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PATTERN LOBES AND BEAM WIDTHS OF A NOVEL FRACTAL ANTENNA

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Important element of any transceiving wireless devices are antennas, form of which influences on the quality of transmission and reception of information. These systems require multirange, broadband antennas that are small in size. In this paper experimental results on the determination of the radiation pattern of a novel small-size fractal antenna of based on an anisotropic curve are described. The fractal structures on the basis of which the antennas are built have self-similarity properties and are characterized by scaling effects. All this provides unique in comparison with standard types of antennas characteristics of uniformity of the radiation pattern over a wide range of frequencies while minimizing (5-10 times) the linear dimensions of the antennas, which is especially important for long-distance communication bands. The antenna beamwidth is the angular width expressed in degrees which is measured on the major lobe of the radiation pattern of an antenna. We present the experimental results for determining the width of the prototype pattern of the anisotropic fractal antenna. We used the software and hardware complex that we created. An anisotropic fractal antenna was used as the radiating antenna.

Keywords: Radiation pattern, fractal, antenna, anisotropic curve, software, LabVIEW, experiment.

Introduction

Fractal antennas are available in multiband and broadband configurations [1-3]. This allows them to work effectively with all existing and future wireless standards. Fractal antennas are universal points of view of multifrequency, and have excellent amplification. They are small enough and easily get into almost any wireless device on the market. The available broadband properties of fractal antennas are also optimal from the point of view of information protection. The theory of fractal antennas is at the stage of formation at present days. Researchers experimentally, by trial and error, try to apply known geometric fractals to antenna designs. We use a new fractal curve, called the anisotropic fractal [4] in our work. This fractal structure has several advantages over classical fractal curves. The properties of the antenna based on an anisotropic curve are described in detail in our articles [5-6]. The electrodynamic characteristics of the anisotropic antenna we were studied using the High Frequency System Simulator software (Ansoft HFSS).Here we present the experimental results on the determination of the width of the anisotropic antenna pattern.

1. Antenna pattern

Any antenna has a property of concentration (focusing) of the energy of electromagnetic waves emitted by it in a certain area of space. Special characteristics and parameters of the antenna are used to describe its directed properties. Patterns of the field intensity and the power flux density of the transmitting antenna are related to the characteristics of the antenna. The width of the radiation pattern, the level of the side lobes of the diagram, the directivity factor, the efficiency of the antenna are related to the parameters of the antenna. The concept of directivity gives a special parameter the amplitude characteristic of the directivity. It is defined as the dependence of the amplitude of the intensity of the antenna field emitted by the antenna (or a quantity proportional to it) from the direction in space with an unchanged distance to the observation point M (Fig.1). The direction is given by the meridional (θ) and azimuthal (φ) angles of the spherical coordinate system. We obtained the directivity patterns of the antennas in question with a step of 100 MHz in the frequency range from 0.1 GHz to 2.7 GHz. The results are given in the paper [6]. The results of our work are also widely used in reading special courses [7] for students of the Department of Physics and Technology Al Farabi Kazakh National University.

Any diagram in space is a closed surface, the distances to all points of which from the origin of the chosen coordinate system are proportional to the values $F(\theta, \varphi)$. $F(\theta, \varphi)$is the function describes the amplitude response characteristic. The image of the spatial pattern of the antenna is difficult on the plane in both spherical and rectangular coordinate systems in practice, because some parts of the spatial pattern shade each other. Therefore, the sections of the volume diagram are represented by two mutually perpendicular planes: vertical (for which φ = const) and horizontal (for which $\theta = \pi/2$) (Fig. 2). The pattern of real antennas has many lobe character. The width of the main lobe determines the degree of concentration of the emitted electromagnetic energy. The width is the angle between the two directions within the main lobe, in which the amplitude of the electromagnetic field strength is a level of 0.707 of the maximum value. The width of the diagram at the half-power level is $2\theta_{0.5}$ and the zero-radiation level is $2\theta_0$ usually.

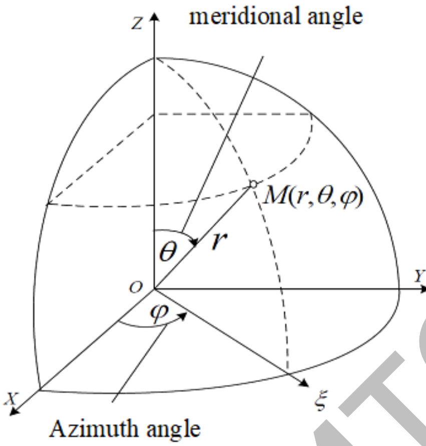

Fig.1. Graphical representation od the antenna pattern in a spherical coordinate system.

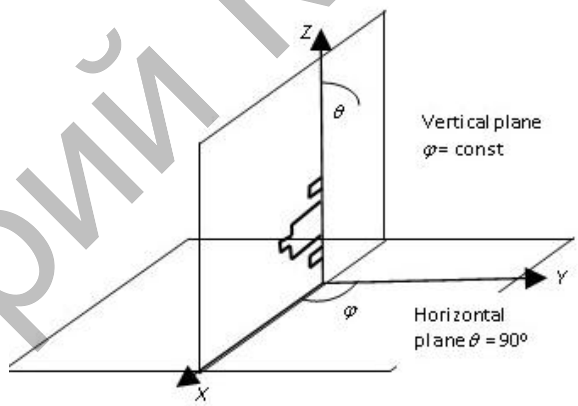

Fig.2. Cross-sectional area of the antenna pattern.

The value $2\theta_{0.5}$ will correspond to the angle between the directions, where $F^2(\theta) =(0.707)^2=0.5$ for a power directivity pattern. The value $2\theta_0$ corresponds to the angle between two directions of the radiation pattern, at the boundaries of which the field strength drops to zero values.

2. Experimental results and discuss

We created a software-hardware complex. We took into account all the necessary requirements for the creation of such complexes [8-9]. The hardware and software complex consists of a high-frequency generator NI PXIe 5652, fractal antennas of various types used as a transmitting antenna, a horn antenna as a receiving antenna; the Agilent N9340b spectrum analyzer, the interface implemented in the LabVIEW software. Here we give only the experimental results for determining the width of the directional pattern of the experimental sample of an anisotropic fractal antenna. The anisotropic fractal antenna is taken as a radiating antenna. The antenna pattern was displayed in a specially developed interface in the LabVIEW software. The signal was fed from the NI PXIe generator with a frequency of 2.8 GHz. The transmitting antenna was rotated automatically at a 5-degree step using a rotary system based on the Atmega microcontroller. Figure 3 shows the installation.

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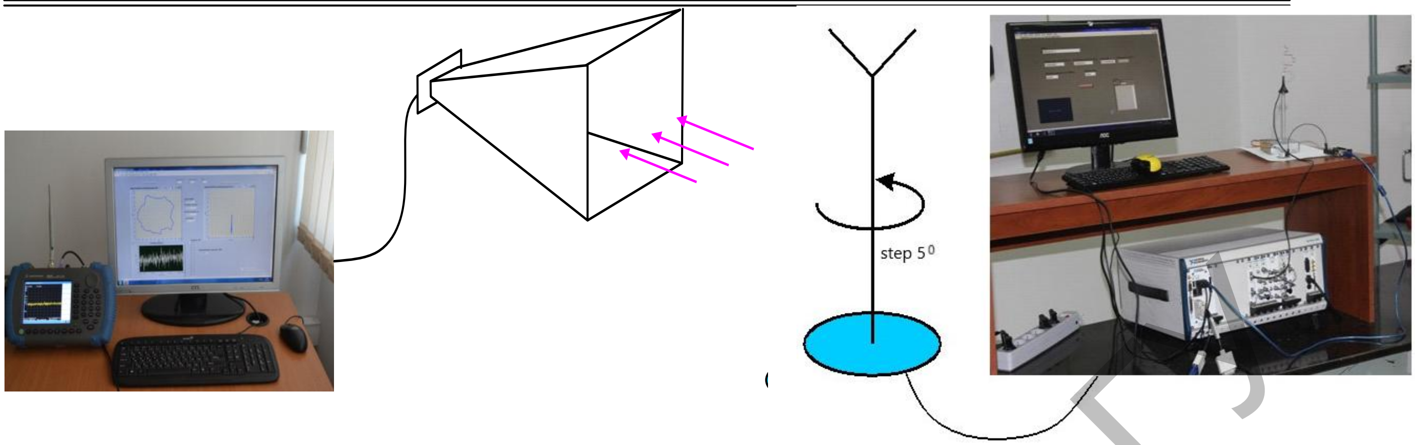

Fig.3. Block scheme of the experimental setup.

The program sheet, which is embedded in the controller, is shown in Figure 4.The stationary horn antenna after reception of radio waves transmits via a matched feeder (50 Ω) to the spectrum analyzer. The radiation pattern is displayed in the interface windows in the polar coordinate system.

```
#include <Stepper.h>

const int IN1 = 2;
const int IN2 = 3;
const int IN3 = 4;
const int IN4 = 5;
const int stepsPerRevolution = 64;


Stepper stepper(stepsPerRevolution, IN1, IN2, IN3, IN4);


void setup() {
  stepper.setSpeed(10);
}

void loop() {
 Serial.println("clockwise");
  stepper.step(stepsPerRevolution);
  }
```

Fig.4. Anisotropic antenna with rotary system and program code

The scheme of the developed interface is shown in Figure 5. It is a set of virtual instruments, which makes it possible to obtain the directivity patterns of a horn antenna of a given frequency. The module, located in the upper left corner of the block diagram, iterates through the processing of data that enters the central module. Here, the parameters of the signal coming from the microwave antenna are analyzed. By converting the signal spectrum in a given cycle, the received data is delivered directly to the interface of the complex in real time. The module located on the right-hand side of the circuit is responsible for displaying the data acquisition in the interface.

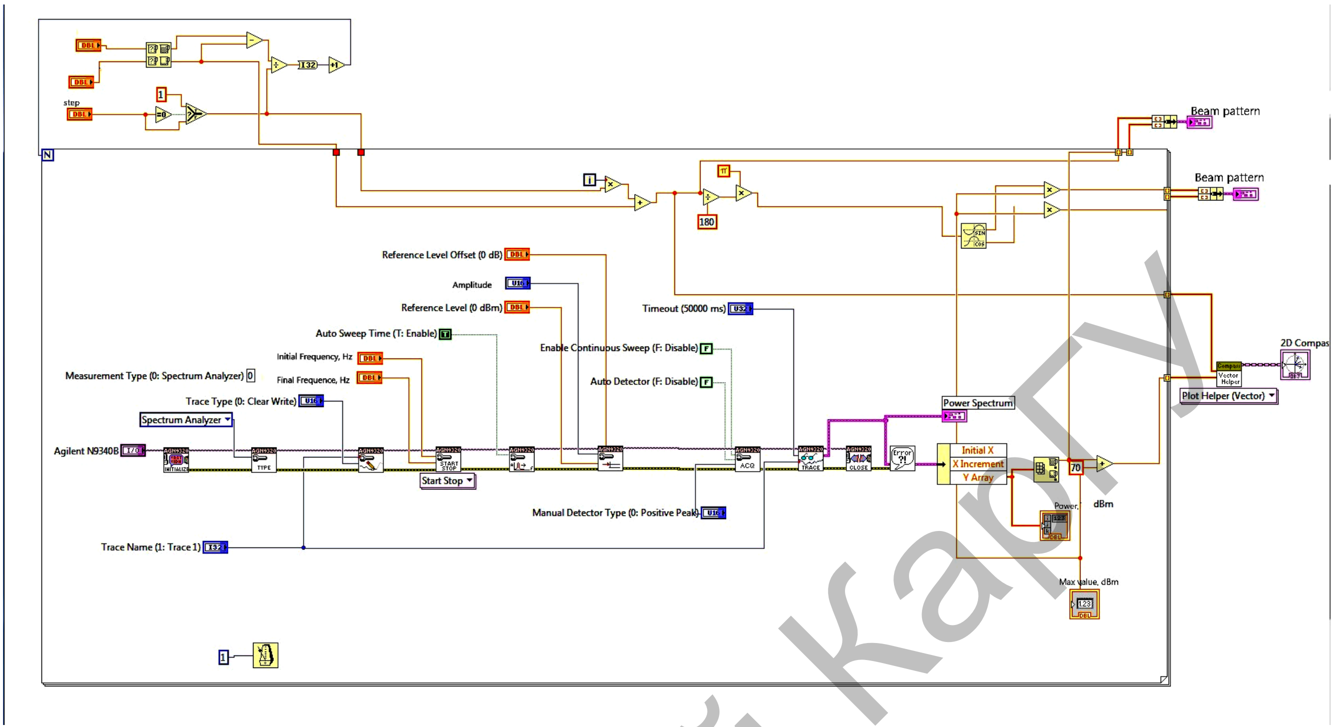

Fig.5. Block diagram of the interface of the hardware and software complex

Figure 6 shows the antenna pattern obtained experimentally. Here we can determine the width of the main lobe. It is approximately 48-50 degrees in our case.

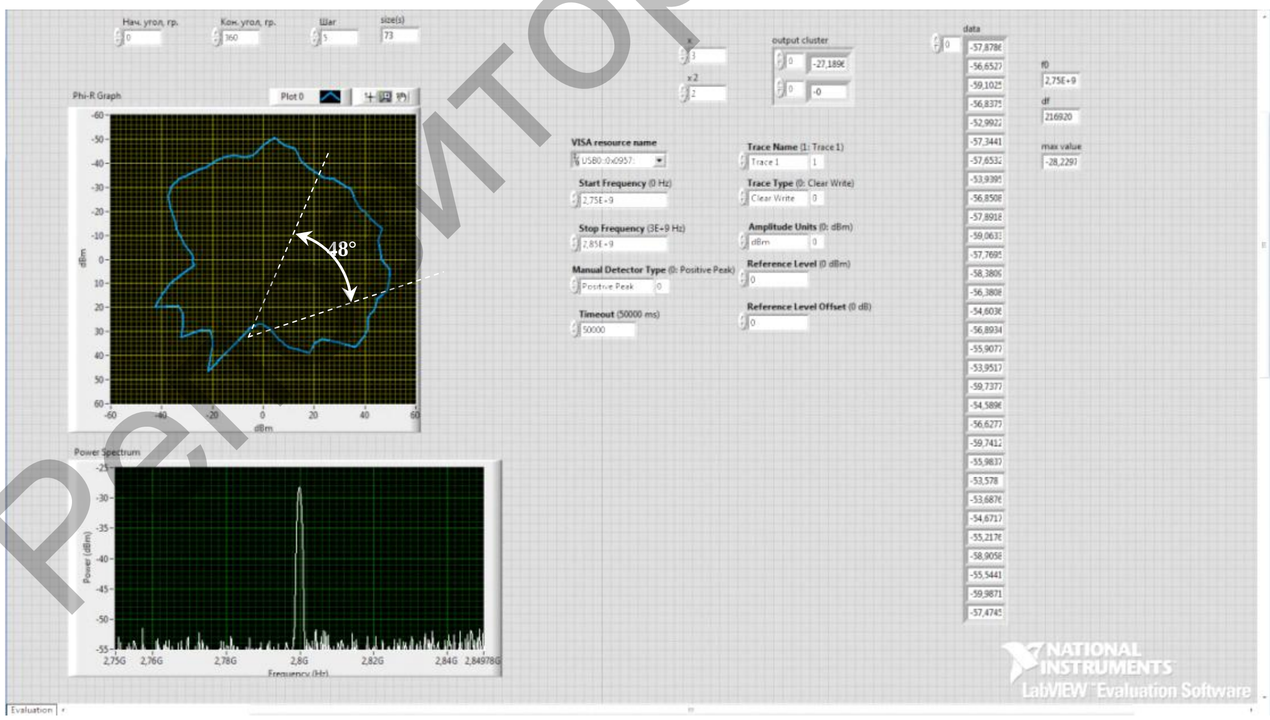

Fig.6. Antenna pattern and beam width of the main lobe

There are slight distortions in the data obtained, but thanks to the high efficiency of the horn antenna, it was possible to obtain a directivity diagram as close as possible to theoretical indices.

The radiation pattern of the fractal antennas differs by the polarity of the radiation, that is, the direction of the radiation changes during the transition.

Conclusion

The antenna based on the anisotropic fractal is more directed and focused, and the degree of concentration of the emitted electromagnetic energy is much larger than that of the selected other models, this is evidenced by the antenna pattern.

Also, we show what dipole fractal antenna based on an anisotropic geometric fractal has a multi-frequency property unlike standard half-wave vibrators and has better characteristics than other fractal antennas [10].

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