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Design of Sierpinski Fractal Monopole Antenna

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ABSTRACT: With the encroachment of wireless communication in the last few decades has made the technology more affordable. This escalating attractiveness of wireless communication devices capable of high-speed transfer rate has prompted the need of developing efficient broadband antennas. The incredible increase in wireless communication in the last few decades has led to the need of antennas with increased bandwidth, gain and low profile. One such technique to achieve wideband/multiband antennas is by applying fractal shape into antenna geometry. Fractals, through their selfsimilar property, are natural systems where this complexity provides the sought after antenna properties. Fractal Antennas radically alter the traditional relationships between bandwidth, gain and size, permitting antennas that are more powerful, versatile and compact. The designed antennas can be used for various applications such as military and meteorological satellite communication (8 to 12.5 GHz), Wi-Fi (5.1 -5.825 GHz), PTP communication in US military (6 GHz), radar and navigation services.

KEYWORDS*:* Microstrip Antenna, Fractal, Sierpinski Carpet Fractal Antenna (SCFA), Antenna Arrays, HCR principle.

I. INTRODUCTION

Over the last decade the wireless communication systems kept fascinating the engineers, hence receiving a lot of attentions because of their inherent advantages such as convenience, low cost and ease of fabrication. Wireless Local Area Networks (WLAN) are being universally recognised as a compact, flexible, economic and high speed data connectivity solution. This leads to an outgrowth of micro strip patch antennas.

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System	Overall Frequency	Bandwidth
Advanced Mobile Phone Service (AMPS)	Tx: 824-849 MHz Rx: 869-894 MHz	70 MHz (8.1%)
Global System for Mobile Communication (GSM)	Tx: 880-915 MHz Rx: 925-960 MHz	80 MHz (8.7%)
Personal Communication Service (PCS)	Tx: 1710-1785 MHz Rx: 1805-1880 MHz	170 MHz (9.5%)
Global System for Mobile Communication (GSM)	Tx: 1850-1910 MHz Rx: 1930-1990 MHz	140 MHz (7.3%)
Wideband Code Division Multiple Access (WCDMA)	Tx: 1920-1980 MHz Rx: 2110-2170 MHz	250 MHz (12.2%)
Universal Mobile Telecommunication Systems (UMTS)	Tx: 1920-1980 MHz Rx: 2110-2170 MHz	250 MHz (10.2%)
Ultra Wideband (UWB)	Tx: 3100-10600 MHz	7500 MHz (109%)

Table 1.1 Wireless Communication Spectrum

Table 1.1 demonstrations the operating frequency ranges of some of the most frequently used wireless communication systems. Microstrip antenna offers numerous advantages as well as some disadvantages compared to the conventional one. The disadvantage includes lower gain, excitation of surface waves, narrow bandwidth, high quality factor (Q), Ineffective use of available physical area and low power handling due to its smaller size. Researchers proposed several approaches to shrunken the antenna size, enhancement in bandwidth by decreasing the quality factor. Today's small handheld devices challenge antenna designers for ultrathin, convenient and high performance devices that have the capability to meet the multi standards. This feature emerged antenna examination in different ways; one of the methods is the use of fractal shaped geometry. Fractal is a concept extension to the microstrip antenna. Fractals will expand the bandwidth and shrunken the parameter dimensions of the antenna.

II. SYSTEM IMPLEMENTATION

A. Fractal Geometries

Fractals are used to define structures whose dimensions are not whole number. Fractal geometry is that branch of study which deals with properties and behaviour of fractals. These geometries have been used to characterise objects in nature that are difficult to define with the help of Euclidean geometries including length of coastlines, branches of trees etc. Fractals represent a class of geometry with properties including:

• Self-similarity

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- Fractional dimension
- Formation by iteration
- Plane filling nature

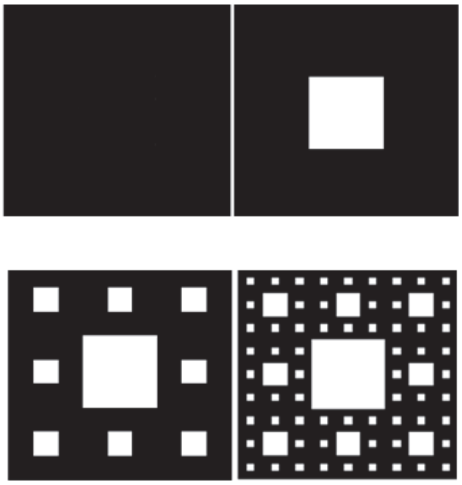

Fig.1 Sierpinski Carpet Antennas upto 3rd iterations

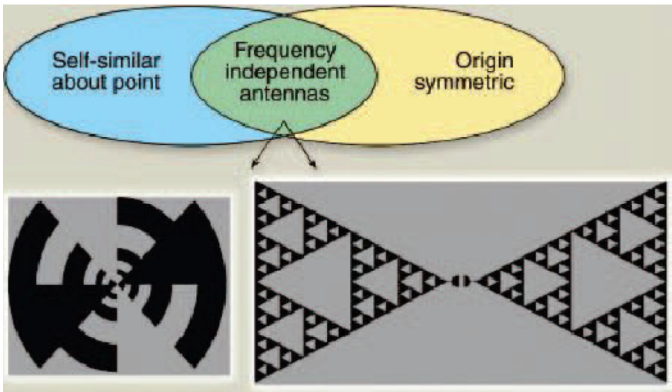

Fig. 2 Hohlfield-Cohen-and-Rumsey(HCR) Conditions

III. LITERATURE SURVEY

Design and Implementation of Sierpinski Carpet Fractal Antenna for Wireless Communication - Rahul Batra, P.L.Zade & Dipika Sagne - 2012 This article presents the design and simulation of a multi-band microstrip patch antenna, using Sierpinski carpet fractal concept. The proposed antenna is designed on a FR-4 substrate with a relative permittivity of 4.4 and excited using a microstrip feed line at the edge of the patch. Sierpinski carpet fractal with iteration-3 is applied to the radiating patch. After the application of fractal, this patch antenna resonates at 14.80 GHz, 17.92 GHz, 23.12 GHz, and 27.92 GHz with impedance bandwidth of 5800 MHz, 3040 MHz, 2960 MHz, and 3840 MHz respectively. With these four bands, this antenna finds application in commercial 5G wireless communications. To illustrate the effectiveness of the fractal concept, four patch antennas are designed independently at those four resonating frequencies and compared with the single fractal antenna in terms of their size and other performance parameters. All the antennas proposed here, are designed using HFSS15 and results are analyzed in terms of return loss, VSWR, gain, and bandwidth.

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Antenna Theory - Analysis and Design - C.A.Balanis - 2012 This system introduces the fundamental principles of antenna theory and explains how to apply them to the analysis, design, and measurements of antennas. Due to the variety of methods of analysis and design, and the different antenna structures available, the applications covered in this book are made to some of the most basic and practical antenna configurations. Among these antenna configurations are linear dipoles; loops; arrays; broadband antennas; aperture antennas; horns; microstrip antennas; and reflector antennas. The text contains sufficient mathematical detail to enable undergraduate and beginning graduate students in electrical engineering and physics to follow the flow of analysis and design. Readers should have a basic knowledge of undergraduate electromagnetic theory.

Design of Microstrip fed Sierpinski carpet fractal antenna(SCFA) upto third iteration upto third iteration - Rogert R.T. - 2011 The incredible increase in wireless communication in the last few decades has led to the need of antennas with increased bandwidth, gain and low profile. One such technique to achieve wideband/multiband antennas is by applying fractal shape into antenna geometry. This paper presents the design of Sierpinski carpet fractal antenna (SCFA) up to third iteration. To increase the gain further some modifications in the fractal geometry have been proposed. This paper further proposes the modified geometry SCFA and a corporate feed SCFA array. These antennas are designed using HFSS on FR4 substrate with dielectric constant of 4.4 and fed with 50 ohms microstrip line. Out of these a simple 3rd iteration SCFA antenna has been fabricated and tested using a VNA and the fabrication results are in good comparison to the simulation ones, thereby suggesting the credibility of all the designed antennas.

IV. SYSTEM ANALYSIS

A. Existing System

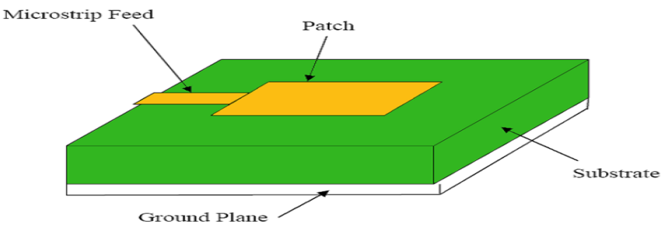

Fig. 3 Existing System Illustrations

Drawbacks

- It has a narrow bandwidth.
- Low gain .
- Leads to undesirable cross polarization.
- Low efficiency.

B. Proposed System

It provides good impedance matching. Need to measure VSWR at each stage. Fractals are better around 4 GHZ. Scales are infinite. It has broadband and multiband frequency response. Self similar geometrical shapes. IFS-Iterative function scheme is used. Four parameters are used to describe IFS.

- Scaling
- Rotational
- Reflection
- Translational

There are two stages of fractal generation

- Initiator/ Zeroth stage
- Generator
- Initiator-it ranging from triangle to other polygon.
- Generator-this is nothing but scaling results.

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V. RESULTS AND DISCUSSION

In this section, we provided the simulated results of entire project with its practical proofs.

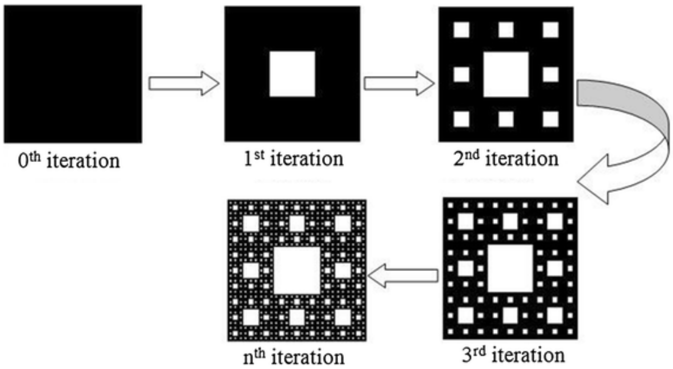

Fig.4 Various Iterations

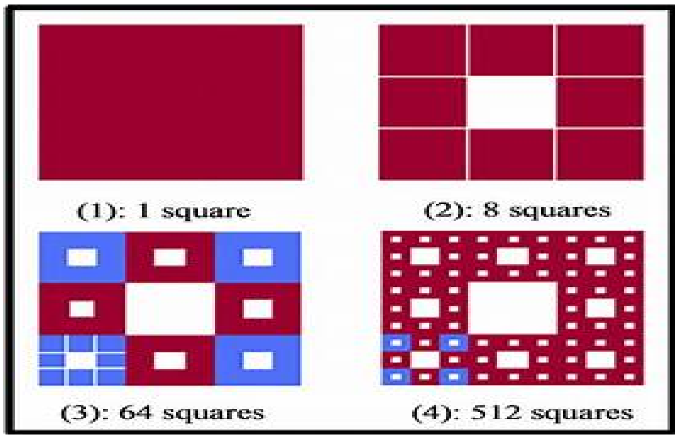

Fig.5 Structural Overview

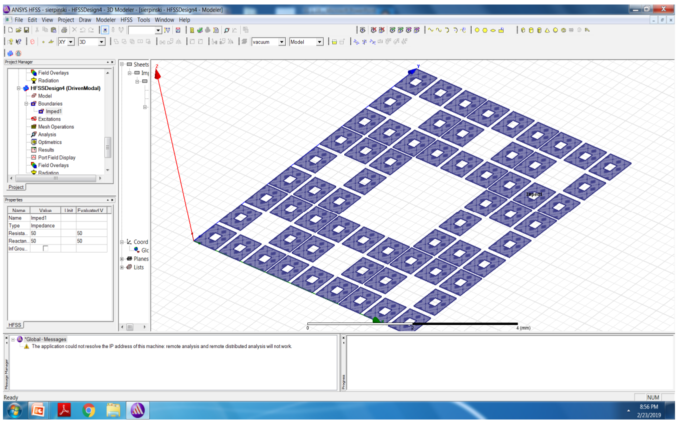

Fig.6 Recursive Structure

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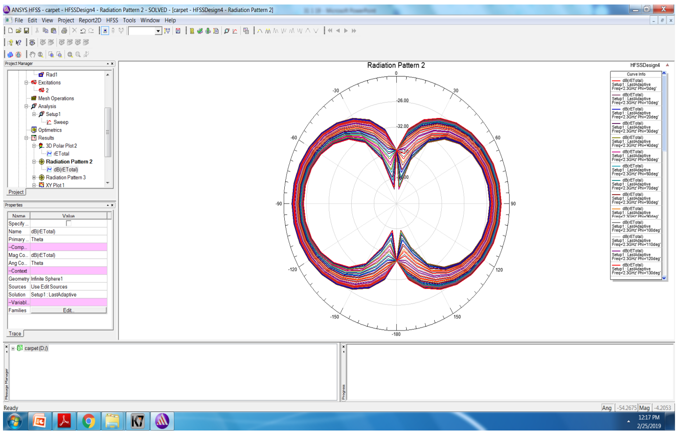

Fig.7 Radiation Pattern

VI. CONCLUSION

Good multiband characteristics and to achieve low profile and ease of integration. The aim is to reduce the antenna size ,as well as return loss. Increases gain, efficiency, radiation patterns. In this work fractal concept is applied to microstrip patch antenna and sierpinski carpet fractal antenna upto third iteration. From the results obtained, it was evident that by applying fractal concept to microstrip antenna the antenna can resonate at multiple frequencies so the design antenna can be operated at multiple frequencies. As the iteration increases the gain of the antenna increases, thereby size of the patch is reduced upto 33%.

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