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Processing of Multifrequency Radar Signals

D. I. Popov
Ryazan State Radio Engineering University, Ryazan, Russia
ORCID: 0000-0003-0342-8208, e-mail: adop@mail.ru
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Abstract—Algorithms and systems of quasioptimal and suboptimal processing of multifrequency radar signals against the background of correlated and noncorrelated interferences have been considered. Functional block diagrams of the multifrequency signal processing systems are presented. The analysis of probabilistic characteristics of multifrequency signal processing systems has been carried out.

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INTRODUCTION

Coherent-pulse radar systems have found application for solving a wide range of tasks of the civil and defense nature [1]. However, a priori uncertainty of correlation characteristics of passive interferences and blind speeds of target essentially hamper the implementation of effective detection of moving targets that stimulates the innovative development of radar systems and methods of radar signal processing.

Overcoming of a priori uncertainty of interference parameters in accordance with methodology of adaptive Bayes approach is based on the replacement of unknown parameters with their consistent estimates that results in building adaptive algorithms and processing systems.

One of the techniques employed for eliminating blind speeds is the use of multifrequency signals that open additional possibilities of echo-signal detection allowing us to obtain a gain in the target detection range without increasing the total radiated power. To this end, the reflected components of multifrequency signal should be statistically independent that is achieved by an appropriate carrier frequency spacing selected from the condition of smallness of wave lengths corresponding to difference frequencies as compared to the radial size of the target.

An optimal algorithm of multifrequency signal processing against the background of passive correlated interferences including adaptive matrix filtering of samples of each frequency component with subsequent multichannel coherent accumulation of the matrix filtration results was synthesized in [2]. Estimates of elements of the matrix inverse to the correlation interference matrix are the weighting coefficients of matrix filter. The calculation of these estimates under conditions of a priori uncertainty is a time-consuming procedure complicating the implementation of optimal processing algorithms that results in the search for and building of simpler quasioptimal and suboptimal algorithms and systems considered below and using the vector rejection of passive interferences.

QUASIOPTIMAL PROCESSING OF SIGNALS

Optimal processing in each of M frequency channels of a sequence of N digital samples $U_{jl} = x_{jl} + \mathrm{i}y_{jl}$, $j = \overline{1, N}$, $l = \overline{1, M}$ repetitive with period T in one range resolution cell is reduced to the calculation of the minimum sufficient statistic $u_l(\theta_l) = |X_{0l}(\theta_l)|^2$ [2]. The latter follows from the likelihood ratio and is based on the algorithm of optimal linear filtration:

$$X_{0l}(\theta_l) = \sum_{k=1}^{N} \mathrm{e}^{-\mathrm{i}k\theta_l} Y_{kl} = \sum_{k=1}^{N} \mathrm{e}^{-\mathrm{i}k\theta_l} \sum_{j=1}^{N} \hat{w}_{jk}^{(l)} \mathrm{e}^{-\mathrm{i}j\hat{\varphi}_{\mathrm{i}}^{(l)}} U_{jl},\ l = \overline{1, M}, \tag{1}$$