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The use of genetic algorithm for construction objects with necessary average values scattering characteristics

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Abstract

In the paper we consider the possibility of constructing models of objects that have the maximum average values of the characteristics of scattering at a certain sector of angles. For optimization of these characteristics we use genetic algorithm. We developed algorithm on the base of the dependencies of the characteristic dimensions of a hollow structure with a maximum average values of the characteristics of scattering were calculated.

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Keywords: hollow structure; optimization; genetic algorithm; integral equation; characteristics of scattering.

1. Introduction

In some cases it is necessary to know not the angular dependence of the scattering parameters and their average values in certain sectors of the viewing angles. The literature provides data for the average radar cross section (RCS) values of some objects. Based on the analytical formulas for bodies of simple shape it is possible to obtain analytical expressions of the average values of RCS from the size of the object. In the general case the calculation of the scattering parameters is performed with the use of numerical methods[1,2,3].

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It is of practical interest to construct a fairly simple algorithm for calculating the sizes of objects with maximal average values of scattering characteristics of a specific sector of observation angles[4,5,6]. For bodies of simple shape dependence of the maximum of the average values of the characteristics from the dimensions of bodies can be written analytically. This paper addresses the problem of determining the maximum of the average values of the scattering parameters for the two-dimensional model of the hollow structure[7,8,9]. The analytical dependence of the maximum of the average values of the scattering parameters from the dimensions of the object in this case cannot be derived, however, there is the possibility of constructing the approximate function (interpolating polynomial), allowing to obtain an approximation of this dependence at sufficiently small error[11-16].

2. The model

Illustration of our proposed approach will be conducted in the framework of the two-dimensional model. It is known that two-dimensional model of the hollow structure can be used to estimate the scattering characteristics of hollow structures with rectangular cross section[17,18,19]. Let the dimensions of the hollow structure L_1, L_2, L_3 (Fig. 1). Then, the total value of the loop structure $L= L_1+L_2+L_3$. As the characteristic size, select the size of L_1+L_3. It is necessary to find L_1+L_3, and L, for which the average RCS at specified sectors of the angles $\Delta\theta$ reaches the maximum values. The angle θ measured from the normal to the aperture of the cavity.

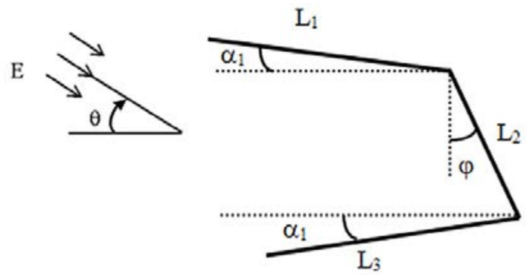

Fig. 1 Scheme of the scattering of electromagnetic waves on a hollow structure with the size L_1, L_2, L_3, the load has a slope at the angle of φ.

The sector angle was varied in wide range: $5° \le \Delta\theta \le 90°$, that is considered the area of the front hemisphere. The calculation of the scattering parameters was based on the method of integral equations. A strict calculation method was performed due to the following reasons:

1) the size of the object was varied over a wide range, including in the low frequency region;

2) On the basis of approximate analytical methods to obtain an acceptable estimate only for values of RCS in the area of local highs chart backscattering. The lows and back scattering error can be many tens of dB.

Fredholm equation of the first kind for the density of the unknown electric current in the case of E-polarization the following:

For Fredholm equations of the first kind that contains the unknown density of the electric current in the E-polarization[20], we can write the following expression:

$$\frac{\omega\cdot\mu}{4}\cdot\int_{\alpha}^{\beta} j(t)\cdot H_0^2[k\cdot L_0(\tau,t)]\cdot\sqrt{\xi'^2(t)+\eta'^2(t)}dt = E_z^0(\tau)\,,\ \alpha\le\tau\le\beta\,, \quad (1)$$

where $L_0(\tau,t)=\sqrt{[\xi(\tau)-\xi(t)]^2+[\eta(\tau)-\eta(t)]^2}$ - represents the distance between the observation point and the point of integration. $E_z^0(\tau)$ – denotes the longitudinal component of the tension of the primary electric field for points on the contour. The contour is specified in a parametric form: $x=\xi(t),\ y=\eta(t),\ \alpha\le t\le\beta$ and are the first derivatives of the corresponding functions, $k=2\cdot\pi/\lambda$, λ – length of the incident electromagnetic wave.