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SYNTHESIS OF FILTERS FOR MULTICHANNEL DOPPLER PROCESSING OF SIGNALS

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The paper is devoted to synthesis of a multichannel filter based on such a criterion as maximum probability of proper detection of the signal, when the probability is averaged over Doppler channels. The gain in probability of correct detection with the use of the known and synthesized time windows makes up 15%. The comparative analysis of frequency properties of the synthesized and classical weighting windows is performed.

One of the ways to overcoming a priori uncertainty of Doppler frequency F_D of a reflected signal is the interperiod multichannel frequency filtering in the range of unambiguous determination of Doppler frequencies. Usually, the filtering of radar signals is preceded by weighting of time samples, allowing for lowering the side lobe level of amplitude-frequency responses of the channels. Optimization of the windows in every individual frequency channel prevents using the algorithm of fast Fourier transformation (FFT). The traditional windows [1], often called classical, are synthesized by the frequency criterion, which is related with energy redistribution between the main lobe and side lobes of the amplitude-frequency response (AFR). Hence, their application in a Doppler filter usually does not guarantee the optimality and high performance characteristics of the multichannel detector of the radar signal observed against interference background. Optimization of the filter by the energy criterion averaged in the channel results in the windows whose characteristics tend to optimal ones for the Doppler phase equal to π. This fact is associated with a substantial nonuniformity of the dependence of energy criterion on the signal Doppler phase [2].

The purpose of this work is optimization of the weighted processing to obtain the best characteristics of signal detection performed against the background of additive mixture of noise and interference.

The algorithm of multichannel filtering stems from the optimal processing algorithm defined by the expression for the sufficient statistic

$$\xi = \ln \lambda(x) = u^{\mathsf{T}} Q s$$

where $Q = R^{-1}_{\text{s-i-n}} - R^{-1}_{\text{i-n}}$ is the processing matrix while $R^{-1}_{\text{s-i-n}}$ and $R^{-1}_{\text{i-n}}$ correlation matrices of the signal-interference-noise or interference-noise mixture, respectively.

The processing becomes much easier if we introduce a limitation on the matrix Q appearance: represent is as a vector product $Q = w^{\mathrm{H}} w$, where $w = [w_i \cdot e^{-j\psi_i}]$ is the complex-valued column vector of processing of the linear digital filter, ψ_i is the angle of rotation for the repetition period, and H denotes complex conjugation and transpose.

In this event the minimally sufficient statistic (decision rule) takes the form $\xi = u^{\mathrm{H}} Q u = u^{\mathrm{H}} w^{\mathrm{H}} w u = |u^{\mathrm{H}} w|^2$ and includes calculation of convolution of the sequence u with the processing vector w, i.e., $\tilde{\xi} = u^{\mathsf{H}} w$.

Figure 1 shows a typical realization of a multichannel filter based on FFT algorithm providing for high computational efficiency.

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