction of many new wireless standards, more frequency bands are used to cover a wide range of functions. But it's inefficient to possess separate antennas for every application. Instead of having separate antennas for different functions, it is desirable to have a single antenna that can accommodate multiple functions in a single antenna.

In modern wireless communication, it's required to possess small size, high gain, high directivity, wide/multi-band, and low-cost antennas to supply all-time communication which should be cost-effective, noise-free, and robust. An ultra-wideband antenna has its advantages such as low transmission power, high data rate, high performance, and resistance to jamming which can be satisfied using fractal antenna geometry. Compact microstrip patch antennas are increasing in popularity for use in communication systems due to their miniaturized size and cost-effectiveness. They offer good compatibility for embedded antennas in hand-held devices. Ultra-wideband technology has attracted much attention recently because the communication systems promise high bandwidth, high data rate, reduced fading from multipath propagation, and low power requirements. Fractals were first introduced by Mandelbrot in 1977 as a way of ordering structures whose sizes were not whole numbers. Fractals have unique geometrical features in nature. TO overcome the disadvantages of the microstrip patch antenna and for ultra-wideband applications, fractal geometry is useful.

The main advantages of the fractal are compact size, self-similarity, and high gain. It can be used in the form of branching of tree leaves, plants, and more examples in nature. There is many fractal shapes are designed like Minkowski, Koch curves, I-shaped fractals or E-shaped fractal, etc. The use of fractals geometrics has significantly impacted many areas of science and engineering. Many DGS (Defected Ground System) structures have been proposed for improving parameters of antenna by incorporating DGS in the form of slots, I-shaped, U-shaped, and elliptic shapes. Tuning of the DGS structure is the most important part of antenna design for ultra-wideband applications. The proposed fractal antenna formed of defected ground plane structure is simulated and fabricated for achieving ultra-wideband characteristics with wide bandwidth and high gain for various wireless applications. The simulated reflection characteristics, radiation pattern, and gain of the proposed antenna are presented.

ANTENNA DESIGN:

The basic form of a patch antenna consists of a conducting patch printed on a ground plane which radiates only at the specified frequency band. The geometry proposed antenna is designed on FR4 epoxy substrate having a thickness of 1.6mm and having a relative permittivity of 4.4, with a resonant frequency of 4GHz. Here decagonal shape is used on the top side with DGS on the bottom of the antenna to achieve ultra-wideband characteristics with wide bandwidth. The addition of small fractals near the edges of the central decagon leads to an increase in the total electrical length of the inscribed decagon shape. The overall dimension of a substrate of length (Ls) of 22.907mm, width (Ws) of 18.644mm with a height(hs) of 1. 6mm.For bandwidth enhancement stepped ground plane that is defected ground plane is used. The proposed antenna design can be shown in the figure1

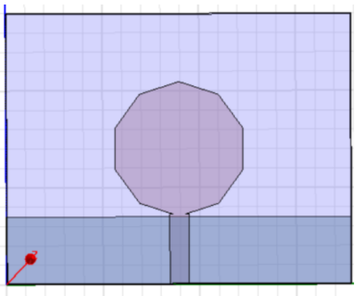


Figure1: Proposed antenna geometry

Different parameters of the antenna are calculated using the below formulas:

$$W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad L = L_{eff} - 2\Delta L$$

Where

W-width of the patch

c-velocity of light(3x10^11mm)

L-length of the patch

An er-dielectric constant of the substrate

Effective length is given by:

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{\mathrm{reff}}}}$$

Normalized extension in length is given by:

$$\Delta L = 0.412\mathrm{h}\frac{(\varepsilon_{\mathrm{reff}} + 0.3)\left(\frac{W}{\mathrm{h}} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{\mathrm{h}} + 0.8\right)}$$

Effective dielectric constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{\mathrm{h}}{w}\right]^{\frac{-1}{2}}$$

Substrate length and width:

$$L_g = L + 6h$$
$$W_g = W + 6h$$

Lg- length of the substrate

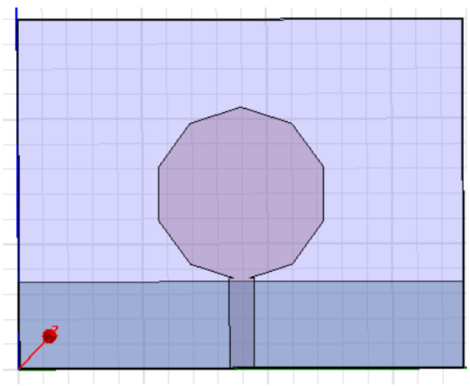
Wg- width of the substrate

Table1:

Optimized parameters of the proposed antenna:

Parameter	Length (mm)	Width (mm)	Height (mm)
Substrate	22.907	18.644	1.6
Ground	22.907	18.644	1.6
Feed	1.24	7.15	0
Radiation box	80	80	40

The designed antenna consists of four iterations decagon fractal radiating patch with the defected ground system. In the first iteration, a triangle of a side length of 1.80mm on each side of the decagon is inscribed in the patch, then all the triangles of the decagon are united and subtracted from the patch which creates the first iteration. This is how all the iterations are followed with different positions and decagon length which increases the gain decreases the return loss and improves the bandwidth.



(a) Iteration

Results and Discussions:

By using the Ansoft High-Frequency structure simulator of version11, every simulation is performed and observed. The fractal antenna gives ultra-wideband operations. All the simulated results are extracted from HFSS software into origin software, where every data plot is plotted into a single plot simultaneously.

Return loss:

Return loss indicates the proportion of radio waves arriving at the antenna input that is rejected as a ratio against those that are accepted. The simulated return loss S11 of the antenna with the stepped ground plane with decagon fractal indicates that this proposed antenna is broadband and has a UWB ranging from 3.79GHz to 8GHz Db impedance bandwidth which is acceptable for practical considerations for better impedance matching. The proposed antenna resonates at

VSWR:

The voltage standing wave ratio is a measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load. A VSWR value under 2 is considered suitable for most antenna applications.

GAIN:

Gain is the ability of the antenna to radiate more or less in any direction compared to a theoretical antenna. If an antenna could be made as a perfect sphere, it would radiate equally in all directions. The proposed antenna has a gain of 9db.

Radiation pattern:

It refers to the directional dependence of the strength of the radio waves from the antenna or other source. The best performance antenna is that when it radiates in the main lobe and not in the side lobes.

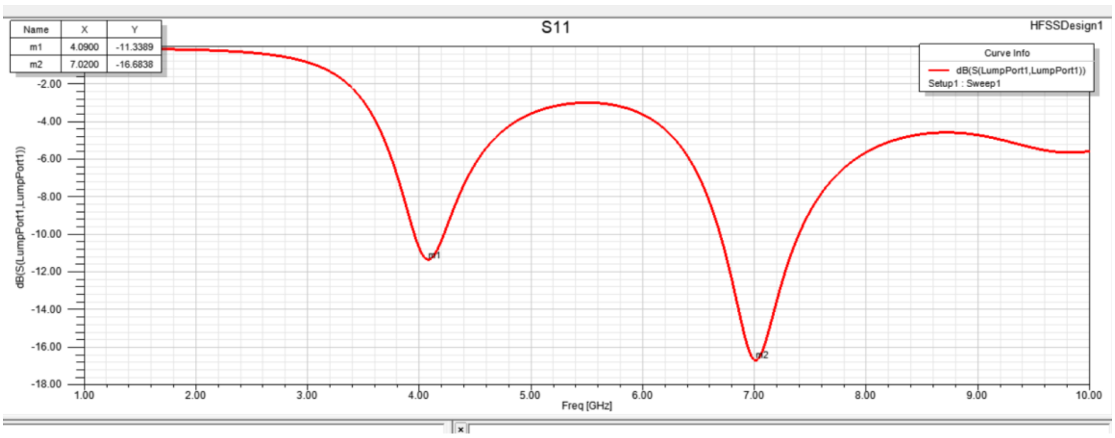


Figure: S11 of the antenna

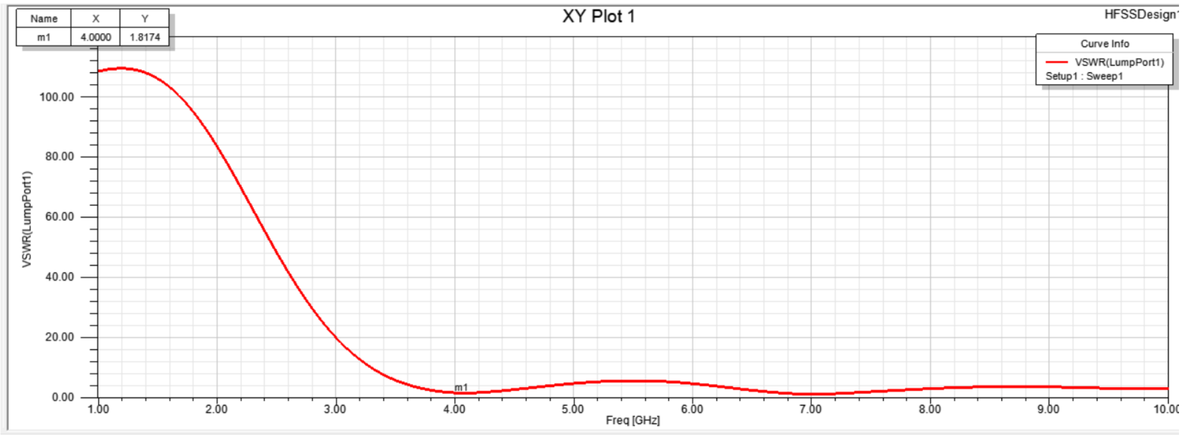


Figure: VSWR plot of antenna

Radiation pattern:

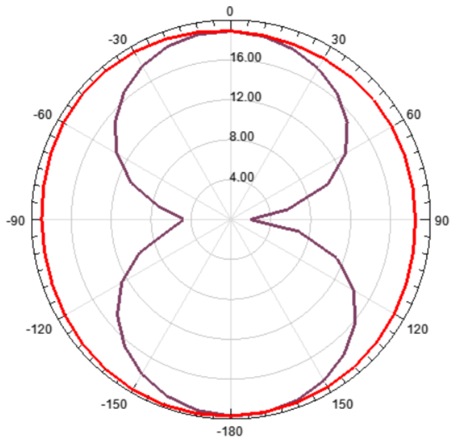


Figure: Radiation pattern of antenna

Gain:

Figure: Gain of Basic antenna

Figure: Simulated and experimental VSWR plot of intermediate stages of the antenna

parameters	Iteration
Resonate frequency (GHz)	4.1GHz
Return loss(dB)	-8.44
VSWR	4.2
Gain (dB)	2.32

Table2: performance parameters of decagon antenna

Resonated frequency (GHz)	4.1GHz
Return loss (dB	-12.8

Table3: Resonate frequency of the antenna

Conclusion:

A decagon fractal antenna is presented and its characteristics such as return loss, VSWR, gain, and radiation pattern are simulated. .In this work a self-similarity of the fractal structure and defected ground charcteristics are used to deisgn antenna with a decagon inscribed triangle frcatal structure is designed.By increasing the number of iterations of the fractal structure,gain of the antenna increases.The designed antenna has a return loss of 12.87dB and has a gain of 4.8dB.

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