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The Study of Influence of Changes of Fractal Antennas Forms during Using Affine "Compression" Transformation on Its Characteristics

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Abstract

This article gives information about results of computer simulation to determine the specifications of fractal antennas during using "compression" affine transformation to change the shape of fractal antennas. It was found in the simulation that an affine transformation degrades the characteristics of the fractal antenna on the lower operating band section and the upper section improves the range. Using the affine "compression" transformation to change the form of broadband fractal antenna makes it possible to place them on structures which have to face strict requirements for overall dimensions.

Keywords: broadband fractal antennas, affine transformations, the technical characteristics of fractal antennas, fractal antennas' simulations.

INTRODUCTION

Nowadays, more and more applications are finding a variety of remote-controlled cars moving on the ground, water or air. These robotic vehicles are stricted requirements for mass-dimensional indicators. At the same time there is need for their managing to send images with high resolution sometime. There is need for ultra-wideband communication systems. One type of broadband antennas for communication systems are fractal antennas. However, the placement of fractal antennas on robotic machines may be difficult to requirements for overall dimensions of the structure or the presence of any external elements. The placinfg on a limited area of the fractal antenna is possible, when we apply for it change shape with the help of geometric transformations, one of the type is an affine transformation of "compression". However, any change of size of the antenna affects the antenna characteristics are important, as bandwidth and characteristic impedance.

SIMULATION RESULTS

To simplify the task of analyzing changes in fractal antenna's characteristics when changing the shape design has been taken as a basis, which has circular symmetry, namely the circular monopole MSTF (Modified Star-Triangular Fractal) (рисунок 1), which is widely described in the literature [1- 9].

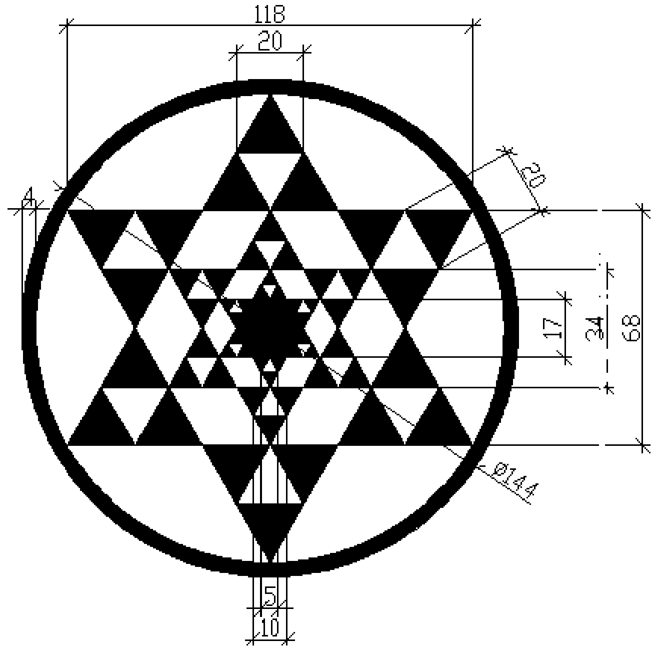

Figure 1: The initial geometric shape of fractal antenna

0,26 ÷ 15 GHz frequency range has been selected for the simulating.

The sizes of the initial shape of the fractal antennas were obtained according to the method of calculation [5-9]:

$$L_{ar} = \frac{\lambda}{4} = \frac{c}{4 \cdot f_L}, \text{м}, \qquad (1)$$

where L_{ar} – the length of radiating antenna element;

f_L = 0,26·10^9 Hz – the lower cut-off frequency;

c = 3·10^8 м/s^2 – the speed of light.

We obtain L_{ar} = 288 мм after making calculations. Taking into account that as a radiating element selected circle of radius $r = L_{ar}/4$ = 72 мм, we obtain the initial shape of the fractal geometry of the antenna, which is presented in Fig. 1 with all other dimensions. The "compression" ("stretching") affine transformations along the coordinate axes are defined as:

$$x' = \alpha x,$$

$$y' = \beta y.$$

If the values of α and β is greater than zero, there is a transformation of "stretching", if it is less, there is the "compression" [10].

In order to make it more noticeable impact of affine transformations on the characteristics of fractal antennas the values of α and β were taken equal to 0.5. Two variants of the fractal antenna, has been simulated with a modified form: when α=0,5 and β=1 – horizontally compressed fractal antenna; when α=1 and β=0,5 – vertical compressed fractal antenna. The obtained antenna dimensions and antennas are shown in figure 2 (the sizes vary along the Y axis during the vertical compression, during the horizontal along axis X).

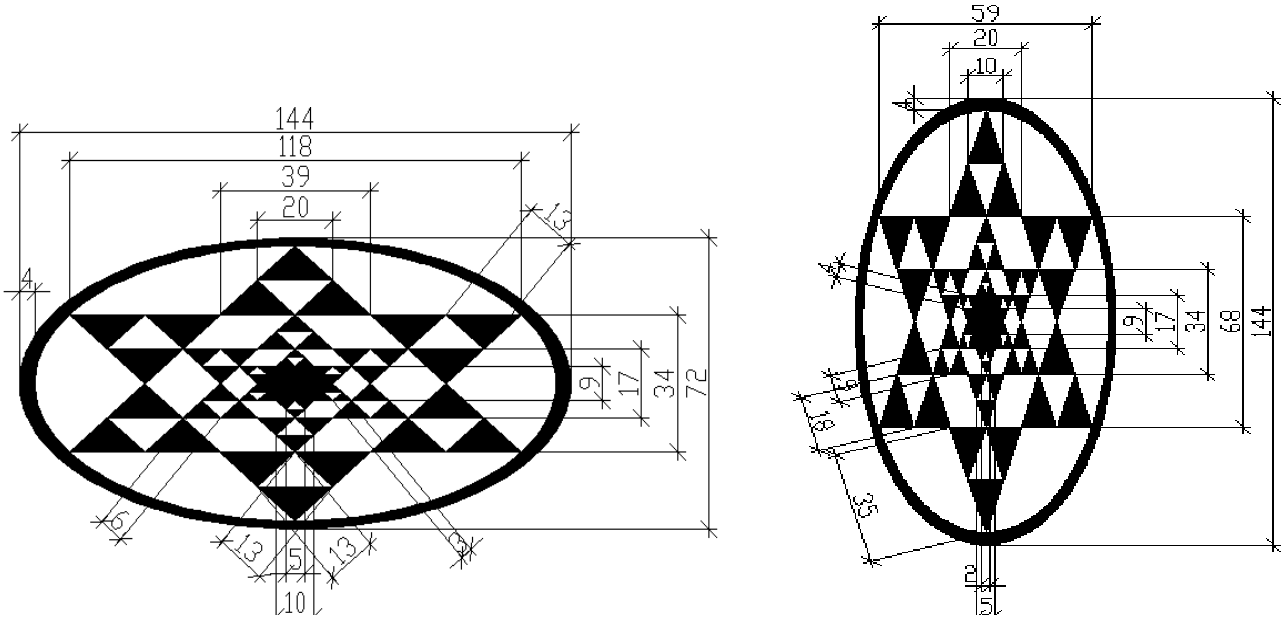

Figure 2: Vertically and horizontally compressed fractal antennas

The simulation of fractal antennas is performed in the program "High Frequency Structure Simulator".

The dependence of SWR frequency is shown in Fig. 3 (solid line - the initial shape of the antenna; dashed line - compressed in the X-axis, two-dotted line - compressed in the Y-axis).

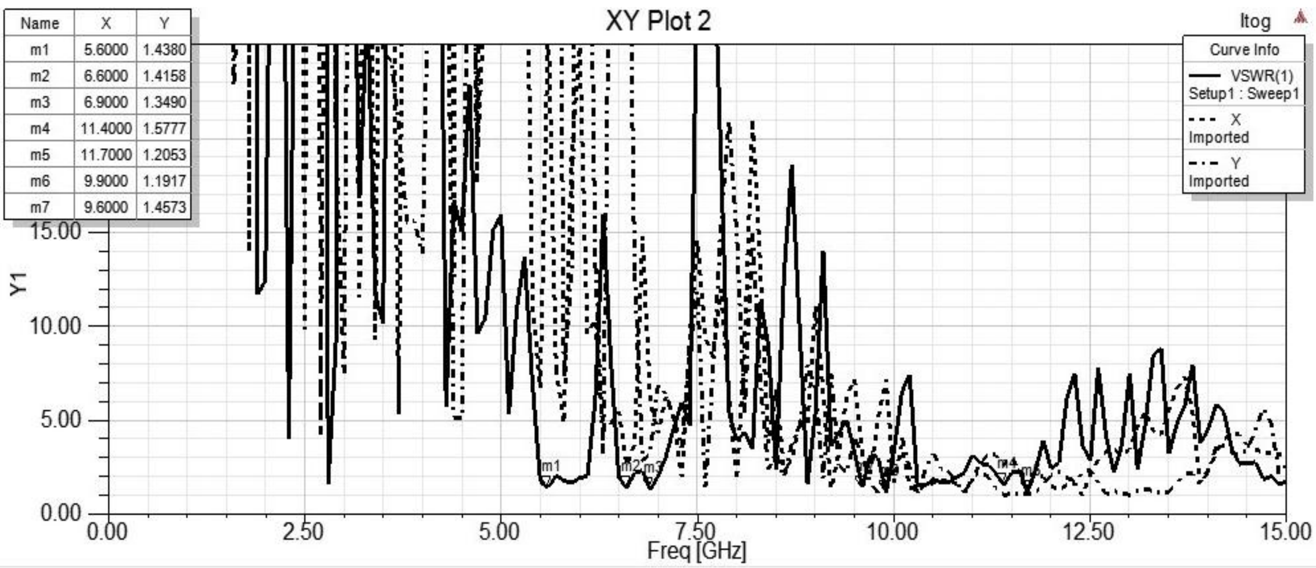

Figure 3: The dependence of the RSW from frequency for all forms of antennas

The analysis of the frequency dependence from SWR shows that bandwidth shift in the direction of increasing frequencies. This is especially noticeable in the shift fractal antenna two passbands located within a range from 5 GHz to 7.5 GHz, which are pressed together and shifted in the frequency range of 6 GHz - 7.5 GHz, and their SWR have increased. Overall SWR in the range of 0.26 GHz - 7.5 GHz have increased and there are less possible operating frequencies less in this plot are determined by the level of SWR no more than 5. At the same time in the frequency range of 7.5 GHz - 15 GHz is observed decline of SWR unevenness that demonstrates fractal antenna bandwidth, which has expanded to a range of 10.25 GHz - 12.25 GHz to 10 GHz - 13.5 GHz horizontally compressed fractal antenna and 9.25 GHz - 14.75 GHz for vertically compressed fractal antenna.

The changes of active and reactive antenna impedance versus frequency are shown in Fig. 4, 5 and 6.

The dependences show more strong change of resistance and reactance versus frequency at frequencies below 7.5 GHz for both compressed fractal antenna vertically and horizontally compared with the initial form. At the same time vertically compressed fractal antenna reactance undergoes small oscillations in the vicinity of ± 40 Om, and the active in the region of 50 Om in most modeling range greater than 7.5 GHz, which determines the bandwidth of fractal antennas in this range.

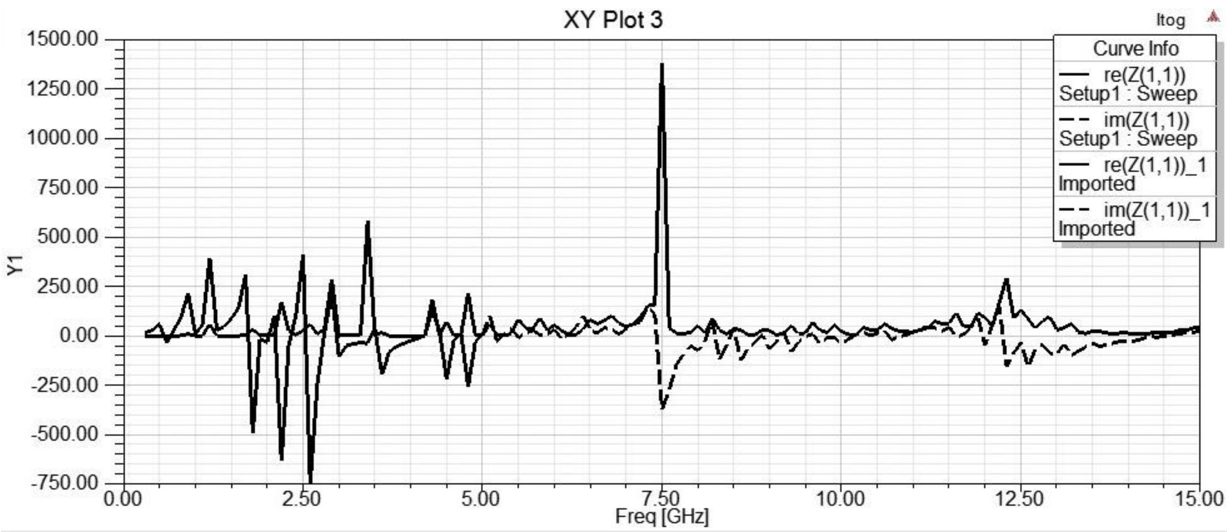

Figure 4: The dependence of the resistance from the frequency for the initial geometric shape of the antenna

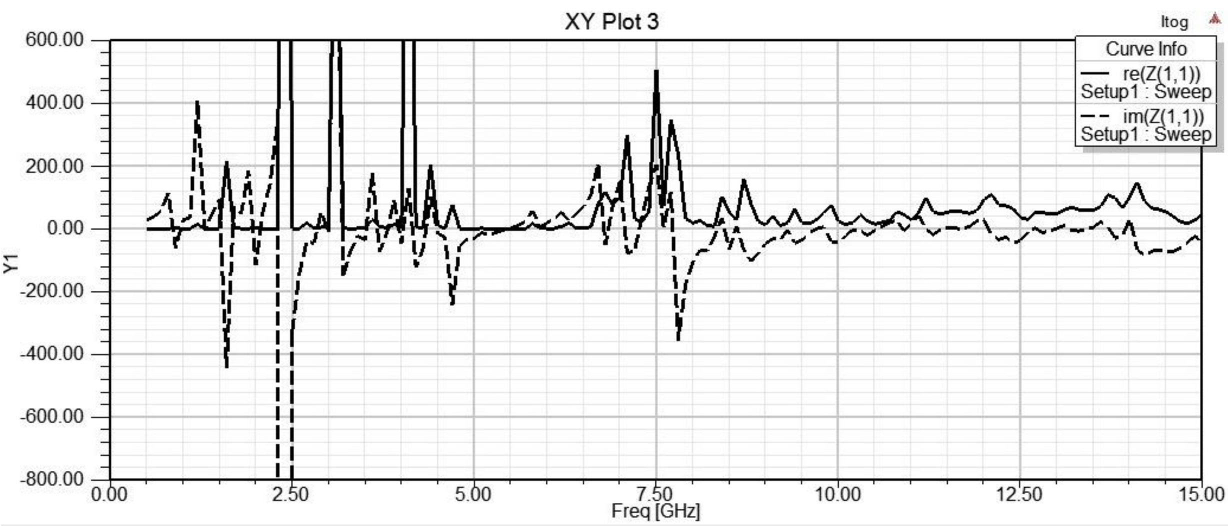

Figure 5: The dependence of the resistance from the frequency of the vertical compressed antenna

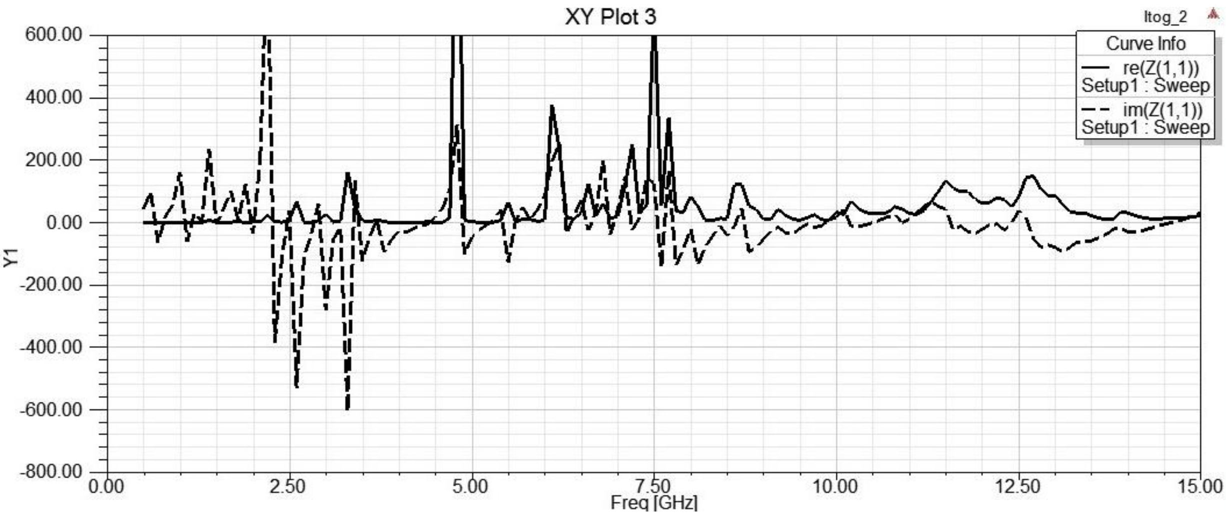

Figure 6: The dependence of the resistance from the frequency of the horizontal compressed antenna

CONCLUSION

The using of affine transformation compression to change the shape of the fractal antenna for placing it on the robotic machines is possible. Thus it is necessary to take into account the deterioration of fractal antenna characteristics in the lower part of the bandwidth. For wideband communication systems most suitable upper part of the bandwidth at which the fractal antenna characteristics are stable over a wide frequency range.

As the lower limit of the operating frequency is determined by its perimeter, it is necessary to consider the possibility of compensation by the "stretch" affine transformation for perpendicular affine transformation axis of "compression" to the perimeter has remained constant, however, such a conversion may not be possible by the restrictions on overall dimensions design robotic machines so in this article is not considered.

During the placing the robot on a fractal antenna design it is also must to consider the power point and the fractal antenna which is below in the simulation of antennas (as shown in Fig. 1 and 2) as an affine transformation on the vertical compression axis Y gave the best performance compared to a horizontal axis H.

REFERENCES

[1] Gupta, A., Chawla, P., June 2015, "Review On Fractal Antenna: Inspiration Through Nature", International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-4, – p. 508-514.

[2] Verma, S., Verma, A., September 2014, "A Review of Miniature Fractal Antenna Design for Wireless Communication", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 3, Issue 9.

[3] Kundarapu, V., Mathews, J., Sharma, S., Wagh, H., Prof. Patil, P., April 2014, "An Overview of Different Patch Antennas with Structural Defects to Achieve Multiband Characteristics" Journal of Applied Engineering and Technologies, Issue 1, – p. 14-17.

[4] Lavanya, M., Sivaranjani, S., July 2015, "Star Fractal Antenna and Triangular Slots Embedded with DGS for Super Wide Band Applications", International Journal of Engineering Trends and Technology (IJETT), Volume 7 – p. 39-43.

[5] Kingsley, N., Anagnostou, D., October 2007, "RF MEMS Sequentially Reconfigurable Sierpinski Antenna On a Flexible Organic Substrate with Novel DC-Biasing Technique", Journal of Microelectromechanical Systems, IEEE.

[6] Waladi, V., Mohammadi, N., 2013, "A Novel Modified Star-Triangular Fractal (MSTF) Monopole Antenna for Super-Wideband Applications", IEEE Antennas and Wireless Propagation Letters, Vol.12, – p. 651-654.

[7] Singh, H., Kaur, S., September 2015, "Bandwidth and Gain Enhancement of Star – Triangular Fractal Monopole Antenna", International Journal of Engineering Trends and Technology (IJETT), Volume 27, Number 1 – p. 46-50.

[8] Singh, H., Kaur, S., 19th-20th Dec. 2014, "Star-Triangular Fractal Monopole Antenna for Super-Wideband Applications", Proc. ICRIET, Amritsar.

[9] Abdrahmanova, G., 2013, "Fractal UWB antenna is based on the circular monopole", Radio-electronics, # 8. `

[10] Marsh, D., 2005, "Applied geometry for computer graphics and CAD", Springer-Verlag London Limited, 2nd ed.