Vicsek Small Antenna for Low-Range Applications and Future Bands for 5G

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Abstract: - Various types of antennas with fractal geometry have high frequencies and considerably high bandwidths of up to 20 GHz. However, modern applications with low latency and high transmission speeds make it necessary to use antennas with higher bandwidths. The dielectric used was FR4 substrate with dielectric constant $\varepsilon_r = 4.4$ and thickness of substrate 1.544 mm. The S_{11} scattering parameter was obtained. The simulations of this article were carried out using Ansys High Frequency Structure Simulator (HFSS).

Key-Words: - Wideband antenna, WPAN, Viseck antenna, UWB, SWB, small antenna, HFSS, 5G.

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1 Introduction

Today there are multiple communication services in portable devices for both short-range and medium-range communications in different fields such as: telemedicine, monitoring, short-range radars that allow high-precision walls to be passed through, display systems, military, Control systems in automobiles, etc.

Applications demand the management of low latency, high transmission rates, large volumes of information, low weight, low volume, mobility, etc. which determines the complexity and cost of the transmitting and receiving devices of the communication system.

The systems that allow hosting the applications require devices that handle modulation, coding, access scheme and multiplexing techniques such that they provide greater channel capacity, as well as quality of service, [1].

Some various systems and technologies allow the requirements of the aforementioned applications to be provided, such as Ultra Wide Band (UWB) systems.

Ultra Wide Band (UWB) technology operates with bandwidths from 3.1 GHz to 10.6 GHz. in systems that require high transmission speeds over short distances and even radars that allow you to see through walls, which are ideal for Wireless systems. Personal Area Network (WPAN). In UWB systems multipath fading is reduced with the use of PPM modulation. Since they are used from low to high frequencies, despite reflecting bodies such as walls and other objects, the low frequencies penetrate these bodies, improving the detection capacity. Furthermore, another characteristic of UWB systems is their high electromagnetic compatibility with other systems due to their low power (short range), [2], [3], [4]. Among the best features that this technology presents we can mention:

- High channel capacity.
- High robustness to multipath effects.
- High temporal resolution.

The characteristics allow the development of high-precision radars, low power consumption, robustness against multipath, and high electromagnetic compatibility, among others, [5]. There are applications of UWB systems, like [6], [7]:

- Imaging Systems.
- Vehicular Radar Systems.
- Communication system.
- Measurement systems.

Various systems such as Wireless Personal Area Networks (WPAN), currently have a wide range of applications, especially in the field of medicine, sports, security, etc. [8], [9], [10].

Although UWB systems offer various advantages mentioned above, the aim is to operate at higher frequencies such as Super Wide Band (SWB) systems, where there is a greater diversity of applications. However, the complexity of terminal equipment increases, for example, the antenna design must operate with very large bandwidths, [11], [12], [13].

Among the antennas that offer characteristics such as low profile, low cost, small size and large bandwidths, we have fractal antennas. These antennas are suitable for mobile applications due to their low profile, low cost, high bandwidth handling, and small size, [14], [15], [16], [17].

There are various types of antennas with fractal geometry, among them, is the antenna called Vicsek which has a small size, zero area and infinite perimeter, which is why it is also used in Multiple inputs multiple outputs (MIMO) systems, thus showing large bandwidths. in cellular, WLAN and WiMAX applications, [16], [18], although it is also used in 5G systems.

In this article, a Vicsek antenna is presented which is suitable for SWB applications up to 48 GHz. The simulations were carried out using Ansys HFSS (High Frequency Structure Simulator).

2 Antenna Design

The design of the Vicsek antenna has the same principle as several other fractal antennas, it performs segmentations of its area or length, as well as variations or repetitions of the geometry on a smaller scale including specific rules.

The initial geometry of the Vicsek antenna consists of a regular square polygon, which is divided into 9 squares of equal size (Figure 1). From here, there are two ways to perform segmentation.

Case 1: The corner squares are removed (Figure 2a).

Case 2: Squares 2, 4, 6, and 8 are eliminated, leaving only squares 1, 3, 5, 7, and 9, forming an "X" with the remaining squares (Figure 2b).

The approximation of case 1 was used, from which the rule was made again (Iteration 2) with the remaining tables (squares 2, 4, 5, 6, and 8) as shown in Figure 3.

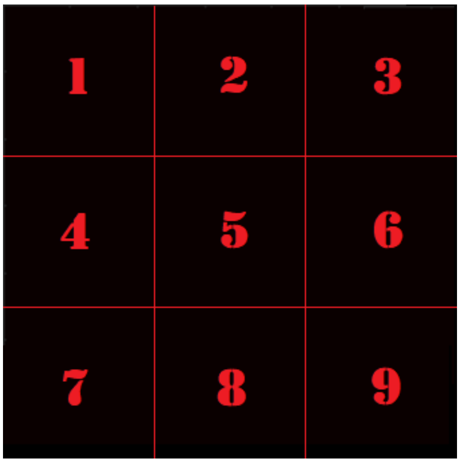

Fig. 1: Original Vicsek geometry

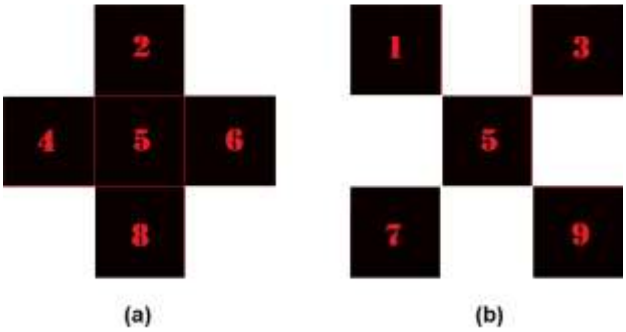

Fig. 2: Construction cases, (a) Case 1, (b) Case 2

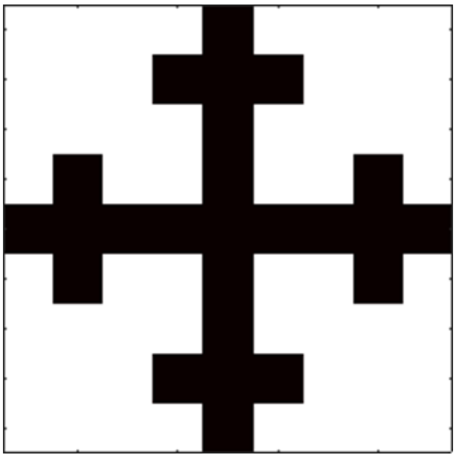
Fig. 3: Vicsek antenna iteration 2

Finally, an iteration of order 3 was proposed as shown in Figure 4.

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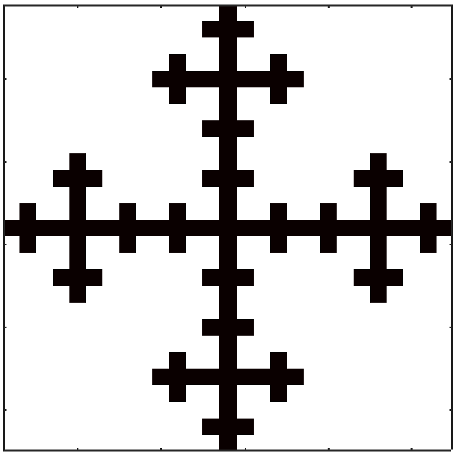

Fig. 4: Vicsek antenna iteration 3

The broadband antenna was designed over a FR4 substrate with a dielectric constant of 4.4 and a thickness of 1.544 mm.

For the future frequencies of the use of 5G systems according to the European Broadcasting Union (EBU), 48GHz frequencies are viable, and using equation 1, we calculate the dimensions of the Vicsek antenna.

$$W = \frac{c}{2f\sqrt{\varepsilon_r}} \qquad (1)$$

Donde:

W: width.
f_r: operation frequency.
ε_r: dielectric constant.

Because $W = 1.49mm.$, hence, the width of the antenna is $W = 40.23mm.$ as seen in Figure 5.

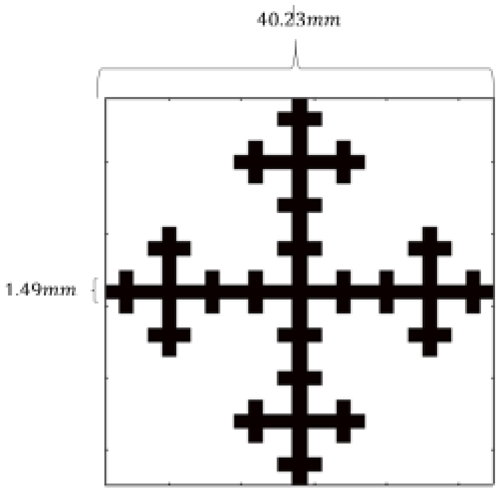

Fig. 5: Vicsek antenna dimensions

The antenna feeder transmission line is based on the λ/4 transformer model and also the decoupling network.

3 Results

The Vicsek antenna was modeled and simulated in HFSS (Figure 6).

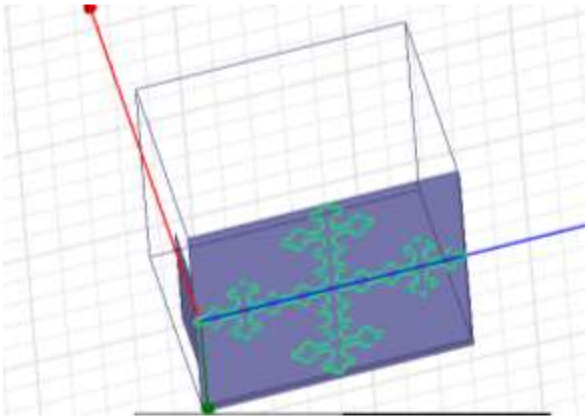

Fig. 6: Vicsek antenna model in HFSS

The return losses were obtained showing a big bandwidth (from 28.8 GHz to 50 GHz) as can be shown in Figure 7.

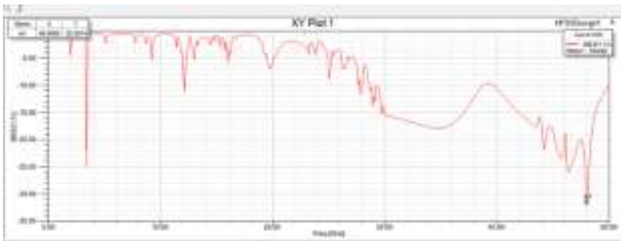

Fig. 7: Return Losses (S_{11} Parameter)

The Vicsek antenna is coupled in a bandwidth of 21.8 GHz, with a small decoupling point at 39 GHz, which can be neglected.

4 Conclusion

In future work we will seek to increase the bandwidth of the antenna since there are insignificant decoupling points. The Vicsek antenna can be used in MIMO antennas, so this analysis will be carried out in the short term for 5G applications improving isolation between the elements like in [19].

The antenna has considerable operating frequencies and bandwidths for its application in broadband systems and high transmission speeds (5G systems).

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Daniel Alonso Lucas, Edgar Alejandro Andrade González and Mario Reyes Ayala carried out the Vicsek antenna design.
- Hilario Terres and Sandra Chávez carried out the simulation in HFSS to get de scattering parameter S_{11}.
- Gerardo Salgado Guzmán and René Rodríguez Rivera described the introduction of the paper and checked spelling and grammar. Also, he wrote, review and edited. Finally, he helped with supervision.

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Conflict of Interest

The authors have no conflict of interest to declare.