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Design and Simulation of Fractal Antenna for the WiMAX Application

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ABSTRACT: Modern telecommunication system requires antennas with broader bandwidth and smaller dimensions than conventional antennas. Researchers are looking for systems that can perform over several frequency bands. So researchers have involved in designing and development of antenna for various applications, one of which is by using geometries of fractal. The types of operations now being demanded includes multiband operation, different bands are required for different radiation pattern. For example, the mobile handsets are required to produce with terrestrial cellular capability coupled with satellite based communications along with Personal Communication Service (PCS), Global System for Mobile (GSM), Multichannel Multipoint Distribution Service (MMDS) Band, WiMAX Technology, Non Direct Line of Sight (NLOS), Wireless Internet Service Provider (WISP), Homeland Security, Public Safety Services and many other operations are expected from a single antenna which can be disadvantageous (like increased cost, number of antennas etc.) if multiple antennas are used. In this paper an antenna is designed for the application ofWiMAXexperimentally shows the results using HFSS simulation software.

KEYWORDS: Cognitive Radio, Spectrum Sensing, Efficient Communication, System Security.

I.INTRODUCTION

Antennas are essential components of any wireless communication system. They are used in systems such as radio and television broadcasting, radio communication receivers and etc.The success for wireless communication system is increasing day by day as the demand for frequency spectrums and due to consumer demand for high speed and high data rate services. The size of an antenna is main constraint for wireless application because its size gets reduced. Therefore researchers looking for an antenna design which is well suited for wireless applications. So they move towards monopole antenna which characteristic and radiation properties fulfil the researchers demand. The monopole antennas which are designed for multiband and wideband operations are recent topic of research so the researchers get an idea of an antenna which is basically a monopole antenna but configured using fractal geometries so it is also type of fractal antenna.

There are many types of fractal geometries which is described in section two. Among these Sierpinski gasket is popular due to its log periodic behaviour and space filling curve properties so our propose antenna designed is based on the principle of it. In this paper we describe a circular ring monopole antenna which was reported in [16], [17] and [20]. This antenna improved the results as prior mentioned in [20] in terms of gain and return loss.

In literature survey from 1996 to 2014 towards monopole antenna using Sierpinski gasket geometry which is one of the type of fractal geometry authors found that this type of antenna shows multiband behaviour experimentally as well as numerically. Resonating frequency depends on no. of iterations for ex. for five iterations antenna will resonant at five operating bands. Iteration means additional of similar structure using self- similarity property of fractal antenna. During survey years different researchers investigated towards the monopole antenna which is based on a Sierpinski gasket geometry and simulate their proposed antenna model using different simulator.

Researchers concluded that monopole antenna using this geometry shows multiband behaviour and gives better results in terms of return loss and radiation pattern. they also concluded that antenna exhibits discrete structure so current will show on the outer surface of the structure for ex- in case of multiple ring current will well defined by the outer radius of the ring and in case of triangular Sierpinski gasket it will defined at the outer edges of the triangular structure.

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In this paper author proposed an antenna which based on keeping all the above points during literature survey so authors proposed multiple ring monopole antenna and which is based on the principle of Sierpinski gasket fractal antenna.

II.FRACTAL GEOMETRY

There are many fractal geometries that have been found to be useful in developing new and innovative design for antennas. The different types of fractal geometries are as follows.

A. Koch Snowflake
The geometric construction of the standard Koch Curve is fairly simple. It starts with a straight line as an initiators. This is divided into three equal parts, and the portion at the middle is replaced with two others of the same length. This is the first iterated version of the geometry and is called the generator. The process is used in the generation of higher iteration [12].It was originally described by Koch and is constructed with only one of the three sides of the original triangle. In other words, three Koch curves make a Koch snowflake.

B. Sierpinski Carpet
Sierpinski Carpet fractal geometry is realized by successive iterations applied on a simple square, which can be termed as the zeroth order iteration. A square of dimension equal to one third of the main patch is subtracted from the centre of the patch to retrieve first order iteration. The next step is to etch squares which are nine times and twenty seven times smaller than the main patch as demonstrated respectively. The second and third order iterations are carried out eight times and sixty four times respectively on the main patch. This fractal can be termed as third order fractal as it is designed by carrying out three iterations. The pattern can be defined in such a way that each consequent etched square is one-third in dimension as compared to the previous one sharing the same centre point. It can be realized as the set of points in the unit square whose coordinates written in base three do not both have a digit '1' in the same position. The process of recursively removing squares is an example of a finite subdivision rule.

C. Sierpinski Gasket
The Sierpinski gasket design is named after the polish mathematical Sierpinski. He described the properties of this fractal in 1961[11]. The geometry is obtained by subtracting the central part of the main triangle with an inverted triangle. After the subtraction, these equal triangles remain on the same structure, each part is half of the size of the original geometry. Iteration procedure is done by the same process of subtraction, and procedure will be follow on the remaining triangles infinite no. of times the ideal fractal Sierpinski gasket is obtained. It has been found that by perturbing the geometry the multi-band nature of antennas by these geometries can be controlled. Variation of the flare angle of these geometries have been explored to change the band characteristics of antenna. Antennas using this geometries have their performance closely linked to conventional bow-tie antennas. It has been found that the multiband nature of the antenna can be transformed into wideband characteristics by using a very high dielectric constant substrate and suitable absorbing materials [4].

D. Minkowski Curve
The Minkowski curve is one of the type of fractal geometries and is also mainly used in wireless application because it gives better size reduction and was dated back to 1907 where Hermann Minkowski, a German mathematician investigated quadratic forms and continued fractions.

The construction of the Minkowski curve is based on a recursive procedure, at each recursion an eight side generators is applied to each segment of the curve.Minkowski curve fractal antenna reveals to have excellent performance at the resonant frequencies and has radiation patterns very similar to the straight wire dipole at the same frequencies. It is also demonstrated in that Minkowski geometry helps reducing the size of an antenna by 24% in its first iteration and 44% on the second and that the self-similarity of the fractal shape shows multiband behaviour. This was also concluded by Paulo H. Da. F. Silva who analysed the frequencies from 2.620– 2.650GHz and 5.725 – 5.875 GHz and results were very promising. A third iteration of the Minkowski curve was used in and a reduction of 45.6% was achieved.

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III.CIRCULAR MONOPOLE FRACTAL ANTENA

A. Antenna Design

The antenna is set of self-contained scaled circular rings similar to the concept of the Sierpinski gasket as shown in Fig. 1(a). The rings are labelled 1 to 4. Each one is half the diameter of the previous ring; thus the disk labelled as element 5 is half the size of ring4. Therefore antenna is fifth iteration circular rings monopole antenna, where the first iteration is circular disk itself. Note that in this case, iteration refers to adding addition ring within the larger disk.The designed antenna has an overall height of 86mm and discrete height of 43 mm, 21.5 mm, 10.75 mm and 5.5 mm. Some corresponds to first and second operating bands and if we further optimize we get three more operating bands. The centre frequency of these bands is 1.9 GHz (f_1) and 2.6 GHz (f_2). The antenna is printed using conventional printing technique on a 0.5 mm thick FR4 substrate (ϵ_r= 4.4). It is then mounted perpendicular over a metallic ground plane of 15 × 15 cm. A 50Ω SMA connector is used to feed the antenna at the centre of the ground plane. The feed probe directly excites the bottom of element 5.

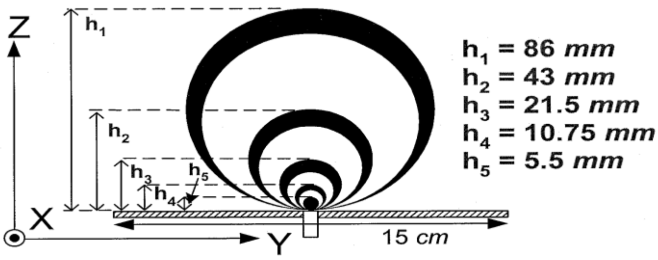

Fig. 1. Construction of circular rings monopole antenna

IV. RESULT AND DISCUSSION

After the designing of the Fractal antenna the simulation is carried out.Firstly, Validation check is performed to observe warnings and errors if any in the design.Next, the setup is assigned to the antenna, sweep in the range of 0.5 to 6 GHz. With step size of 0.1 GHz. After that the antenna is simulated. The required antenna parameters (VSWR, Radiation pattern, Return loss) graphs are observed in HFSS.

In HFSS Software, once we have defined the co-ordinates of the design we can develop a 3D view of the Fractal and simulate to obtain various characteristics (Return loss, Radiation pattern, Gain etc.). If the characteristics don't match with the reported, the dimension of the rings, thickness of the circles and the thickness of the substrate are varied in small steps and re-simulated until required characteristics are obtained. Thus, optimization of parameters like width of rings, radius of the inner rings and their centre positions play a key role in antenna performance.To achieve the desired performance of the antenna, various design parameters of the fractal antenna were optimised. If the thickness of the circles is increased, then the return loss increases. As the thickness of the substrate is increased, return loss is greater than -10dB.

The simulation results obtain after optimizing the fractal using HFSS software presented here. From the Figure 4. It can be observed that the antenna is resonating at 1.9GHz and 2.6GHz as shown in fig. 4.Achieved bandwidth centred at 1.9GHz is 1.86 GHz toI1.92GHz and at 2.6GHz is 2.58GHZ to 2.65GHZ.Theradiation pattern at 1.9GHz in both the principal plane is shown in the Fig. 5.

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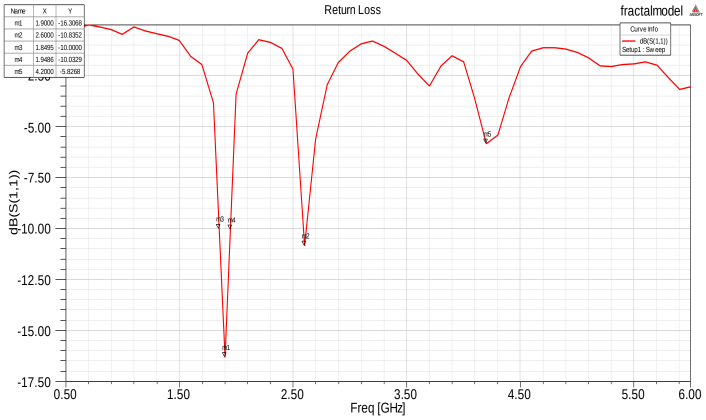

Fig. 4 Return loss plot

In the fig 4,it shows the graph of Return loss (S_{11} parameter) Vsfrequency.Return is the loss of power in the signal returned/reflected by a discontinuity in a transmission line.

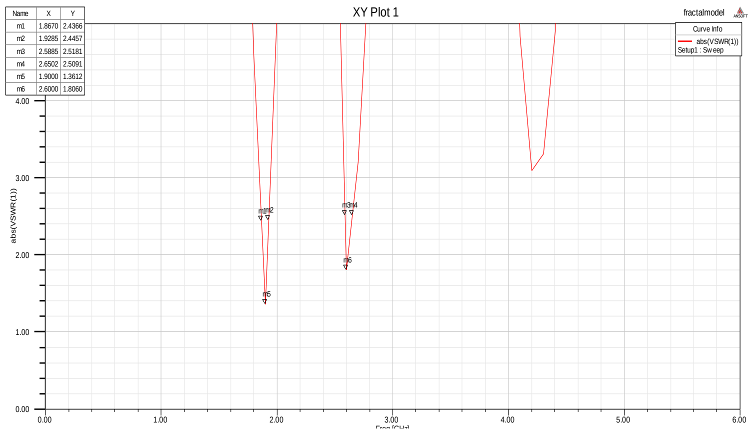

Fig.5. VSWR graph

In the fig 5,it shows the graph of Voltage Standing Wave Ratio (VSWR) Vs frequency. Low values for VSWR (<2.5) indicated good antenna match.

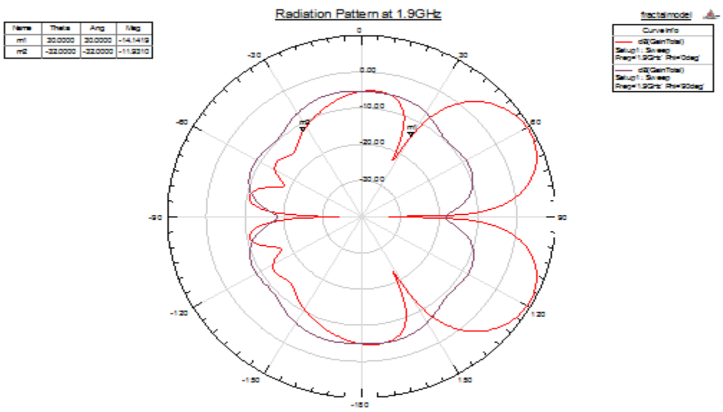

Fig. 5. Radiation pattern at 1.9GHz

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In fig. 6,it shows radiation pattern of proposed antenna at resonating frequency of 1.9 GHz. Achieved radiation pattern should be similar to omnidirectional and we can observe from the radiation pattern plot that pattern gets improvedand gain at this frequency is 9dBi

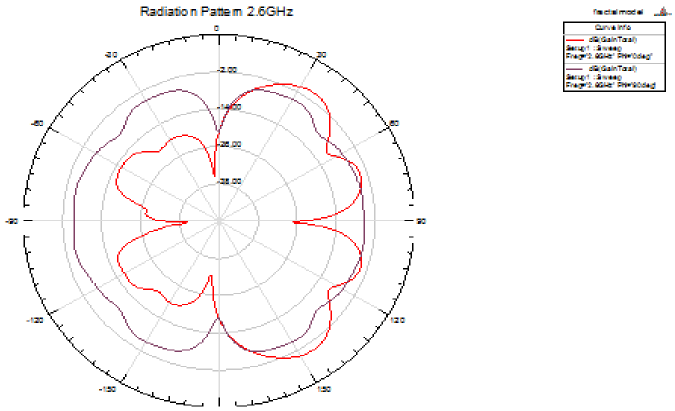

Fig. 6. Radiation pattern at 2.6GHz.

In fig. 6,it shows radiation pattern of proposed antenna at resonating frequency of 2.6 GHz. Achieved radiation pattern should be similar to omnidirectional and we can observe from the radiation pattern plot that pattern gets improved.

V.CONCLUSION

A method for designing a wideband monopole antenna based on the principles of fractal Sierpinski Gasket and circular disk monopole has been simulated. The discrete structural properties of these multiple ring monopoles enables a well-defined current path which gives better control of the radiation pattern than that of the circular disk monopole at high operating bands. The fractal antenna can be used at 1.9GHz and 2.6GHz, their applications being PCS, GSM and WiMAX. Hence it is a multiband antenna. At 4.2GHz the obtained frequency value is -5.8dB and it can be improved by further optimization.Its structural similarity to the fractal Sierpinski Gasket and Parany monopole antennas also results in log-periodic resonant behaviour. Larger bandwidths and improved patterns are achieved by further optimization of its design parameters.This single antenna unit has the potential of operating in several of the currently existing systems such as GSM, DECT, PHS, UMTS, WLAN, Bluetooth and clearly it has been shown that one could achieve fractal antenna properties even with non fractal antenna geometry. More bands can be covered depending on the applications for which we need the antenna. Also, by the change in the parameters of the antenna, better results can be obtained.

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