SPHERO-CONICAL SPIRAL ANTENNA

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Abstract

The mathematical model of radiation characteristics of the sphero-conical helical antenna in the form of extending conductors is offered. This model allows not only to simplify an essentially calculation, but the analysis of similar structures. The results of theoretical and experimental research of the sphero-conical helical antenna are also discussed in the paper.

Keywords: sphero-conical helical antenna, mathematical model, radiation characteristics, polar pattern.

1. INTRODUCTION

The choice of antenna's structure is carried out in agreement with a number of requirements in the development of modern systems of satellite communication, systems of data transmission, systems of communication with mobile objects. The basic requirements are stability of radiation characteristics in an operating range of frequencies, circular polarization of radiation, a high degree of the coordination with a having feeder and also minimal mass-overall parameters.

From the point of view of all these requirements, the use of spiral antennas [1] is effective. The maximal uniformity, both characteristics of radiation, and entrance characteristics, is achieved by using sphero-conical spiral aerials as an extending conducting strip (the relative radius of a conductor remains constant on all length of the aerial). Such antennas show good results in practice, however a theoretical research is mathematically complicated.

Therefore a mathematical model of calculation of radiation characteristics of the sphero-conical spiral antenna as extending conductors is offered in the paper. The results of theoretical and experimental researches, confirming legitimacy of mathematical model, also are submitted.

2. MAIN PART

2.1. THE GEOMETRICAL DESCRIPTION OF A SPHERO-CONICAL SPIRAL RADIATOR

It is necessary for the geometrical description of volumetric spiral structure:

- To describe mathematically a surface of rotation on which the spiral structure will be reeled up. For this purpose it is necessary to set the envelopes of this surface.
- To set a spiral structure on a plane.
- To project a flat spiral structure on the given surface of rotation.

The antenna consists of a conical spiral radiator combined with a spherical spiral radiator on the side of small radius of a cone. The spherical radiator is used as a having line for a conical radiator. The given construction (Fig. 1) allows to reduce the lengthwise sizes of a conical radiator appreciably.

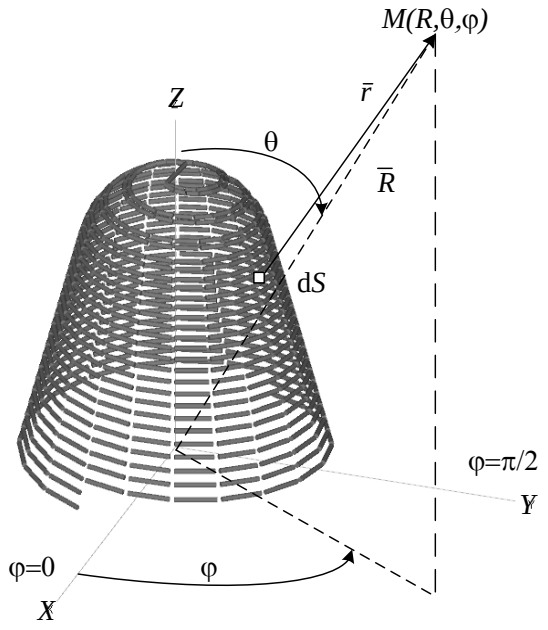

Fig. 1. Geometry of sphero-conical spiral antenna in fine-wired approximation.

2.2. MATHEMATICAL MODEL OF RADIATION FIELD

It is necessary for the mathematical description of radiation field of spiral structure:

- To set geometry of the structure in the Cartesian coordinates *x, y, z*.
- To calculate differentials of these coordinates.
- To set the law of distribution of a current along the structure depending of specified coordinates.

Taking into account a principle of superposition of electromagnetic fields the method of decomposition can be used. Thus complex antenna's system can be presented as a set of discrete radiators. For example, in a case of multithread spiral antenna, separate threads of a spiral can be used as separate radiators. And radiators, generally, can have a various form, be any way located in space and be excited with various amplitude -phase ratios.

Then, radiation field of a complex antenna's system can be found summarizing fields from all radiators forming the antenna. Composition of the components of the vector potential, describing intensity of an electric field of the antenna, it is expedient to carry out decomposing them on components in the Cartesian system of coordinates

The given mathematical apparatus allows to calculate characteristics of radiation of spiral antennas of any configuration in fine-wired approximation. However the prototype antenna is executed as an extending flat strip [2]. It is offered to present a flat extending strip as two wire radiators conterminous with borders of a strip (Fig. 1) for carrying out of calculation.

2.3. THE RESULTS OF RESEARCHES OF CHARACTERISTICS

Design data of a sphero-conical spiral radiator have been chosen on the basis of the results of theoretical and preliminary experimental researches. The prototype of the conical spiral antenna with which experimental researches were carried out is executed with the geometrical parameters: an equiangular two-thread helix [3]; angle of conicity θ_0 = 10 degrees; perimeter of a dimensional circle in the basis of cone P_{max} = 0,32 m; initial radius ρ_0 = 0,015 m; amount of coils of a spiral n_{con} = 5. Parameters of sphere: R_s = 0,019 m, amount of coils n_s = 2.

Excitation was carried out in antiphase in the top of sphere through the balancing device.

Theoretical (solid line) and experimental (dotted line) polar patterns (Fig. 2) of horizontal polarization of a radiation field are measured on the limits of an operating range of frequencies.

3. CONCLUSION

As a result of this work it is established, that the received geometrical description of the sphero-conical spiral antenna allows to calculate the sizes for practical realization of a radiator for work in the set range of frequencies, and the mathematical description - is correct to describe a radiation field of the developed antenna.

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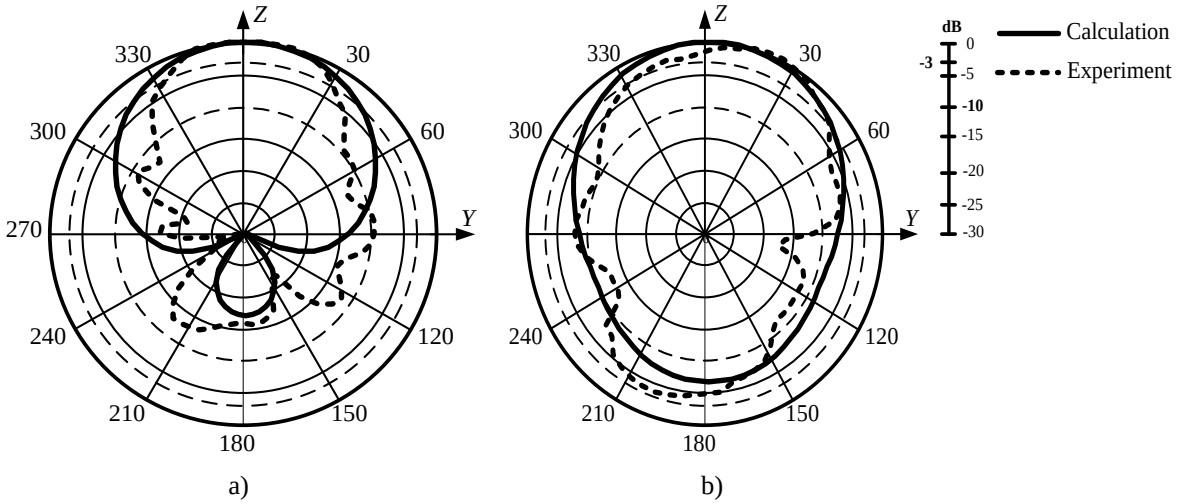

Fig. 2. Polar patterns: a) 2600 MHz; b) 1600 MHz.