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Design of Sierpinski Gasket Antenna for WLAN Applications using Transmission Line Feed

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ABSTRACT: The paper presents the designs of a Sierpinski gasket fractal antenna. The fractal properties have been applied in order to design a low profile, larger gain, compact and multiband antennas. The antennas are analyzed in terms of parameters such as reflection coefficients, voltage standing wave ratio and radiation patterns. The propounded antenna is designed on 1.6mm thick FR4 glass proxy substrate with dielectric constant E_r of 4.4 and is fed by transmission line. The proposed designs are suitable for wireless applications such as Wi-Fi, Wi-MAX, WLAN, Bluetooth, WCDMA and GSM. Details of the measured and simulated results of the individual iterations is presented and discussed.

KEYWORDS: Feed, FR4, Microstrip patch antenna, Return loss, Sierpenski gasket, VSWR, WLAN

I. INTRODUCTION

In communication system, variety of microstrip antennas are being utilized, the most general of which is microstrip patch antenna [12]. A patch antenna is a compact, narrow band, wide-beam, light-weight, conformal-shaped antenna which is fabricated by etching the antenna element pattern in metal trace conjoined to an insulating dielectric substrate [3]. It is incorporated with a flat rectangular sheet or “patch” of metal, mounted over a larger sheet of metal called the ground plane. A patch antenna is mainly build on a dielectric substrate employing the same materials & lithography techniques in order to make printed circuit boards. Microstrip or patch antennas [6] are becoming more and more useful because they can be printed directly onto a circuit board. Furthermore, they are becoming ubiquitous within the mobile phone market [1]. These are somewhat reasonable to manufacture and design since as the simple 2-dimensional physical geometry. These are also excellent in dual & triple frequency operations. These are highly ordered, easily integrated to circuits, compatible to the planer & non-planer surfaces and MMIC design. All these features make microstrip antennas broadly implemented in many applications, such as high performance aircrafts, wireless communication satellite and missile applications. With the advent of 3G & 4G mobile communication, CR has begun to receive a lot of attention [8]. UWB & Multiband technology is now becoming widely used in several applications such as positioning system, radar and short range communications.

Fractal antennas [11] can be put to use in a variety of applications, especially where space is minimal. An exemplar illustrating the advantages of fractal in antenna system is the phased arrays, where fractals can diminish mutual coupling. Besides, microstrip antennas are also subjected to some drawbacks, Narrow bandwidth being a serious restraint [5]. Different techniques have been developed which includes the implementation of thick substrates with low dielectric constant and slotted patch. So, the use of electronically thick substrates only results in the limited success because a large inductance is introduce by the increased length of the probe feed, resulting few percentage of bandwidth at resonant frequency[10].

In this paper, we have presented a design of microstrip Patch antenna using Sierpienksi fractal slot [13], with an aim to achieve a smaller size antenna [4]. Target of this work is to design a microstrip patch antenna and carrying out results using commercial simulation software like IE3D. IE3D, from zeland software,Inc.[17], is an electromagnetic simulation and optimization software useful for circuit and antenna design. IE3D has a menu driven graphic interface

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for model generation with automatic meshing, and uses a field solver based on full wave, method-of-moments to solve current distribution on 3D and multilayer structures of general shape. IE3D usually focuses on general planar and 3D metallic structures in layered dielectric environments [7].

II. LITERATURE SURVEY

Ankur Aggarwal, M.V. Kartikeyan (2010) demonstrated the "Design of Sierpinski Carpet Antenna using two different feeding mechanisms for WLAN applications" described a printed antenna for Wireless application which is working at 2.4/5 GHz for coaxial feeding and 2.4/5.2GHz for co-planar waveguide feeding. The printed antenna uses the sierpinski carpet geometry to design the antenna. As per their paper for different feeding mechanism the same geometry shows different results i.e. coaxial feeding has lower impedance BW and higher gain while CPW feeding has higher antenna impedance BW and lower antenna gain [14].

M.N. Jahromi, Abolfazl Falahati, Rob.M (2011) presented in their paper "Bandwidth and Impedance Matching Enhancement of Fractal Monopole Antenna using Compact Grounded Coplanar Waveguide" they use grounded coplanar waveguide to enhance antenna characteristics namely bandwidth & input impedence. Sierpinski carapet fractal shape with second iteration and miniature size are employed. The result are compared with the conventional standing monopole antenna further with the conventional standing monopole antenna bearing new feeding technique. They concluded this new feeding technique changes the behavior of fractal element from multiband to wideband and provide a very good improvement in retrun loss [18].

Sarita Bajaj, Ajay Kaushik (2012) proposed "Analysis of Patch Antenna Based on the Sierpinski Fractal" they uses software HFSS to design and simulate the antenna. The sierpinski gasket patch fractal antenna with 2^{nd} iteration is designed. As per their paper, Sierpinski Gasket Patch antenna shows less than -10dB return loss which is required for efficient operation for frequency bands 22.5050GHz, 27.7094GHz, 33.5030GHz, 38.5110GHz. VSWR are also in the required region i.e. below 2 [19].

Yogesh Bhomia, Ashvini Chaturvedi and Yogesh Kumar sharma (2012) presented a design of Microstrip Patch Antenna Combining Crown and Sierpinski Fractal-Shapes and experimentally studied on IE3D software. This design is achieved by cutting multi shapes in square pattern combined with crown & sierpinski fractal shapes and placing a single coaxial feed. Crown & sierpinski fractal shapes patch antenna is designed on a FR4 substrate of thickness 1.524 mm and relative permittivity of 4.4 and mounted above the ground plane at a height of 6 mm. Bandwidth as high as 31.14% are achieved with stable pattern characteristics, such as gain and cross polarization, within its bandwidth. Impedance bandwidth, antenna gain and return loss are observed for the proposed antenna [15].

Mustafa Khalid (2012) introduced a novel small size and multiband fractal dipole antenna called combined fractal antenna for 2D and 3D configurations where two different fractal geometries combined together to get the main antenna body. This antenna combines aspects of Hilbert and Koch curves and expected that the resulted antenna have a hybrid or combined properties related to the geometries that constructed this combined geometry.

Ashish Ranjan, Manjeet Singh, Mohit Kumar Sharma, Narendra Singh (2014) presented in their paper " Analysis and Simulation of fractal antenna for Mobile Wimax' presented the design of Sierpinski Carpet fractal Antenna for three iteration using HFSS software on FR4 substrate. The desing has been stimulated by varying two parameters. (i) Postion of the feeding line from the edge of the substrate. (ii) width of the Microstrip feed. They concluded Sierpinski carpet with one third iteration factor size of patch reduces by 33.9% of the conventional Microstrip Patch Antenna [21].

Amanpreet Kaur, Dr. Hardeep Singh Saini (2014) proposed the review of fractal techniques for designing microstrip patch antenna for x band.Tthis paper describes fractal techniques for designing microstrip antenna exhibits details of fractal geometries developed to get multiband behavior of patch resonator antenna. In this paper the review on various techniques of compactness by fractal geometry on microstrip patch antenna for X band used for satellite communication and radar application are presented [23].

Dr. Yogesh Bhomia, Kapil Kumawat, Manish Kumar (2014) presented a design of microstrip patch antenna combining circular and square slots by cutting different slots on rectangular microstrip antenna and experimentally studied on IE3D software. This design is achieved by cutting multi shapes in square pattern combining with circular and square slots & placing a microstrip line feed. This design has been studied in III iterations. With fractal shapes patch antenna is designed on a FR4 substrate of relative permittivity of 4.4 and thickness 1.524mm and mounted above the ground plane at a height of 6 mm [24].

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P.Satish Rama Chowdary, A.Mallikarjuna Parsad, P.Mallikarjuna Rao, Jaume Anguera (2015) proposed "Design and Performance Study of Sierpinski Fractal based Patch Antennas for Multiband and Miniaturization Characteristics" described the sierpinski Geometry based Patch antenna for Multiband operation and Miniaturisation of the radiating elements.The characteristics of fractal based Antenna are investigated as a function of fractal iteration. The fabricated prototypes are used to validate the simulated results [22].

III. DESIGN OF FRACTAL ANTENNA

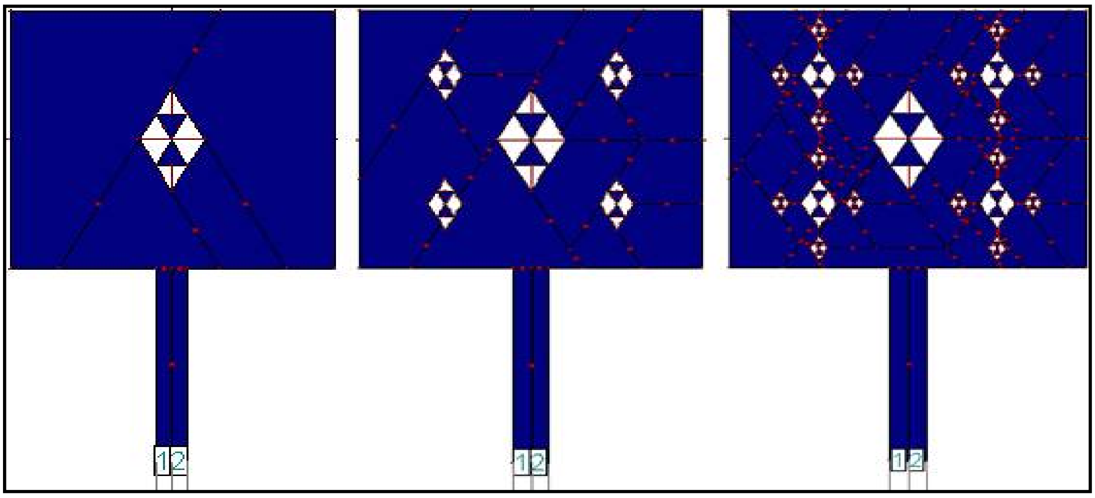

Fig.1**.** Model of 1st iteration, 2nd iteration, 3rd iteration

There are three essential parameters for design of a rectangular microstrip Patch Antenna-

The dielectric constant of the substrate material is an important design parameter. Firstly, the dielectric material of the substrate is selected for the design. The proposed antennas is designed using FR4 EPOXY substrate with dielectric constant, $\varepsilon_r = 4.4$, loss tangent equal to 0.001and h= 1.6mm which is the height of the substrate. Low dielectric constant is used in the prototype design because it gives better efficiency and higher bandwidth, and lower quality factor Q. For feeding, transmission feeding method is used. For all iterations, the location of feed is same is same and the length of feed is 15mm. In this work, design of microstrip Patch antenna using Sierpienksi fractal slot is presented. Same procedure is repeated and the result of simulation studies is presented up to third iteration. The frequency range is used from 2GHz to 6GHz.

Secondly, substrate thickness is another important design parameter. Thick substrate increases the fringing field at the patch periphery like low dielectric constant and thus increases the radiated power. The height of dielectric substrate employed in this design of,antenna is h= 1.6mm.

Lastly, the resonant frequency (f_r) of the antenna must be selected appropriately. The frequency range used is from 2GHz – 6GHz and the design of antenna must be operated within this frequency range. The resonant frequency selected for this design is 5.11GHz.

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IV. FEED TECHNIQUES (MICROSTRIPLINE)

First iteration

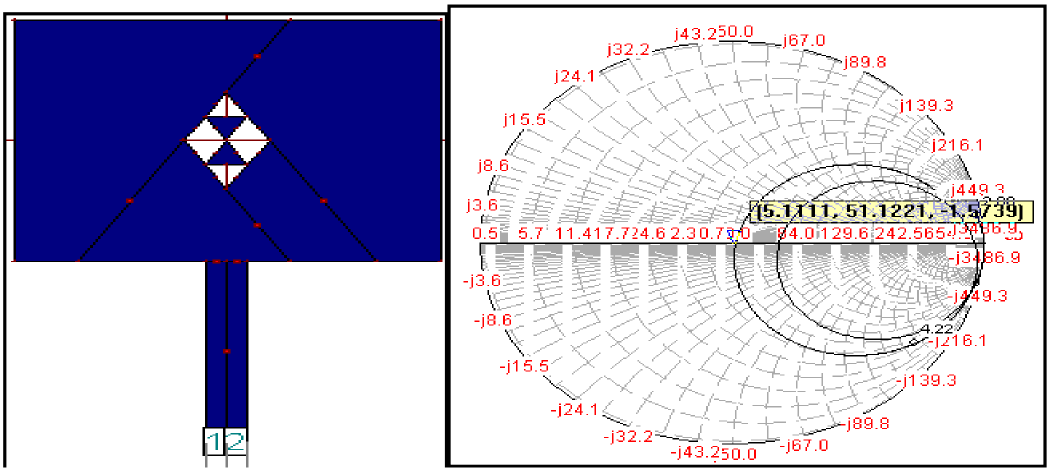

Fig.2. The model for 1st iteration, Input impedance loci using smith chart of first iteration

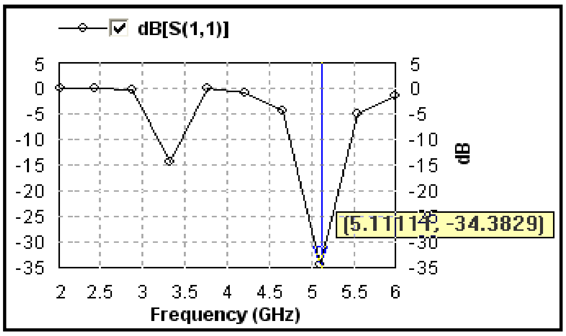

Fig.3. S11 parameter

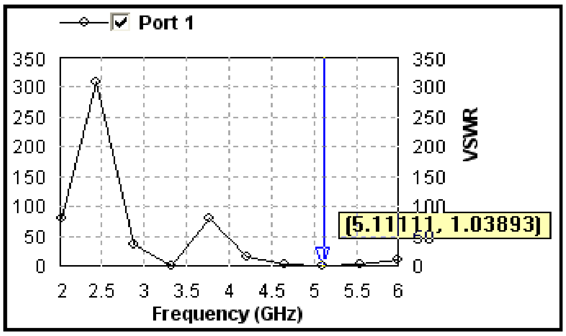

Fig.4. VSWR

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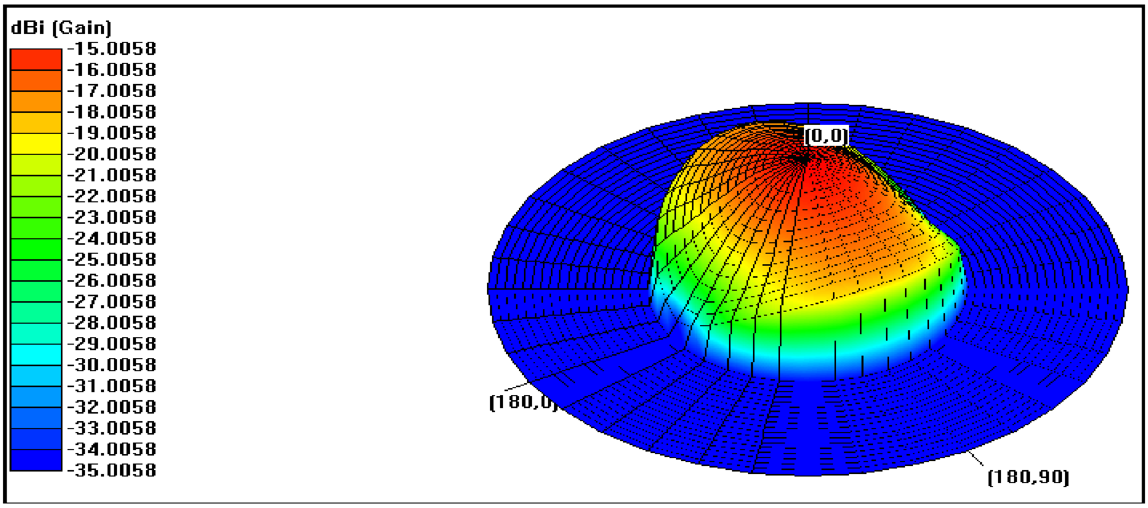

Fig.5. Radiation Pattern

Second iteration

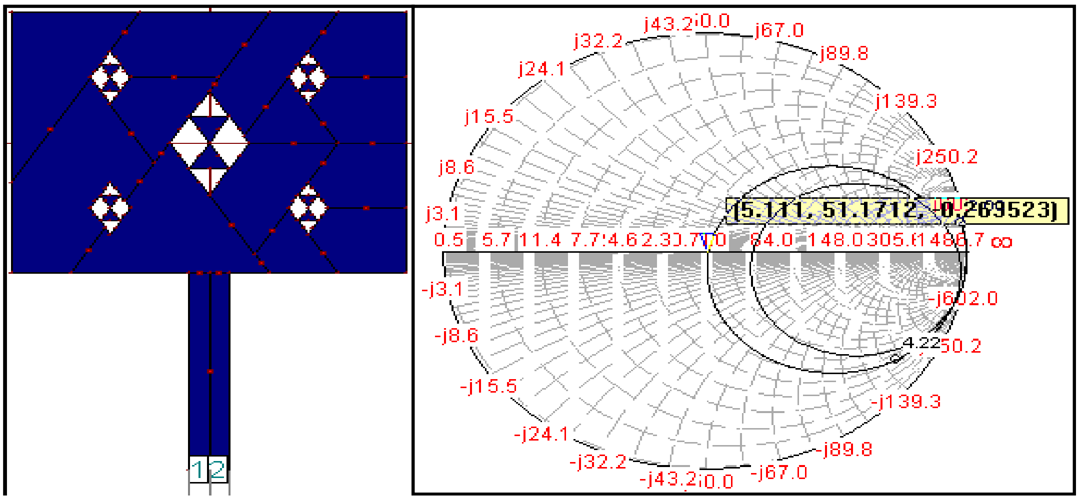

Fig.6. The model for 2nd iteration, Input impedance loci using smith chart of second iteration

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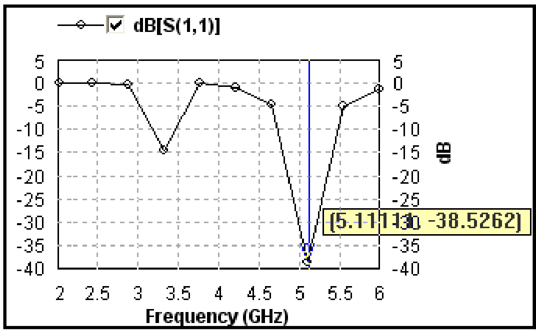

Fig.7. S11 parameter for 2nd iteration antenna

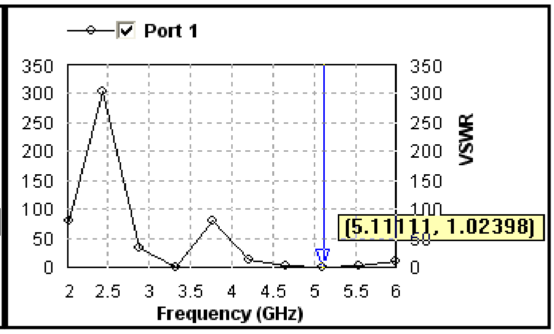

Fig.8. VSWR

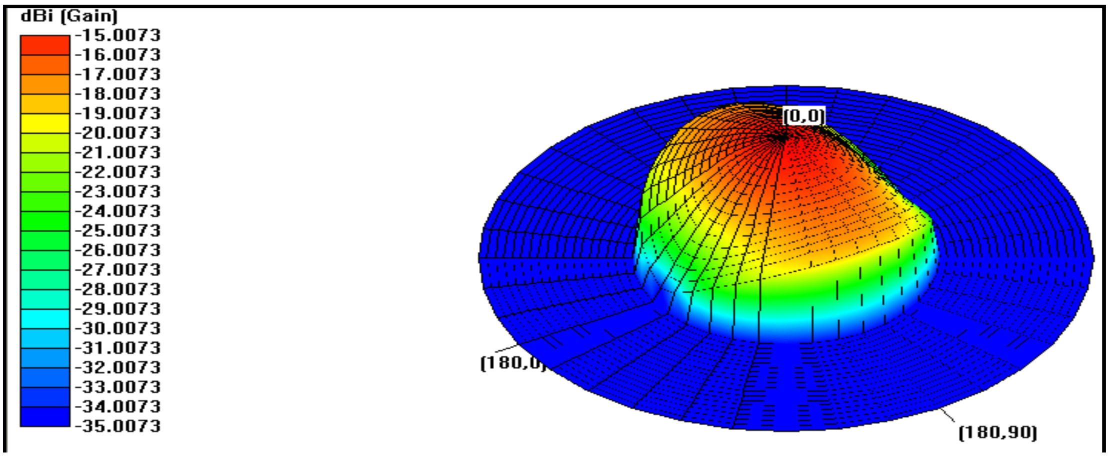

Fig.9. Radiation Pattern

Third iteration

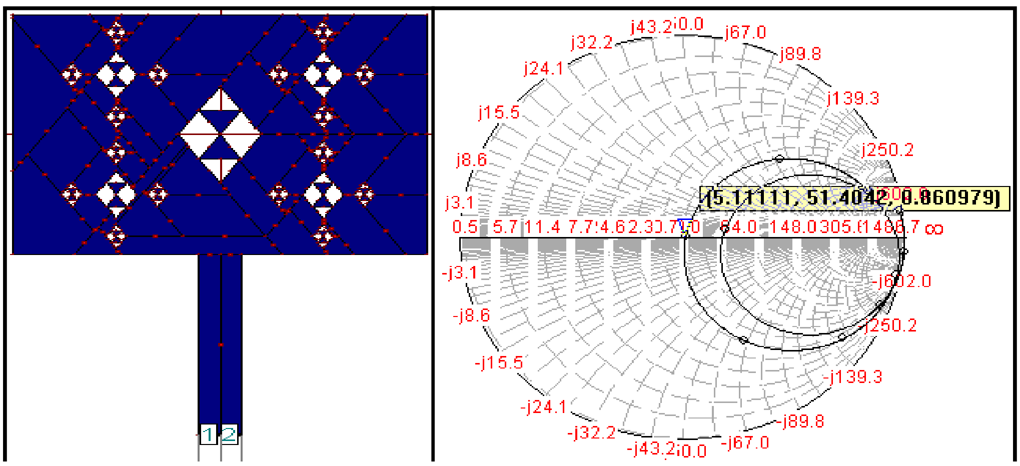

Fig.10. The model for 3rd iteration, Input impedance loci using smith chart of third iteration

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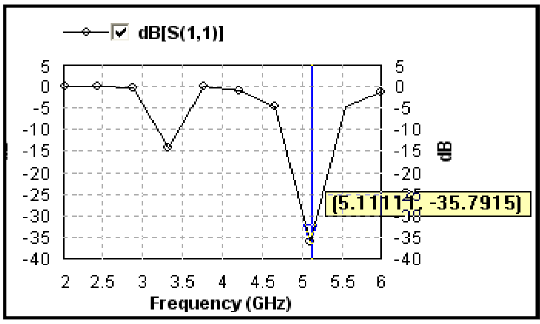

Fig.11. S11 parameter

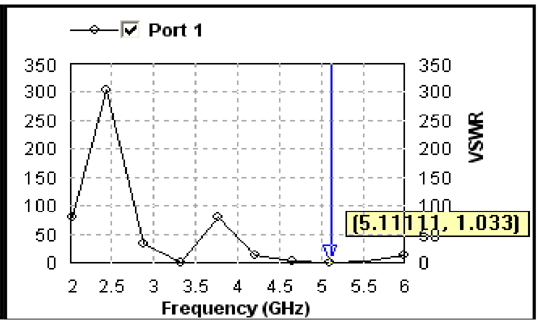

Fig.12. VSWR

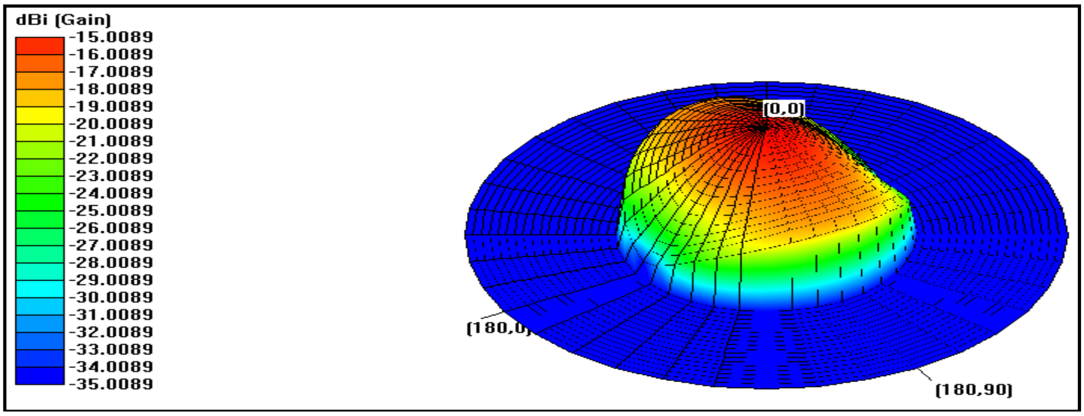

Fig.13. Radiation Patterrn

Table.1. Comparison of different results of Iteration 1, 2& 3
TRANSMISSION –LINE FEED-

Parameters	Iteration 1	Iteration 2	Iteration 3
Resonant frequency	5.1111	5.1111	5.1111
Bandwidth	13.48%	14.36%	14.45%
VSWR	1.0389	1.0238	1.0330
Return Loss	-34.3829	-38.5262	-35.7915

V. CONCLUSION

The discussed antenna is simulated by using IE3D by Zealand Software Inc.[17]. It is considered as a standard for electromagnetic simulation packages. The prime formulation of the IE3D is an integral equation that is obtained through the use of Green's functions. Formerly, the wideband antennas (spiral and log-periodic) and arrays were designed using Euclidean geometry [16]. The results demonstrated a maximum patch size reduction by the proposed fractal antennas, without degrading antenna's performance, such as the return loss and radiation pattern, VSWR. This

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size reduction technique is loading the inductive elements along the patch edges, and loading self-similar slots inside the patch, to increase the length of the current path. The basis of the maintenance of the antenna radiation patterns is the self-similarity and centro-symmetry properties of the fractal shapes [9]. The main advantages of the discussed method are: (i) miniaturization (ii) maintained radiation patterns, (iii) wider and better operating frequency bandwidth (iv) simple and easy to design. Thence, this is the most effective technique propounded for the size reduction of microstrip patch antennas so far. In future fractal microstrip antenna reduced patch size and improved bandwidth can be achieved positively [15].

This paper presented a modified sierpinski gasket antenna on a FR4 substrate of relative permittivity of 4.4 & thickness 1.6 mm.

Table 1 shows the variation of return loss with frequency, VSWR and Bandwidth for iteration I, II and III for transmission line feed.The simulated results indicate that the antenna is suitable for Wi-Fi, WiMAX, WLAN, Bluetooth, PCS and GSM. Sierpinski gasket is one of the most common fractal design used for designing antennas. This geometry shows high self similarity and symmetry [14].

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BIOGRAPHY

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Dr. Yogesh Bhomia received the B.E. degree from IETE, New Delhi in Electronics & telecommunication and M.E. in digital communication from M.B.M. College, Jodhpur and also received Ph.D. degree from Bhagwant University, Ajmer, Rajasthan, India. He is currently working as Director Principal in SSCET, Badhani. He has been published more than 25 papers in International Journals. He is reviewer of various Journals and also member