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MAXIMAL FREQUENCY OF REFLECTION OF A DECAMETER WAVE FROM THE SPHERICALLY STRATIFIED IONOSPHERE

V. P. Pashintsev, M. E. Solchatov, A. Ye. Kondrashin, and A. V. Senokosova

Affiliate of the Rostov Military Institute of Missile Troops, Stavropol, Russia

An analytical method is developed permitting to obtain rather simple expressions for calculating, with a small error, the maximal frequency of reflection of a decameter wave from the spherically stratified ionosphere — depending on the angle of incidence of the wave on the reflecting layer, altitude of layer's lower boundary, and half-thickness.

It is well known that the frequency (f_0) of an oblique decameter (DCM) wave, reflected from the plane-stratified ionosphere, is related to its angle of incidence (φ_0) on the lower boundary of the ionosphere layer, and to the frequency of the equivalent vertical wave (f_v), through the secant law, i.e., $f_0 = f_v \sec \varphi_0$ [1–3]. According to the latter, the maximal frequency of reflection ($f_0 = f_{max}$) is defined, for the critical frequency of the reflecting layer ($f_v = f_{cr}$), as $f_{max} = f_{cr} \sec \varphi_0$ [1, 3]. Here the altitude of reflection ($h = h_{ref}$) of the oblique wave is nearly coincident with the altitude of its maximum ionization ($h = h_{max}$) [3].

With regard for sphericity of the Earth and of the ionosphere, the f_0 magnitude, apart from f_v and sec φ_0, depends also on true altitude of wave reflection with respect to the lower boundary (h_0) of the layer $Z_{ref} = h_{ref} - h_0$, i.e., $f_0 = \psi(f_v, \varphi_0, Z_{ref})$. Accordingly, the maximal value $f_0 = f_{max}$ is defined in [1] by a similar relation, if we replace f_v and Z_{ref} by their maximum values f_{cr} and $Z_{max} = h_{max} - h_0$, i.e., $f_{max} = \psi(f_{cr}, \varphi_0, Z_{max})$. However, in conformity to [3, 4], in the spherically stratified ionosphere the largest altitude of reflection of oblique wave $Z_{ref\ max}$ does not coincide with the altitude of the ionization maximum Z_{max}, being located much lower ($Z_{ref\ max} < Z_{max}$). Because of this, the use of a rather simple analytical relation $f_{max} = \psi(f_{cr}, \varphi_0, Z_{max})$ from [1] may give considerable errors in the calculation of f_{max}. The true f_{max} values have been determined in [4] by a known technique, with regard for reduction of $Z_{ref\ max}$ against Z_{max} in the spherically stratified ionosphere. However, this technique deals with an extremely sophisticated and difficult for calculation analytical dependence of f_{max} on the angle of incidence (φ_0) of the wave on the spherically stratified ionosphere, and on its parameters (h_0, Z_{max}, f_{cr}). Because of this, it would be expedient to develop some analytical method permitting to obtain a simpler dependence $f_{max} = \psi(\varphi_0, h_0, Z_{max}, f_{cr})$ — as compared with [4], and giving a smaller calculation error than in [1].

The purpose of this paper is to develop a method and to estimate the error of analytical calculation of the maximal frequency (f_{max}) of reflection of decameter wave from the spherically stratified ionosphere as a function of the angle of incidence (φ_0) and of the parameters (h_0, Z_{max}, f_{cr}) of the reflecting layer.

The known [4] method of calculation of f_{max} in the case of parabolic model of the reflecting layer of the ionosphere reduces to treatment of an equation system

$$Z_{ref}^2 + 0.5Z_{ref}(a + Z_{ref} - 3Z_{max}) + 0.5Z_{max}\left[Z_{max}(f_0 / f_{cr})^2 - a - h_0\right] = 0,$$

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