STATISTICAL PARAMETERS OF INTERFERENCE NOISE ABOVE A RANDOMLY UNEVEN INTERFACE

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Methods of statistical diffraction theory have been used to investigate the parameters of interference noise which arises in a tropospheric channel due to interfering reflections from an underlying surface. It has been assumed that the explicit form of the bistatic scattering cross section of radio waves by a randomly rough surface is known. The systematic errors in measuring the signal parameters, the energy spectra, and the variances of the fluctuations in the values of the parameters relative to their average values have been determined. The spectrum of the fluctuations in the bearing of a point source moving horizontally above a rough surface having mildly sloping roughnesses has been calculated.

In radar tracking of low-flying targets or radiation sources, a substantial role in estimating the parameters of their trajectory (bearings in two planes, range, and instantaneous speed) is played by the interference noise which appears as a result of reflection of the signal from the underlying surface. The resulting errors which develop in determining the parameters of the trajectory, the target recognition, and the target classification may greatly exceed the errors associated with atmospheric fluctuations of the refractive index and with the internal noise of the radioengineering devices. Calculation of the statistical parameters of this noise is a fairly complex problem in statistical radiophysics and radio-wave propagation theory. Fairly complete results have been obtained only in the simplest case of specular reflection when the underlying surface is considered to be ideally flat and the interference noise arises due to superposition of the signal from the target and from its specular reflection in the plane. The estimates given for the role of diffuse scattering were based on representing the signal reflected from the underlying surface as the sum of the contributions from individual scatterers (see [1]), the results obtained for multielement targets having a complex shape which are described as an ensemble of statistically independent reflectors being used for calculations of the statistical parameters of the signal fluctuations. Such an approach allowed certain general results to be obtained - for example, for the probability distribution functions of fluctuations in the target bearing, and permitted their first statistical moments to be related to the spatial distribution of the reflected-signal brightness (see [2]).

The present work derives formulas for the correlation functions and spectra of the fluctuations of the signal parameters in the presence of interference noise on the basis of solving the problem of the diffraction of waves by a statistically rough surface.

Assume the equation for the underlying surface S in a Cartesian coordinate system (x, y, z) has the form $z = \zeta(\mathbf{r})$, $(\mathbf{r} = \{x, y\})$. We shall assume that at the point $Q_1(0, 0, z_1)$ there is an observer (Fig. 1), and that at the point $Q_2(D, 0, z_2)$ there is a source of radiation moving at the velocity v_1 and v_2, respectively. The field U at the reception point may be written as the sum of the direct signal U_0 corresponding to the propagation of waves in free space, and the field U_s reflected from the rough surface S: $U = U_0 + U_s$. Assuming that the source radiates a spherically diverging monochromatic wave having a directivity pattern $G_2(\alpha_0)$, the field of the direct signal may be represented in the form $U_0 = [G_1(\alpha_0) \times G_2(\alpha_0)/D^{\sim}] \exp[i(kD^{\sim} - \omega_0 t)]$. Here α_0 is a unit vector in the direction toward the source; D is the inclined range to the source; G_1 is the directivity pattern of the receiving antenna; ω_0 is the angular frequency of the radiation; $k = \omega_0/c$ is the wave number. Assuming that the surface roughness is great enough compared to the radiation wavelength $\lambda = 2\pi/k$, the field of the signal U_s reflected from the surface (see [3, p. 264]) is written in the tangential-plane approximation:

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