SIMULATOR FOR THE TRANSIONOSPHERIC CHANNEL INCLUDING STRONG SCINTILLATIONS

Strangeways Hal, N.N. Zernov, V.E. Gherm
Electronic Engineering,University of Leeds,Woodhouse Lane,Leeds,W. Yorks,U.K.

Abstract:

A new model for scintillation on transionospheric links (such as employed for satellite navigation) has been developed based on a hybrid method and has been utilized as the basis of a software transionospheric channel simulator. This method is a combination of the complex phase method and the technique of a random screen. In contrast to the random phase screen method, where the parameters of the effective phase screen are chosen to best fit a given set of the experimental data, in the new hybrid method, the parameters of the random screen, appropriately introduced below the ionosphere, are not chosen empirically but are the result of a rigorous solution to the problem of propagation inside the ionospheric layer.The procedure includes generating a 2-dimensional random screen below the ionosphere by means of the complex phase method. Its random 2-dimensional spatial spectrum is then transferred down to the Earth's surface employing the propagator written in terms of the Fourier variables conjugated to the transversal variables. Detailed investigations using the complex phase method have shown that, for the points inside the ionospheric layer, fluctuations of the amplitude of the field at frequencies of the order of 1 GHz, and higher, are always well within its range of validity, even for very large relative electron density fluctuations (up to 100%) and high values of the total electron content (TEC). Although the regime of strong scintillation may be found in the region below the ionosphere where the fields are propagating down to the Earth's surface, the rigorous relationships of the random screen theory are used to correctly convey the field down to the surface of the Earth in this region.The new technique is capable of producing statistical characteristics and simulating time realisations of the field (including regime of strong amplitude fluctuations) for a wide range of the input parameters including co-ordinates of the satellite and receiver, slant electron density profile along the path, zenith angle of a satellite, magnetic azimuth of the plane of propagation, magnetic field dip angle at the pierce point and parameters of the random irregularities. These latter include the spectral index, the outer scale of the irregularities along and transverse to the geomagnetic field, the variance of the fractional electron density irregularities and their drift velocity. Outputs from the simulation include the amplitude and phase variation over the random screen and on the ground, and in addition to the time realisation of phase, the differential of

this with respect to time. These outputs have been used to investigate how the amount of fading and scintillation and the resulting scintillation indices depend on the parameters of the irregularities as well as the path orientation. This information can then be compared with real data (e.g. variation of observed scintillation index with path orientation) in order to both validate the propagation model and enable the use of received data to infer irregularity parameters. Calculated scintillation indices of amplitude and phase have also been compared with scintillation index levels known to result in phase lock loss so that the conditions likely to result loss of lock can be better identified.