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THE FEATURES OF THE CALCULATION OF SCATTERED ELECTROMAGNETIC FIELDS AND DESIGN OF ELECTRODYNAMIC OBJECTS

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The paper discusses some peculiarities associated with the evaluation of scattered electromagnetic waves and the design of objects. A comparative analysis of waveguide and integrated approaches. Specify the criteria by which methods are selected. The obtained results can be useful when building systems to investigate the scattering properties of various objects.

Key words: propagation of electromagnetic waves, design of objects, methods.

One of the tasks of great importance in the development of technology, is the study of the scattering of electromagnetic waves in hollow structures of various sections and shapes in radar range of wavelengths in the resonant region.

In this case, the characteristic size of entrance holes (apertures) hollow structures range from one to ten wavelengths of the incident electromagnetic waves.

When modeling the scattering of electromagnetic waves in hollow structures using the method of integral equations there are two possible approaches: a waveguide and diffraction. The first approach is characterized in that the hollow structure is provided in the section of the waveguide (or waveguide sections connected to each other).

These waveguides can be part of different power circuits of the antenna-feeder tracts, microwave devices and so on. The theory of regular and irregular waveguides as an independent discipline in applied electrodynamics had the opportunity development through the practical need to build a transmission line of the microwave range and the construction of radar equipment.

When you build the circuitry systems were used for the study of waveguide transmission lines – significant results were obtained already in the 1960-ies of the 20th century.

Mathematical modeling allows to take into account the features of propagation electromagnetic waves inside the antenna-feeder tract, given its curves and reflection of electromagnetic waves from the body, is placed inside the waveguides. So in waveguides can be different aperture probes, the cracks. Mathematical methods used to calculate waveguides of different types, is given in the extensive literature.

There is the possibility of using the method of integral equations to determine the modal coefficients for the waves propagating inside the hollow structure, and the calculation of their eigenvalues (i.e., to solve the internal electromagnetic problem).

Already existing electromagnetic waves it is possible to obtain a complete picture of the propagation of electromagnetic waves in single-mode and multimode bands.

Since structures in practice have a fairly complex form, then strict mathematical model allows to obtain the information that it is difficult to obtain from experiments, or to receive based on approximate methods.

The paper presents several criteria for determining the applicability of existing methods for solving problems of scattering of electromagnetic waves in waveguides of different cross sections and forms:

1) the effectiveness of the method for waveguide of arbitrary shape.

2) the existence of the method of computation of the first few modes, in addition to the fundamental mode;

3) the existence of a method of calculating the distribution of electromagnetic fields and the critical wave number of the waveguide;

4) the accuracy of the method;

5) the existence of working computer programs.

Based on the analysis of existing domestic and foreign literature it can be concluded that the method of integral equations in the vast majority of cases meets the above criteria, which explains its widespread use in modeling a variety of antenna-feeder devices.

When using the diffraction approach the hollow structure is considered as a body of

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complex shape, in which the scattering of electromagnetic waves.

The method of integral equations when considering hollow structures (and other objects), is a rather cumbersome method, often requiring large resources, like other numerical methods.

However, if we consider structures that are bodies of revolution, the most successful is a combination of methods of integral equations and eigenfunctions.

The main role is played by the angular, or azimuthal coordinate φ. For this coordinate the required fields, as when using the method of eigenfunctions, are decomposed in Fourier series, and the field of individual harmonics because of the orthogonality be independent.

This allows for each azimuthal harmonic to build a relatively simple integral equation which is solved numerically.

This reduces the dimensionality of the electrodynamic problem is solved and reduced requirements for the amount of machine memory and computation time of electromagnetic waves.

But in many cases, hollow structures are not bodies of revolution and may be complex. In this case, it is necessary to solve the integral equation taking into account the nature of the change of each portion of the surface of the structure.

Of course, will increase significantly and time accounts, and the amount of required computer memory. But this approach has its advantages:

1. Based on the considered methods we get the opportunity to carry out modelling of dispersion of electromagnetic waves in hollow structures of various shapes, cross sections, taking into account the dielectric inclusions on the surface of this structure.

2. In contrast to existing waveguide methods, it appears possible to analyze the electromagnetic field reflected from the outer surface of the hollow structure. Next, you will also a comparison of the results of calculations based on the considered methods with the results of calculations based on the modal method.

3.The size of the structure may be such that a single element may be sufficient machine resources, but can then be used approaches to assess the characteristics of several such elements combined into a group.

The results of the calculations of the radar characteristics of hollow structures are used in calculating and evaluating the characteristics of radar antennas and antenna systems.

Integral equations for one body can be generalized to a system telephone under the integration domain and the domain of variation of the observation point in this case should be understood the surface of not one but set of bodies and these bodies can contain dielectrics on its surface. In the analysis of diffraction on many objects is a special case of the problem of diffraction on periodic structures.

However, there is a possibility of reducing the dimension of the problem.

The combination of the method of integral equations to the theory of periodic structures allows one to calculate the characteristics of two-dimensional periodicity of the combs with a dielectric waveguide.

This structure can be used to create a planar microwave antennas of diffraction with electronic polarization control.

It is possible to calculate similar structures on the basis of approximate or heuristic approaches, but they have poor versatility.

The analysis shows that in practice there are hollow structure, extended in a certain direction and having a uniform cross section along this direction. In mathematical modeling of such structures can be represented in the form of a segment of a homogeneous waveguide cross-section. This model is one of the simplest models of cavities included in the composition of real objects. On the other hand, this model allows for the rigorous modal analysis of the fields inside the hollow structure. The field inside the structure is represented as a decomposition by a known waveguide modes. The unknown modal coefficients are at the basis of the reciprocity theorem.

When calculating the scattered field of this class of hollow structures with rectangular and circular cross-section, as is known from the literature, a modal method was used. The structure of modern object technology also includes a large number of hollow structures with the cross-sectional shape close to an elliptical (e.g., input and output nozzles, antenna on-Board radio-electronic complexes, the waveguide emitters included in the composition of phased antenna arrays, etc.). The most fully investigated phased antenna arrays of waveguides of rectangular and circular cross sections, however, using the known advantages of the waveguides of more complicated cross-section is elliptical, you can improve speed, energy and polarization characteristics in a wide angle sector scan. By varying the shape parameters of the waveguide it is possible to obtain while developing an additional degree of freedom for matching of the

radiator with free space. Use emitters of different absorbing coatings reduces the reflection coefficient in a large enough sector of the scan when negotiating an antenna array with free space.

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ОСОБЕННОСТИ РАСЧЕТА РАССЕЯННЫХ ЭЛЕКТРОМАГНИТНЫХ ПОЛЕЙ И ПРОЕКТИРОВАНИЯ ЭЛЕКТРОДИНАМИЧЕСКИХ ОБЪЕКТОВ

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В работе обсуждаются некоторые особенности, связанные с оценкой рассеянных электромагнитных волн и проектированием объектов. Проведен сравнительный анализ волноводного и интегрального подходов. Указаны критерии, по которым отбираются методы. Полученные результаты могут быть полезны при построении систем, позволяющих исследовать рассеивающие свойства различных объектов.

Ключевые слова: распространение электромагнитных волн, проектирование объектов, методика.