Signal Reception Characteristics Estimation of Radar with Moving-Target Indication in Case of Turbulent Atmosphere

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Abstract—Signal reception characteristics of radar with typical moving-target indication systems in case of turbulent atmosphere with representative correlation radii for the wind velocity vector fluctuation are obtained.

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Previously analytic expressions were obtained [1] allowing to estimate radar’s signal reception characteristics during work in conditions of passive interference from turbulent volume-distributed weather formations. In this case according to [2] turbulent movement of reflecting particles is modeled using three-dimensional normal random process with exponential correlation function

\[ B(r_{x,y,z}) = \sigma_{x,y,z}^2 \exp(-r_{x,y,z} / R_{x,y,z}), \]

where \( \sigma_{x,y,z}^2 \) means wind velocity vector fluctuations dispersion with respect to coordinates \( x, y, z \); \( R_{x,y,z} \) stands for wind velocity vector fluctuations correlation radius with respect to coordinates \( x, y, z \); \( r_{x,y,z} \) denotes distance between turbulence sections with respect to coordinates \( x, y, z \).

True detection probability \( (D) \) is defined by [1]

\[ D(q_0^2, F) = \sum_{i=0}^{\infty} a_i(F)(q_0^2)^i \text{Coeff}_i, \]  

where \( a_i(F) \) mean power series expansion coefficients for function defining true detection probability; \( F \) is false alarm probability; \( q_0^2 \) stands for signal-to-interference ratio without accounting for turbulence; \( \text{Coeff}_i \) denotes correction coefficient determined by atmosphere parameters (radial component of average velocity \( (v) \), mean square deviation \( (\sigma_r) \), and wind velocity fluctuations correlation radius), radar parameters (wavelength \( (\lambda) \), antenna beam width \( (\Delta_{ant}) \), bang repetition period \( (T_{rep}) \)) and moving-target indication type.

The article aims to estimate the influence of wind velocity fluctuations upon radar detection characteristics using relations obtained earlier and assuming the use of a defined turbulence model.

Analysis for typical moving-target indication systems and representative wind velocity vector fluctuations correlation radius has been carried out.

Let’s mark out two stages of estimation process. At the first stage calculation relations will be simplified. As a result, expressions requiring determination of minimal parameters number will be obtained. This will allow to decrease the number of considered instances. At the second stage numeric computations will be performed.

STRONG CORRELATION OF WIND VELOCITY VECTOR FLUCTUATIONS
\( (R_{x,y,z} \text{ MUCH GREATER THAN RADAR RESOLUTION ELEMENT}) \)

It is well known [3] that in case of deviated antenna radiation pattern and laminar air masses flow the shape of resolution element’s Doppler spectrum replicates transmitting and receiving antennas radiation pattern squares product. Using this, expression for \( \text{Coeff}_i \) estimation in case of strong wind velocity vector fluctuations

\[ \text{Coeff}_i = \text{expression for Coeff}_i, \]