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# A Novel Ultra Wide Band Antenna Using Sierpinski Fractal Slots For Medical Imaging Applications

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***Abstract:***

*With the rapid development of wireless communication systems and increase in their applications, compact and ultra wideband antennas are required. In this paper a novel ultra wideband antenna using sierpinski fractal slots is proposed. The broadband characteristics are achieved by introducing a sierpinski fractal into a wide slot without increasing the overall antenna size. As the iteration order of the sierpinski fractal slots increases, the number of resonance increases, and also the bandwidth of the antenna will increase. The proposed antenna is giving 160 % impedance bandwidth. This Proposed Novel UWB antenna will be used for Medical Imaging Applications.*



Key words: UWB Antenna, Fractal antenna, Wide slot antenna, Medical Imaging Applications

## I INTRODUCTION

In modern wireless communication systems wider Bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. Ultra-wideband (UWB) radio is an emerging technology with some unique attractive features which are combined with researches in other fields such as wireless communications, radar, and medical engineering fields. Formally before 2001, UWB's application is limited mainly in military areas. However, since 2002, FCC has gradually allowed the commercial usage of these bandwidths, which makes it possible that every common people could benefit the UWB features. Federal communications Commission (FCC) regulate that the frequency for the UWB technique is from 3.1GHz to 10.6GHz in America. However, in Europe, the frequencies include two parts: from 3.4 GHz to 4.8 GHz and 6 GHz to 8.5 GHz. The power radiation requirement of UWB is strict and it would not disturb the existing equipment's because UWB's spectrum looks like background noise[1,2,3].

Fractal geometries have been applied to antenna design to make multiband and broadband antennas. In addition, fractal geometries have been used to miniaturize the size of the antennas. However, miniaturization has been mostly limited to the wire antennas. The geometry of fractal antenna encourages its study both as a multiband solution and also as a small antenna. First, because one should expect a self similar antenna to operate in a similar way at several wavelengths. That is, the antenna should keep similar radiation parameters through several bands. Second, because the space-filling properties of some fractal shapes (the fractal dimension) might allow fractal shaped small antennas to better take advantage of the small surrounding space. The fractal antenna is formed by applying a generator shape repetitively at a constant scale factor and results in an antenna with log-periodic characteristics which is a multiband antenna and a miniaturization characteristic[4,5,6].

In this paper a novel ultra wideband antenna using sierpinski fractal slots is proposed. The broadband characteristics are achieved by introducing a sierpinski fractal into a wide slot without increasing the overall antenna size. As the iteration order of the sierpinski fractal slots increases, the number of resonance increases,

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and the bandwidth of the antenna. Such an increase in bandwidth results from decline in the lower edge of the operating frequency band with upper edge of operating frequency band of slot antenna remaining unchanged. Detailed design of proposed antenna is described and experimental results of constructed prototype are presented.

## II ANTENNA CONFIGURATION

The geometry of the proposed structure of Sierpinski Fractal antenna is shown in figure 1. For the given resonance frequency $f_r$ and dielectric constant $\varepsilon_r$ the Width of the rectangular patch is given by

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

The effective dielectric constant can be found using equation below

$$\varepsilon_{reff} = \left(\frac{\varepsilon_r+1}{2}\right) + \left(\frac{\varepsilon_r-1}{2}\right)\left(1+12\left(\frac{h}{W}\right)\right)^{\frac{-1}{2}} \qquad (2)$$

The extension in length $\Delta L$ is given by

$$\frac{\Delta L}{h} = 0.412\left[\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}-0.8\right)}\right] \qquad (3)$$

The length of the rectangular patch is given by

$$L_{eff} = L + \Delta L \qquad (4)$$

The proposed antenna was designed and simulated wth EM simulation software (HFSS 11.0) using following parameter as shown in Table 1.

| Parameters | W | L | Wf | Fl |
|---|---|---|---|---|
| Values (in mm) | 28 | 30 | 2 | 20 |
| Parameters | a | b | c | D |
| Values (in mm) | 6 | 3 | 2 | 1 |

Table 1: Dimensions of the Proposed Antenna

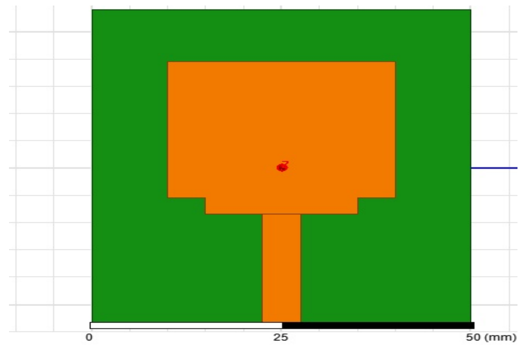



Figure 1: Geometry of proposed antenna without Sierpinski Fractal slots

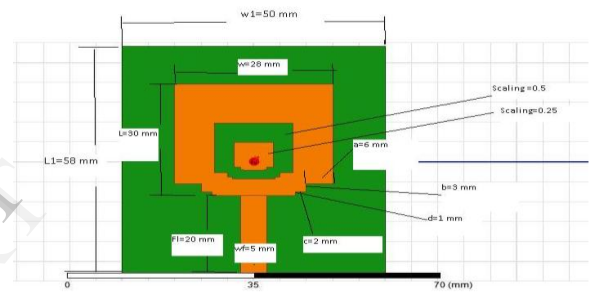
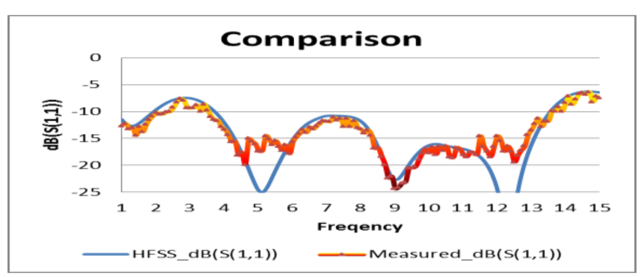



Figure 2: Geometry of proposed antenna with Sierpinski Fractal slots



## III SIMULATED AND MEASURED RESULTS

The proposed antenna is Simulated using HFSS Software. The comparison of return loss for the proposed antenna without Slot is shown in figure 3(a) and after 1st iteration is shown in figure 3(b). The 3D radiation pattern is shown in figure 4. Desired Peak Gain (6 dbi ) is achieved after first iteration.



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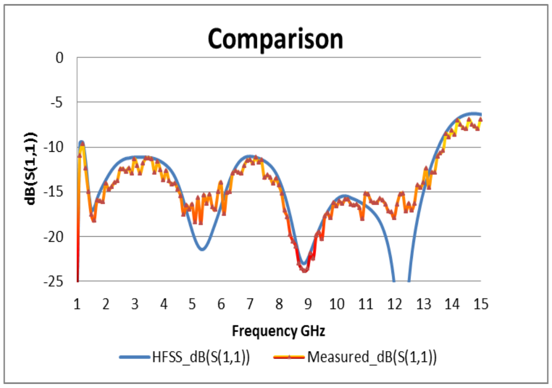
(a)




(b)

Figure 3: Comparison of return loss plot of the proposed antenna (a) without Slots.(b)after 1st iteration of Sierpinski Fractal slots

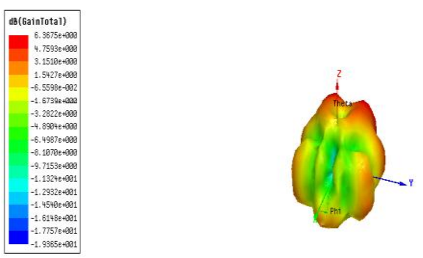



Figure 4: 3D radiation Pattern after first iteration

Table 2 summarizes the comparative study of observed impedance bandwidth for with and without slot iterations.

| Iteration | Frequency range (GHz) | Impedance Bandwidth(GHz) |
|---|---|---|
| 0 | 4 to 13.5 | 9.5 |
| 1 | 1.5 to 13.5 | 12 |

Table 2: Impedance Bandwidth of Fractal Slot Antenna for different iterations

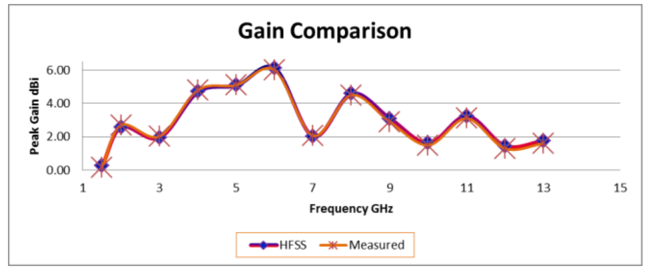



Figure 5: Comparison of Peak Gain plot for the proposed antenna

The auto cad design of the proposed antenna is shown in figure 4.The proposed antenna is printed on RT/Duriod 5880 substrate with dielectric constant of 2.2. The thickness of substrate is 1.6 mm.

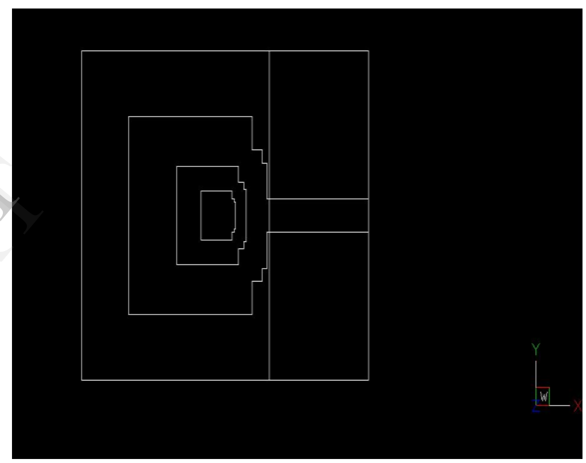


Figure 6: Auto cad design of proposed antenna

The prototype of the proposed antenna are shown in figures 7,8,9,10.The performance of the prototype antennas were observed in Network Analyzer provided by CEME, Osmania University. Comparisons of simulation and measured Return loss plots are shown in figure 3 (a) and 3(b), and peak gain plot showed in figure 5. Return loss is less than 10 db over the operating frequency band 1.5 GHz to 13.5 GHz. The Simulated and the measured results were in good agreement.

Figure 7: Front View of the proposed antenna without Slots

Figure 8: Rare view of the proposed antenna without Slots

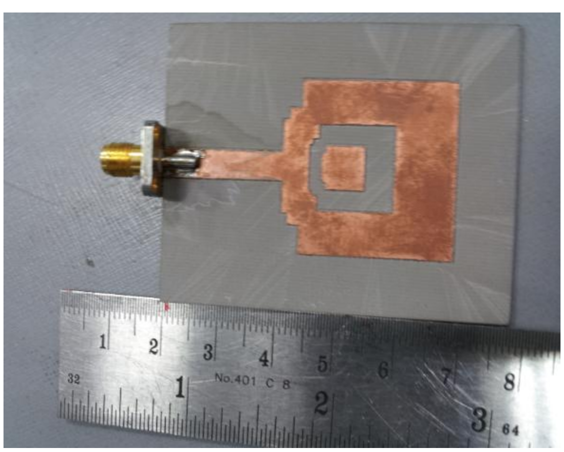


Figure 9: Front View of the proposed antenna.

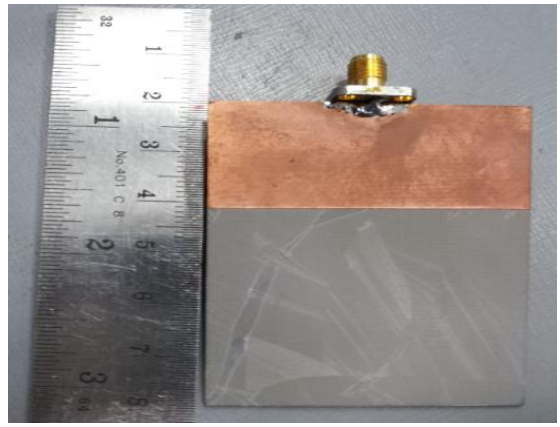


Figure 10: Front View and Rear View of the proposed antenna.

## V CONCLUSION

In this paper Sierpinski Fractal Wide Slot antenna is employed for wideband operation covering over the range from 1.5 GHz to 13.5 GHz. By using Sierpinski iteration technique the lower edge of the operating frequency band is lowered as the number of iteration increases which results in compact size. The proposed antenna is giving 160 % impedance bandwidth. The performance of the antenna is stable over the operating bandwidth and can be used in ultra wideband medical imaging applications.



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**Mr. Kumara Swamy K** born on 27 Oct 1986 in Warangal, Andhra Pradesh, India, Obtained his B.Tech degree in Electronics & Communication Engineering from P.R.R.M Engineering, JNTU-Hyderabad in 2007, M.E in Microwave and Radar Engineering from University College of Engineering, Osmania University, and Andhra Pradesh, India in 2009. He has been awarded with **Best Thesis Award** for his M.E. project from C.E.M.E, Osmania University , India in 2009. He was worked as Research Assistant, from R&D Department in Astra Microwave Products Limited, Hyderabad in Center for Excellence in Microwave Engineering (CEME), UCEOU, and Osmania University. Currently he is working as a Design Engineer in Powerwave Technologies R&D India. His area of interest includes RF Systems & UWB Antennas for wireless communications, Aerospace and Missile applications.

**Dr.Chandra Sekhar Paidimarry** completed B.E. from Nagapur University in 1991, M.Tech. from JNTU, Hyderabad in 1999 and Ph.D. in VLSI from Osmania University in 2009. He has been awarded with Post-doctoral Fellowship from Shizuoka University, Japan in 2009. He worked in Digisun Electronics, Hyderabad and actively involved in Design and Development of Micro-processor/Micro-controller based industrial applications from 1991 to 1999. He worked as Assistant Professor in Vaagdevi College of Engineering, Warangal from 1999 to 2001. Presently he has been working as Assistant Professor in Department of Electronics and Communication Engineering, University College of Engineering, Osmania University since 2001. Currently he is Head at the Department of ECE, University College of Engineering, Osmania University. He guided more than 50 M. Tech students/50 UG students for their project disseration. He is actively involved in setting up VLSI/Embedded Systems Lab under TEQUIP. He has 20 research papers in various journals and conference proceedings. His present research interests include development of new algorithms to study of Interconnect & EM effects in VLSI circuits and design of Parallel computational systems & high performance integrated circuits.