ISSN 0735-2727, Radioelectronics and Communications Systems, 2016, Vol. 59, No. 4, pp. 184–193. © Allerton Press, Inc., 2016.
Original Russian Text © S.V. Marchenko, V.M. Morozov, 2016, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2016, Vol. 59, No. 4, pp. 50–60.

Electrodynamic Calculation of Infinite Plane Waveguide Phased Array Antenna with External Dielectric Sheets

S. V. Marchenko[1*] and V. M. Morozov[2]**

[1]*Dneprodzerzhinsk State Technical University, Dneprodzerzhinsk, Ukraine*
[2]*Dnipropetrovsk National University, Dnipropetrovsk, Ukraine*
**e-mail: smars@inbox.ru*
***e-mail: morozovvmu@mail.ru*

Received in final form July 15, 2015

Abstract—Using the penetrating area technique we have considered the solution of three-dimensional diffraction problem for an infinite plane phased array antenna consisting of rectangular waveguides with location in the form of a triangular mesh in the presence of plane-layered dielectric filling. The article presents the results, which confirm the correctness of the developed algorithm for electrodynamic calculation.

DOI: 10.3103/S0735272716040063

INTRODUCTION

In practice, one often utilizes phased array antennas with radiators in the form of open-ended rectangular waveguides. According to the number of following reasons, this type of radiating element is suitable for the phased array antennas of the centimeter wave band. It forms a natural extension of the waveguide sections, in which the phase shifters are placed, and it allows one to operate at a high level of the transmitted power. Its characteristics can be previously calculated, which plays an important role in the development process of the phased array antenna. In the large plane phased array antennas the main part of the central area elements is almost uniform in their characteristics and the behavior peculiarities are quite accurately described by the behavior of the infinite array antenna radiators [1].

PROBLEM STATEMENT

In this paper we consider the problem of electromagnetic wave diffraction by the plane waveguide phased array antenna with dielectric coating sheets, which performs the *H*-plane scanning. In order to solve the three-dimensional problem we utilize the penetrating area technique (PAT), which takes into account the dielectric filling. This three-dimensional problem possesses its inherent peculiarities of the integral equation generation compared with the similar problem in the case of dielectric filling absence, as well as the differences in terms of calculation of the normal components of the electric field vector in dielectric sheets based on the equivalent tangential components of external radiation space.

Figure 1 demonstrates the geometry of the infinite plane waveguide phased array antenna with dielectric coating sheets. Let us divide the entire complex domain of the field determination in the selected cell into two areas [2], taking into account the dielectric filling: area I refers to the regular waveguide with dielectric filling (ε_1–ε_4), partial areas II, III, IV refer to the "Floquet channel", namely the external radiation space, which is filled by dielectrics with ε_2, ε_3, $\varepsilon_4 = 1$, respectively.

Using the approach from [2], we obtain an integral representation for the determination of the complete field penetrating the areas. In order to take into account the dielectric filling (for the obtaining of Green's function, external field source) we will utilize the technique proposed in [3].

SOLUTION ALGORITHM

Taking into account the equality of fields in common area of the intersection, in the expressions under integral sign we set equal the electric field vector of the penetrating area $\vec{E}^{\mathrm{I}(n)}(x', y', z')$ and the electric field