The quantitative relation between the both varieties of VLF inverse problem solution with two free parameters

G. F. Remenets, V. V. Bondarenko *(Physics Department of Saint-Petersburg State University)*

According to the papers [1-3] in the conditions of the non-stationary low polar ionosphere there exist two approaches to the solution of VLF inverse problem. In the both approaches due to the relative quantity smallness of the measured input VLF data (5-6 magnitudes) only two parameters (as functions of time) characterising the bottom part of ionosphere are determined by the procedure of minimising the functional containing the differences between the measured and calculated data. In the first approach these parameters are: the complex reflection coefficient of radio waves from the low ionosphere varying intensively (according to the geophysical factors), in the second - two parameters due to which the low part of the ionosphere profile $N_e(z)$ (where z is the altitude) is approximated.

In the first approach it is more suitable to work with an effective height h of the ground-ionosphere wave guide instead of the complex reflection coefficient argument [4]. This h is an altitude of a top boundary of a ground-ionosphere wave guide with a homogeneous non-conductive medium inside and it is such a boundary relative to which the reflection coefficient (for vertical polarisation of e. m. waves) for a given frequency (12,1 kHz) is real and *negative*.

In the second approach (after the solution of the inverse problem) it is possible to state correspondence between an effective electron concentration profile for some fixed moment of the geophysical disturbance and an effective height h' for an effective wave guide relative to which the surface impedance is real (without an imaginary part) and below which the medium is not ionised [5]. In the frames of the approach being discussed it is possible to make so that one of a profile $N_e(z)$ parameter z_0 should coincide in its value (approximately) with the value of h' [6, 1, 2]. In the papers indicated the parameter z_0 is a junction point of two exponential functions.

If for the cylindrical special functions in the region near the top wave guide boundary to use the asymptotic approximations then the following Fresnel formula for plane electromagnetic waves is correct: $R = (\cos\psi - \delta_i)/(\cos\psi + \delta_i)$, where R is a complex reflection coefficient as a function of an incidence angle ψ relative to the top wave guide boundary which is characterised by an impedance δ_i. According to this correlation one sees that in the case of real δ_i and of inequality $\cos\psi \ll \delta_i$ there is an approximation $R \approx -1$. This fact explains the nearness (with the accuracy of one *km*) of the h and h' values achieved in the papers [1, 2].

According to the stated we have for our set of profiles the relation $h \approx h' \approx z_0$ [1, 2]. So the problem of finding of the two $N_e(z)$ parameters according to the two known parameters of the first approach becomes a problem of one parameter calculation, i. e. the problem of β parameter finding (where β is a gradient of the lowest profile part) according to the module of reflection coefficient R, corresponding to the first or the second ionosphere ray which is an incident one on the boundary with an altitude value equal to h (the distance between the radio emitter and receiver was near 900 *km*).

An iteration calculation process, in which the numerical calculation of Ricatty equation is used for the inhomogeneous (according to z) isotropic ionosphere [7], of finding such a β with which for the given ψ one gets the needed value of $|R|$ from the effective ionosphere profile $N_e(z, z_0, \beta)$ solves the problem indicated in the name of the work (with an effective collision frequency profile $\nu_{eff}(z)$ somehow fixed [5, 7]).

The pointed algorithm is possible to use for the analysis to the geophysical VLF disturbances for the radio traces of middle zone (600-1200 *km*) and for the frequencies 10-16 kHz if it is known that the effective electron concentration profile is monotonous [1, 2].

[1] Remenets G. F. Unique ground monitoring of relativistic electron precipitations, in «Problems of Geospace», Eds. M. I. Pudovkin, B. P. Besser, W. Riedler and A. M. Lyatskaya – Austria, Vienna: Austrian Academy Sci Press, 1997. P. 273-278. [2] Ременец Г.Ф. Исследование ионизации средней атмосферы высоких широт высокоэнергичными релятивистскими и ультрарелятивистскими электронами по СДВ экспериментальным данным // Вестник С.-Петербург. ун-та. Серия 4. 2001. Вып. 3 (No. 20). С. 23-38. [3] Ременец Г. Ф., Бондаренко В.В. Количественная связь между двумя вариантами решения обратной двухпараметрической СДВ-задачи. В кн.: Региональная IX конференция по распространению радиоволн. Санкт-Петербург, 2003. С. 68-69. [4] Белоглазов М. И., Ременец Г. Ф. Распространение сверхдлинных радиоволн в высоких широтах. Л., “ Наука”, 1982. [5] Галюк Ю.П., Иванов В.И. Определение характеристик распространения СДВ-полей в волноводе Земля -неоднородная по высоте анизотропная ионосфера. В кн.: Проблемы дифракции и распространения волн. Л.: ЛГУ, 1978. Вып. 16. С. 148. [6] Ременец Г. Ф. Двухпараметрическая модель профиля электронной концентрации, используемая для анализа высокоширотных СДВ-возмущений. В кн.: Распространение километровых и более длинных радиоволн. Тезисы докладов XVI межведомственного семинара. Омск, 1990. С. 41-43. [7] Рыбачек С. Т. О влиянии существенной области ионосферного слоя на характеристики распространения СДВ // Изв. вузов. Радиофизика. 1972. Т. 15. No. 9. С. 1300-1303.