Method for Computation of VLF subionospheric Radio Wave Scattering by 3D Lower Ionosphere Perturbation

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We present the full-wave numerical-analytical method for 3D radio wave propagation problem solving. The surface impedance concept is used to model non-uniform Earth-ionosphere waveguide and a parallel-plate model is adopted whose boundaries for transmitter receiver path lengths less than 2000 km. We are constructing impedance waveguide model from given electron density $N_e(r,\varphi,z)$ and collision frequency $\nu_e(r,\varphi,z)$ altitude profiles allowing for the geomagnetic field for propagation path in question. The electrodynamical problem to be considered is radiation of electric dipole in the three-dimensional domain bounded by the surfaces S_g and S_i, characterized respectively by impedance $\delta_g = const$ and impedance tensor $\hat{\delta}_i(r,\varphi)$ with diagonal components $\delta_i^{(e)}$, $\delta_i^{(m)}$ and off-diagonal δ_{12}, δ_{21}. The surface S_i consists of two parts: S_{io} and S_p. The last one simulates the 3D lower ionosphere perturbation. A smooth shape and sizes of S_p may be arbitrary. In scalar approximation, neglecting the diverse (TM and TE) polarizations of electro-magnetic field coupling, the problem is reduced to surface integral equation for Hertz's vector component. The tensor element what is responsible for TM field scattering into TM, and defines the electrical properties of the upper wall of our model waveguide is $\delta = \delta^{(e)} - \frac{\delta_{12}\delta_{21}}{\delta^{(m)}}$. Using asymptotic ($kr >> 1$) high-precision integration along the transverse to the propagation path direction, we transform this equation to one-dimensional integral equation. This last one is solved combining semi-inversion method and the subsequent iterations. The proposed technique is useful for study of both small-scale and large-scale irregularities. Numerical results of VLF point source field diffraction from two different form S_p perturbations will be presented.