CHARACTERIZATION AND SIMULATION OF HF PROPAGATION IN A REALISTIC DISTURBED AND HORIZONTALLY INHOMOGENEOUS IONOSPHERE

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Abstract:

The technique called the complex phase method extends the classical Rytov's approximation to the case of an arbitrary 3D inhomogeneous medium1. The extension is based on the formulation of appropriate representations for the complex phases of different orders in the ray-centered curvilinear co-ordinate systems together with the reference rays arising from propagation in a 3D smoothly inhomogeneous background medium. The problem of scattering of the wave field by local inhomogeneities, embedded in the inhomogeneous background medium, solved for the 3D case, then permits the treatment of a large number of practically important problems of HF propagation in a real 3D inhomogeneous ionosphere disturbed by deterministic and/or random local inhomogeneities. In particular, paths of propagation in a non-horizontally stratified ionosphere can be characterized in the scope of this technique. Thus, developing the method of solution of the scattering problem of HF fields in the ionosphere to the 3D case, has allowed the authors to substantially widen the technique of HF channel characterization of the real fluctuating ionosphere, which was previously developed and presented only for the case of a horizontality stratified background medium.

More recent work2 by the authors permits a very detailed and general characterization of the HF channel of propagation (including a horizontally inhomogeneous channel) in terms of both the statistical moments and random time series of the field. A pulsed signal propagated through the channel is represented by means of the frequency-domain technique. When the mean energy of the signal (or a more general quantity such as the scattering function of the channel) is constructed, the two-frequency, two-position (two-time) coherence function of the monochromatic components of a signal arises, which is constructed in the scope of the complex phase method, extended, as mentioned above, to the case of the 3D inhomogeneous background medium. These coherence functions are then employed both in constructing the statistical moments of a pulsed signal (mean energy, the scattering function) and for producing random time series of the signal. Random time series also appear as functions of slow time associated with the slow time (in terms of the propagation time of the signal) variations of the ionospheric random inhomogeneities. The above developed theory and methodology has also enabled the construction of a software simulator of the wideband (up to ~ MHz bandwidth) multipath

ionospherically reflected fluctuating channel of propagation, based on a purely physical model. Sample results from the simulator are presented for a channel including E and low and high angle F-modes.

1. V.E.Gherm, Yu.A.Gogin, N.N.Zernov, Diffraction of the wave field on weak inhomogeneities of the dielectric permittivity in 3-D inhomogeneous background medium (in Russian), St.Petersburg University Herald, series 4, issue 2 (^{1}12), 32-38, 2001)
2. V.E.Gherm, N.N.Zernov and H.J.Strangeways, HF Propagation in a Wideband Ionospheric Fluctuating Reflection Channel: Physically Based Software Simulator of the Channel, Radio Science, Vol. 40, No. 1, RS1001, doi:10.1029/2004RS003093, 2005

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