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IMPLEMENTATION OF FRACTAL BASED SQUARE PATCH ANTENNA USING HFSS

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Abstract : This project deals with a multi - band fractal based square micro- strip patch antenna is designed. FR4 substrate having thickness of 1.58 mm is used as substrate material for the design of proposed antenna and micro-strip feed line provides the excitation to the antenna. The antenna operating frequency range is from 1 to 10 GHz. The proposed antenna is designed and simulated by using the Ansoft HFSS V15 (high frequency structure simulator) software. A fractal is a geometric shape containing detailed structure at arbitrarily small scales, usually having a fractal dimension strictly exceeding the topological dimension. Microwave antenna and passive circuit designers have to meet the ever encountered challenges to produce components with miniaturized size and multi band operation. These geometries have two unique features: the space filling and the self-similarity. For more than two decades, these features have opened the novel and essential techniques for the design of the microwave antennas and passive circuits. Furthermore, fractal-based structures offer an additional epoch of optimizing design mechanisms. This is an analytical study through which we design a chip and study the different parameters such as S-parameters, VSWR and other graphical plots. HFSS (High-frequency structure simulator) is used for the simulation of various patch antennas and for observing the parameters of the antenna. HFSS is the software used for the simulation and modelling of the antenna.

IndexTerms **- Fratcal, Voltage Standing Wave Ratio(VSWR).**

I.INTRODUCTION

In recent years, modern telecommunication systems require antennas with wider bandwidth and smaller dimension rather than conventional ones. Most importantly, the antennas should be well impedance-matched over the operating frequency range. Narrowband operation of antennas has become a necessity for many applications too. In recent wireless communication systems, dual band as well as single band behaviour with good gain is the need for many applications, such as GPS, GSM services operates at two different frequency bands. WLAN, Wi-Fi systems require single band operation. In this wireless world, integration of many applications is also required. So it requires same antenna to work for all of the integrated applications.

Design of conventional micro-strip patch with bandwidths as low as a few per cents, wide-band applications are very limited. Other disadvantages include low gain, low power handling capability, high Q value and poor polarization purity. For over two decades, researchers have proposed several methods to achieve miniaturization, improvement in bandwidth in case of wide-band behaviour and realizing narrowband characteristics using planar micro-strip antenna. Due to unique advantages such as small volume, low manufacturing cost and easy integration into planar circuits, planar micro-strip antennas are ideal candidates.

Another method to have compact and small volume antenna is by using fractals in the planar micro-strip antenna geometry. Fractalization of planar antenna will help in make antenna more efficient. It will expand the bandwidth and reduce the dimensions of the antenna. Fractals will increase the total electrical length of the antenna keeping the total area same. It helps in miniaturization of antenna. Size can be shrunk from two to four times with surprising good performance. Multiband performance can be achieved at non-harmonic frequencies.

Wireless communication is one of the most blooming areas in the communication field today. It means the transfer of information between two or more points that are not connected by an electrical conductor. Wireless operations allow facilities, such as distant communications, that are tough or impractical to implement with the use of wires and it is costly too. In numerous homes and offices, the mobile phones free us from the short leash of handheld cords. Cell phones give us even more freedom such that we can communicate with each other at any time and in any place. Wireless local area network (WLAN) technology provides us access to the internet without suffering from managing yards of unsightly and expensive cable. Information is transferred over both short and long distances. These wireless phones use radio waves to enable their users to make phone calls from many locations worldwide.

Since 1960s, it has been a topic of study but the past decade has seen a downpour of research activities in the area. This is due to a union of several factors. To start with, an explosive increase in demand for tether-less connectivity is one of the major factors which are driven so far mainly by cellular telephony. Second, the dramatic progress in VLSI technology has enabled small-area and low-power implementation of sophisticated signal processing algorithms and coding techniques. Also the need of compact and handy communication systems is also one of prime reason behind this.

The antennas need to small dimension, high gain, wide bandwidth, embedded installation, etc. In particular, the impedance bandwidths, polarization or axial ratio, radiation patterns and gain are becoming the most important factors that affect the application of antennas in contemporary and future wireless communication systems.

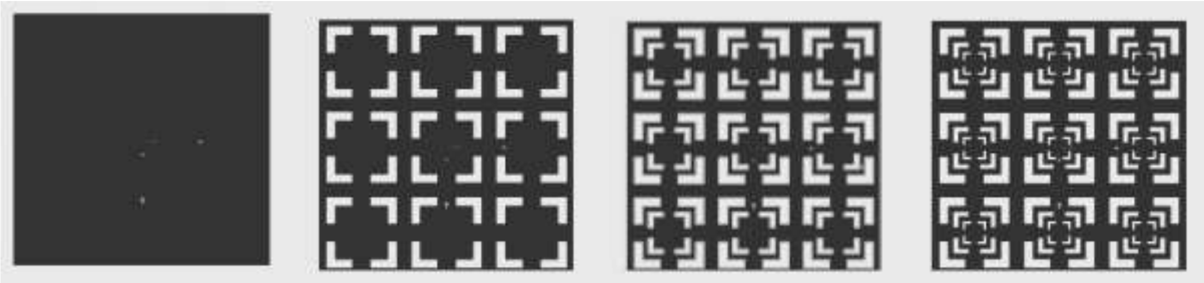
Abbreviations and Acronyms

VSWR-Voltage Standing Wave Ratio; GPS-Global Positioning System; GSM-Global System For Mobile Communication; WLAN-Wireless Local Area Network.

II.RESEARCH METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. This includes the implementation of a fractal based micro strip square patch antenna, which can operate at frequencies ranging from 1 to 10Ghz.

2.1 Antenna design and Configuration



a) Base Geometry b)1st Iteration c) 2nd Iteration d) 3rd Iteration

Fig-1: Structure of all Iterations

Figure-1 shows the 0th (base geometry), 1st, 2nd and 3rd iterations of the proposed antenna. The design of proposed fractal antenna starts with square conductor on a ground dielectric substrate and is termed as base geometry. Steps for design of different iterations of proposed antenna are described below.

Step-1: The geometry of Square Patch Antenna (SPA) is designed with 30 mm side and is known as 0th iteration as shown in Figure. The parameters, dielectric constant (E_r = 4.4), resonant frequency (f_r = 5GHz) and the substrate thickness (h = 1.52mm) are taken for the design of base geometry of proposed antenna.

Step-2: The 1st iteration of the Square patch contains the 36 L-slots. The technique of drawing the 4 L-slots is given in Figure. Now draw the 36 L-slots of the same dimension on the square patch, subtract the L-slots from the square patch designed in the step1. By using automation.

Step-3: The 2nd iteration of the SPA is designed by drawing the 36 L-slots further in the fractal geometry designed in step2. The technique of drawing the 4 L-slots is shown in Figure-1. Now draw the 36 L-slots in the fractal geometry of the SPA designed in step2 and subtract the L-slots from the geometry designed in step 2. By using automation.

Step-4: The 3rd iteration of the SPA is designed by drawing the 36 L-slots further in the fractal geometry designed in step3. The technique of drawing the 4 L-slots is shown in Figure-1. Now draw the 36 L-slots in the fractal geometry of the SPA designed in step3 and subtract the L-slots from the geometry designed in step3. By using automation.

2.2 Design Demonstration

The design and fabrication processes start with numerical simulation using two different approaches: CST MW and HFSS.We use HFSS in our implementation.
The below link demonstrates the iterations on the patch and substrate;

https://drive.google.com/file/d/1kjS4sd3mvnLOgKfModcKEIKAGgv_gkrm/view?usp=drivesdk

III. RESULTS AND DISCUSSION

The Return Loss(RL) Vs frequency plots for 0th ,1st, 2nd and 3rd Iterations of proposed antenna are shown in the Figure-2,3,4 and Figure -6 respectively. 0th, 1st, 2nd iteration of proposed antenna resonate at multiple frequencies and corresponding return losses .

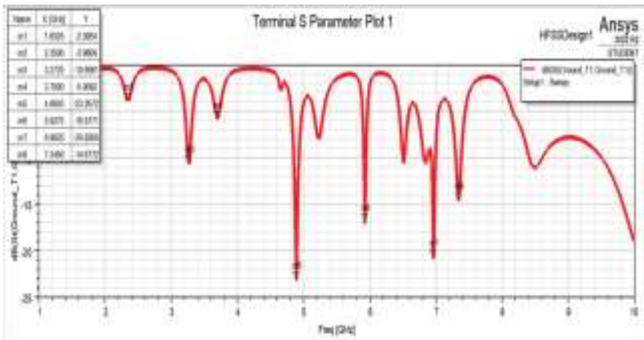


Fig-2:Return Loss Vs Frequency for 0th Iteration

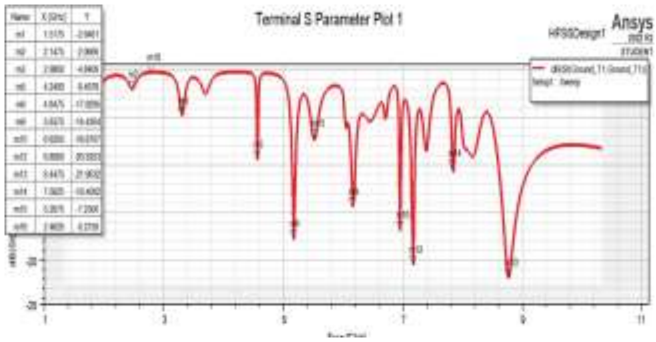
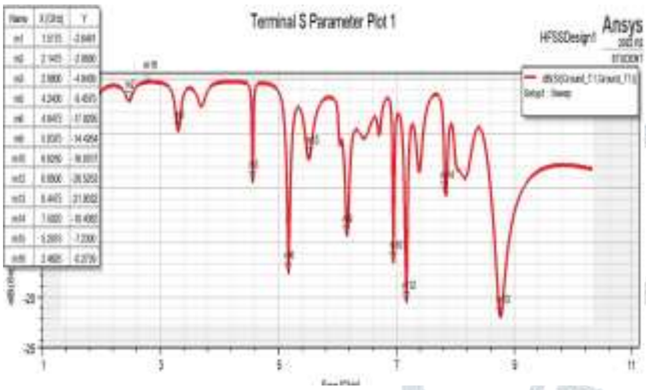


Fig-2:Return Loss Vs Frequency for 0th Iteration



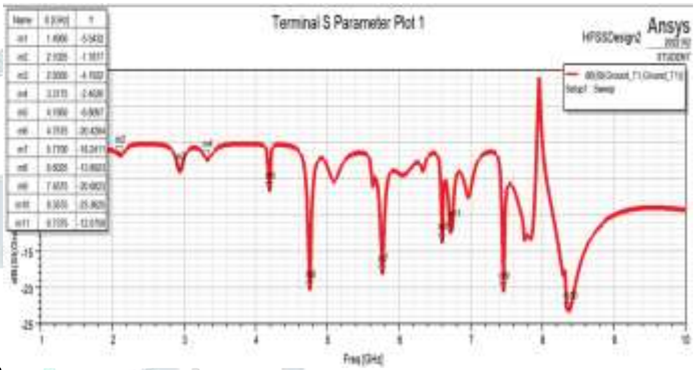


Fig-2:Return Loss Vs Frequency for 0th Iteration

Fig-2:Return Loss Vs Frequency for 0th Iteration

Table-1: Comparison Table of different antenna parameters for all Iterations

Parameters/Iterations	**0^{th} Iteration**	**1^{st} Iteration**	**2^{nd} Iteration**	**3^{rd} Iteration**
Minimum Return losses	-23.2072dB	-21.9032dB	-21.9032dB	-24.2541dB
Optimum Frequency	4.8925GHz	8.4475GHz	8.4475GHz	7.4575GHz
VSWR	1.4379	1.19	1.1952	1.1306
Gain				
Radiation in major lobe	Very High	High	Low	Very Low

The above shows Table-1 shows the comparison of antenna parameters like minimum return losses, optimum frequency, Voltage Standing Wave Ration (VSWR), Gain, Radiation in major lobe for 0th, 1st, 2nd and 3rd Iteration.

III. ACKNOWLEDGMENT

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