

# **Electromagnetic waves propagation in the Earth-Ionosphere waveguide in the presence of strong disturbances of the upper boundary impedance**

**L.P. Kogan**, G.I. Grigor'ev and T.M. Zaboronkova

Radiophysical Research Institute, Nizhny Novgorod, Russia

We consider the propagation of VLF electromagnetic waves in the Earth-Ionosphere wave-guide in the presence of the sufficiently strong inhomogeneities of the dielectric permeability of the filling medium or the upper boundary impedance. The reasons of the appearance of such inhomogeneities may be high power radio waves radiated by ground-based sources, the energetic electrons precipitation, internal gravitational waves, sun eclipses, the area of the terminator, turbulent flows in the ionosphere and so on.

Mathematically such problem can be reduced to the solution of the Helmholtz equation with boundary conditions given on the upper and lower guide walls. For solution of this equation we use the method based on the applying the conformal transformation and differential operator of a special kind. As a result we go over from the initial problem with the Neiman boundary condition to the problem with the Dirichle zero boundary condition. By mean of the geometric optic method we obtain the attenuation function of the field [1]. We result that the module of relation of the disturbed field to the undisturbed field turn out to be proportional to the amplitude and length of the impedance inhomogeneities and depends on the kind of impedance disturbance. Similarly to [1], we obtain that if the disturbance is in the form of several step function (free for example), the increase of the field is one or two orders for the case when the value of the amplitude of impedance disturbance is commensurable with impedance regular value.

Acknowledgment: This work was supported by the Russian Foundation for Basic Research (project # 04-02-16344).

1. Y.L. Alpert, V.L. Ginsburg, V.L. Feinberg. Propagation of electromagnetic waves of a low frequency over the Earth surface. M.: AN SSSR Press. 1953.