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A Novel Small Sierpenski Antennas

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Article Info	ABSTRACT
	In This paper, new small antenna is described and it is designed to be used in RFID applications at microwave frequencies. This structure represents a new version of Sierpenski antenna. The reduction of size by more than 75% gives this patch a great inters. Two equivalent resonant models are presented based on a model of triangular and Sierpenski patch antennas.

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1. INTRODUCTION

The great use and integration of wireless communication systems in our daily life makes people think of the cost and size of their systems. One of the new technologies is the Radio Frequency Identification which is used to identify objects, and people. Those systems are composed of a TAG and a reader. The TAG is attached to an object to be identified and the reader is responsible of this identification. The size of the whole system is very essential and it depends on the size of its components. For both TAG and Reader the antenna is the main component and its size defines the system size. In this way, many works are developed to reduce the antenna size by using different technologies such as replied dipole and fractal patch.

In this paper, we design and simulate a fractal patch by using ADS. Our antenna represents a new version of Sierpenski antenna. It is designed to resonate on 2.45GHz which is one of the RFID frequencies. In order to validate our result, two electrical models of the patch are developed, simulated and compared to physical patch.

2. THE SIRPENSKI FRACTAL ANTENNA

The term fractal means broken (fragmented), it was really defined by the mathematician Benoit Mandelbrot in 1982.The main geometric characteristic of fractal antenna was:
- Infinite perimeter
- Finite surface
- Fractal dimension :

$$D = \frac{\ln\left(\text{number of copies}\right)}{\ln\left(\frac{1}{\text{reduction rapport}}\right)}$$

The general concept of fractal can be applied to develop various antenna elements. Applying fractals to antenna elements allows for smaller, resonant antennas that are multiband frequency. The fact that most fractals have infinite complexity and detail can be used to reduce antenna size and develop low profile antennas. Furthermore the dimension of geometries can be defined through Euclidean dimension, self-similarity dimension [7].

Here we present different fractal antenna based on Sierpenski Microstrip antenna, and a novel fractal antenna which are simulated with ADS.

The Sierpenski gasket is constructed by subtracting a central inverted triangle from main triangle. After the subtraction, three equal triangles stay on the structure. Then the same procedure is repeated to the remaining triangles. The number of triangles N_n, length of a side of triangle L_n and the fractional area A_n can be calculated after every iteration [8]:

$$N_n = 3^n \tag{20}$$

$$L_n = \frac{1}{2^n} \tag{21}$$

$$A_n = L_n^{2} N_n = \left(\frac{3}{4}\right)^n \tag{22}$$

(Figure 1) show three iteration of Sierpenski antenna which is mounted on substrate material with a thickness h=3.2mm with a dielectric constant $\varepsilon_r = 2.52$ and loss tangent (tang δ) = 0.002. The patch is exited by a coaxial feed line at the middle of the right side.
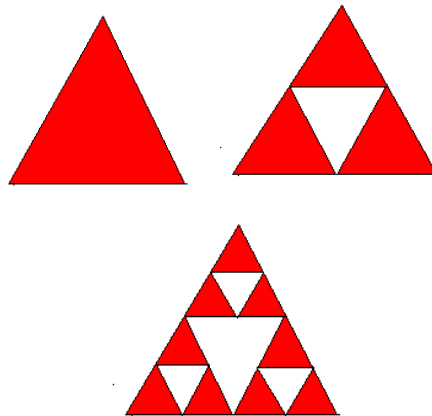

Figure 1. Three First iteration of Sierpenski Gasket Antenna

Electriclas Models

In order to design antenna structures, many techniques are developed. Those techniques use numerical methods based on resolving electromagnetic equations in different form. For this reason, much software was used like ADS simulator, HFSS simulator, and IE3D simulator. Those entire Simulators give their results by resolving electromagnetic equations in their integral or differential forms. But those techniques have some limitation. First, we cannot take the calculation of all kinds of losses. Besides after simulating the structures, we have not the possibility to control antenna parameters like return loss, input impedance when modifying geometry of antenna, nature of substrate. That is why, replacing an antenna by an equivalent circuit will be very important in parametric analyzing of the proposed structure. In this way, the model techniques have a great interest. Building an electrical model means replacing it by an RLC circuit. There were two configurations: a parallel or a series resonant model.

In order to modulate our Sierpenski antenna two models are proposed and simulated.

1. First Model

         The first model proposed is based on the model of a simple triangle patch. We calculate the parameter of every elementary triangle. The model proposed is for the first iteration of Sierpenski Sier1, figure 2.
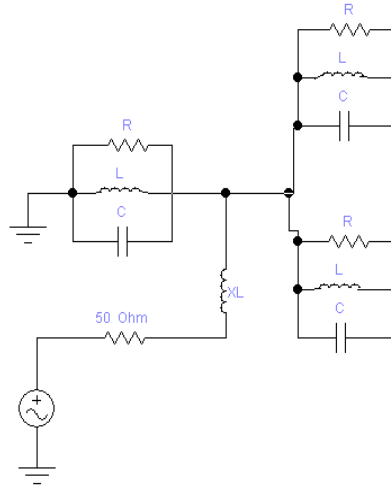
Figure 2. First Model

2. Second Model

         The second model is inspired from the model proposed by Walter Arrighetti, Peter De Cupis and Giorgio Gerosa in [6]. In their model, they assumed that every triangle is composed by dissipative elements and the interconnections are LC-parallel resonating on the resonant frequency, Figure 3.

They used a resistance about a micro- ohm, as for the capacitance is determined using the formula of parallel plate capacitor:

$$C = \varepsilon \frac{w}{h} = \varepsilon_0 \varepsilon_r \frac{w}{h} \qquad (23)$$

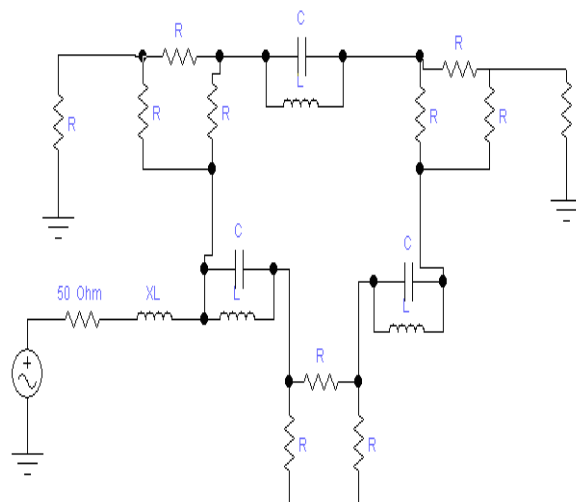And then the inductance L is determined by using the formula given in equation (18):

Figure 3. Second Model

3. Simulation Results

We simulate the model bellow and we obtain the return loss in the (*Figure 4*)
Comparing to the physical patch, it's clear that both the first and second model have the same resonant frequency and a comparable parameter.
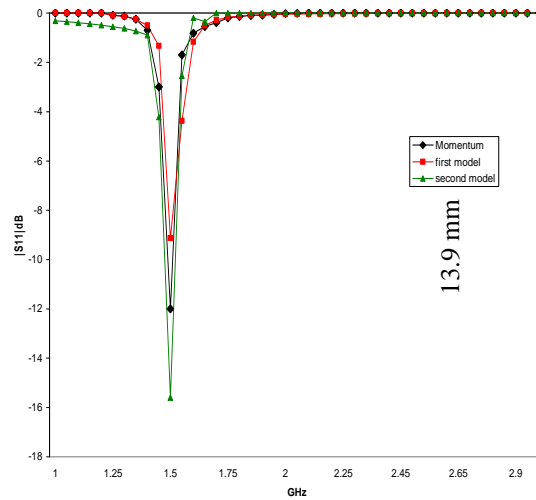

Figure 4. Return loss of physical, first and second model Sierpenski antenna

3. A MULTIPLE SIERPENSKI MICROSTRIP ANTENNAS

1. Proposed Design

The geometry of the proposed antenna is shown in figure 1. It's composed by a four Sierpenski gasket patches. The four triangles are connected by two microstrip line and exited by a coaxial line at the middle figure (5). The antenna are deposed on a dielectric substrate with thickness h = 0.65mm and a permittivity $\varepsilon_r = 2.3$.

The antenna was designed to resonate at 2.45GHz, one of RFID frequency. On this patch we used the fractal technique in order to reduce antenna size and in the same time we keep an acceptable parameter to RFID system.
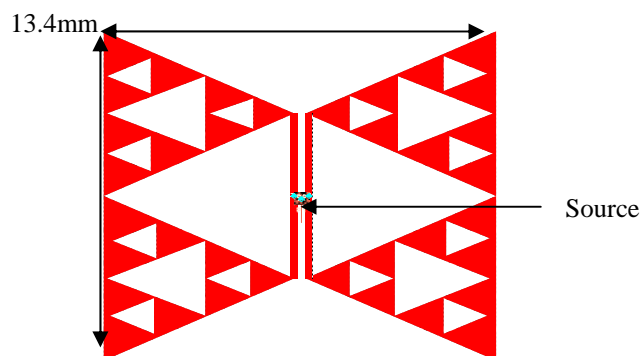

Figure 5. A novel Multi Siepenski Gasket Antenna

In order to study this structure, we have used the same two model developed in the previous section.

2.   Results and discussion:

The return loss for this antenna is shown in figure (6). We can see that the resonant frequency is about 2.45 GHz, the Gain and directivity are respectively 1.7dB and 4.81dB which are a good performance for RFID system.

On this frequency, the antenna size is about 60mm $\times$ 60mm. The structure proposed presents a dimension about 13.4mm $\times$ 13.9mm which means that the size is reduced by more than 75%.

When we compare the result of physical patch and the two electrical models we can see that the three results represent the same resonant frequency but a little difference in Band Width BW.
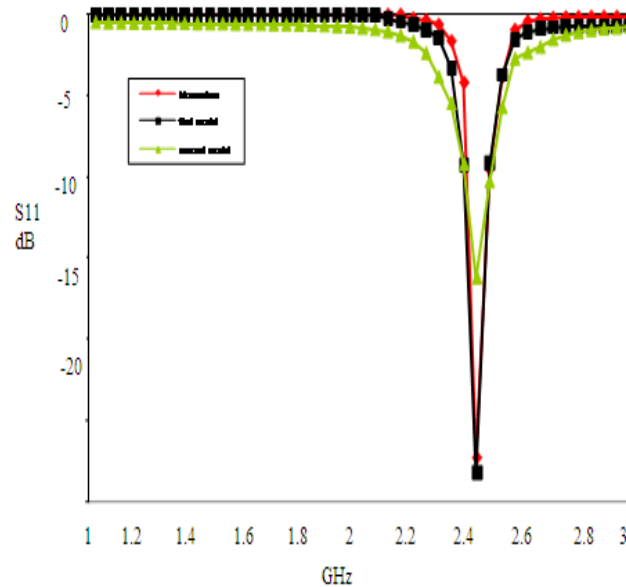

Figure 6. Return loss of physical, first and second model antenna (new Sierpenski antenna)

Finally, it's clear that the multi Sierpenski micro strip antenna is very useful for RFID systems because it's very small and it present an acceptable gain, directivity and band width and it is simple to realize.

4.   CONCLUSION

A new Sierpenski patch is introduced in this paper. When Compared to the normal dimension of antenna which resonate at 2.45GHz the dimension patch is reduced by more than 75% which seems very important. However, the problem of the fractal technique is that after little iteration, the performance of antenna risks to be destroyed that means a limitation for this technique.

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