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ANALYSIS OF SYSTEMS FOR DETECTION AND MEASUREMENT OF MULTIFREQUENCY SIGNALS

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The paper gives comparative analysis of detection characteristics of single-channel systems of processing of multifrequency signals against the white noise background, for different categories of interperiod processing (coherent or noncoherent) in the frequency channels. Also, analysis of accuracy of target's radial speed measurements is performed depending on the multifrequency signal parameters.

The synthesis of processing algorithms and of relevant multi- and single-channel (in Doppler's frequency) systems of detection and measurement of multifrequency signals was described in [1]. Analysis of multichannel systems was performed in [2]. In this work we give the comparative analysis of detection characteristics of single-channel systems of interperiod processing of multifrequency signals, and analysis of measurement accuracy of target's radial speed.

Analysis of detection characteristics. As in [1, 2], we use the statistical description of multifrequency signals, representing in each of L frequency channels a coherent sequence of N samples $U_j^{(l)}$ arriving at every repetition period T and comprising a set of vectors $\{U_l\} = \{U_1,..., U_L\}$, where the column vector $U_l = \{U_j^{(l)}\}^{\mathrm{T}}$, $j = \overline{1, N}$, $l = \overline{1, L}$. The distribution of statistically independent Gaussian signals and noise between the frequency channels is described in every frequency channel by the correlation matrix $R_l^{\mathrm{sn}} = q_l R_l^{\mathrm{s}} + R_l^{\mathrm{n}}$ for the signal and noise, and by the diagonal matrix $R_l^{\mathrm{n}} = R^{\mathrm{n}} = I$ only for the noise, whose entries, respectively, have the form

$$R_{jk}^{\mathrm{sn}(l)} = q_l R_{jk}^{\mathrm{s}(l)} + R_{jk}^{\mathrm{n}} = q_l \rho_l(j,k) \mathrm{e}^{\mathrm{i}(j-k)\varphi_l} + \delta_{jk}, \quad R_{jk}^{\mathrm{n}} = \delta_{jk},$$

where q_i is the signal-to-noise ratio for the lth frequency channel; $\rho_l(j, k)$ are the coefficients of interperiod correlation of the signal; φ_l is Doppler's shift of the signal phase during the repetition period T in the lth frequency channel; $\varphi_l = r_l \varphi_1$, where $r_l = f_l/f_1 < 1$ is the ratio between carrier frequencies of the lth and the first frequency channels; and δ_{jk} is the Kronecker delta.

The system, which is adaptive to Doppler's phase shifts of a multifrequency signal, performs, in each frequency channel, the single-channel coherent accumulation of products of complex conjugate successive samples $U_j^{(l)}$ with subsequent usage of consistent estimates $\hat{\varphi}_l$, particularly, the maximum likelihood estimates [1]. The block diagram of this system has been suggested in [3] while the processing algorithm has the form

$$u(\{\hat{\varphi}_l\}) = \sum_{l=1}^{L} u_l(\hat{\varphi}_l) = \frac{1}{2}\sum_{l=1}^{L}\left(\mathrm{e}^{-\mathrm{i}\hat{\varphi}_l} X_l + \mathrm{e}^{\mathrm{i}\hat{\varphi}_l} X_l^*\right) = \sum_{l=1}^{L} U_l^{\mathrm{T}*} \hat{Q}_l U_l \geq u_0, \tag{1}$$

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