ISSN 0735-2727, Radioelectronics and Communications Systems, 2014, Vol. 57, No. 6, pp. 244–253. © Allerton Press, Inc., 2014.
Original Russian Text © G.S. Zalevsky, O.I. Sukharevsky, 2014, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2014, Vol. 57, No. 6, pp. 13–25.

Calculation of Scattering Characteristics of Aerial Radar Objects of Resonant Sizes Based on Iterative Algorithm

G. S. Zalevsky* and O. I. Sukharevsky**
Kharkiv Air Force University, Kharkiv, Ukraine
**e-mail: g_zalevsky@rambler.ru*
***e-mail: sukharevsky@euro.dinos.net*
Received in final form April 11, 2014

Abstract—The paper considers a method for calculating the scattering characteristics of aerial radar objects of resonant sizes and complex shape, the surface of which can be assumed perfectly conducting. This method is based on applying an iterative algorithm for solving the magnetic field integral equation. The developed method allows obtaining stable results in the case of large-dimensional matrices of integral equation and provides for the elimination of internal resonances caused by the idealization of mathematical model. Peculiarities of the developed numerical algorithm are discussed. The calculation results of the effective cross-section of test object obtained by different methods were compared. In addition, the calculated range profiles of cruise missiles in the VHF band are presented.

DOI: 10.3103/S0735272714060028

INTRODUCTION

One of the techniques for increasing the level of secondary radiation of aerial radar objects is the use of probing signals corresponding to the resonance wavelength band. The VHF band radars are an effective means for obtaining radar data about such objects of resonant sizes as missiles, drones, and small aircraft. In addition, the existing radar-absorbing coatings are inefficient in the specified band. For many years the investigations have been underway for the possibility of recognition of objects on the basis of using their natural complex resonances (in theory not dependent on the aspect of object) that makes it possible to reduce the number of parameters in the algorithm of identification [1, 2].

The extension of information capabilities of radar aids and creation of effective algorithms for reflected signal processing involve the need of investigating the scattering characteristics (SC) of real aerial objects. In this case different methods of mathematical simulation are used: FDTD method [3, 4], surface integral equations (IE) [5–20], and also high-frequency asymptotic methods [21–24].

FDTD method can be applied for the simulation of SC of objects having the complex shape if only the object sizes are quite small. The high-frequency methods, in effect, allow solving the problems of scattering on electrically-large objects with sufficient accuracy. The IE method is the most exact and universal one making it possible to obtain exact solutions of scattering problems for aerial objects of resonant sizes and complex shape in a wide range of electric sizes.

The methods are applied for determining the densities of surface electric current that are based on solving IE of magnetic field (MFIE) [5, 6, 8–12, 14–19], electric field (EFIE) [5, 6, 11–14, 17, 20], and also based on linear combination of these equations, i.e. combined field IE (CFIE) [5, 10–12, 20]. The solving of IE generally involves the application of the method of moments [5–7, 11, 12, 20] using the RWG (Rao–Wilson–Glisson) [8, 9, 11, 12, 17] or other [10, 16–18] functions.

Nowadays the calculation of SC of objects having a relatively simple shape is an easy job. In particular, a method for solving MFIE was proposed earlier in paper [15] making it possible to calculate SC of objects having simple shape and of a simplified model of cruise missile (CM) in a narrow frequency range. The transition to more realistic models of aerial objects having complex shape and the need of extending the frequency range for applying the IE method lead to a series of computational difficulties. The surfaces of real objects may contain elements, the electric dimensions of which change in a wide range. Such elements include edges and electrically thin parts in combination with bulk ones. The most detailed descriptions of advantages and disadvantages of using MFIE, EFIE, and CFIE for calculating SC of complex objects are presented in [12, 17].