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ASYMPTOTICALLY OPTIMAL AFTER-DETECTOR INDICATOR OF WEAK SIGNALS OF UNKNOWN DURATION

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The use of the non-Bayes approach to overcome the parametric a priori indeterminacy of after-detector statistics is substantiated. The main issue of the work is synthesis and analysis of the asymptotically optimal device for processing of rectangular radio pulses with the unknown scheme of intrapulse modulation, unknown small amplitude, and unknown large duration.

In the process of monitoring of radioelectronic situation, we often deal with the reception of signals radiated by various radioelectronic aids (RA). Usually, it is hardly possible to predict beforehand the type of signal arriving at the receiver input. A priori indeterminacy in respect with most of the received signal parameters inevitably causes a deterioration in the quality of their detection. The problem has become even more complicated with the advent of RA working with complex-modulated signals. Due to high-energy potentialities because of large duration, the signals produced by such RA exhibit a small signal-to-noise ratio (in terms of power) at the output of the receiver linear part and, if not matching to the paths, cannot be detected against the background of the receiver intrinsic noise.

Let the input of the receiver be activated by a rectangular radio pulse with a priori unknown type of intrapulse modulation, carrier frequency, duration τ, and amplitude a. Only marginal values of these parameters are known. Under such a priori indeterminacy conditions we have to give up the optimization of the linear path, and intentionally make it broadband — to ensure undistorted reception of any possible signal. A priori indeterminacy as regards to the type of modulating function and the carrier frequency compels to switch to processing of the signal envelope. Our goal is to overcome the parametric indeterminacy in respect with a and τ due to optimization of the after-detector path.

Assume at first that the τ value is set, while the amplitude $a \in [a_1, a_2]$, where a_1 and a_2 are the boundaries of the amplitude a priori value. It is known that for a weak rectangular radio pulse ($0 < a/\sigma << 1$, where σ^2 is variance of the noise at the linear path output) the expression for the logarithm of likelihood ratio of a discrete-analog detector (indicator) is valid [1], and can be represented in asymptotic form

$$L[x_k] = \sum_{k=1}^{N} \ln I_0\left(\frac{a \cdot x_k}{\sigma^2}\right) - \frac{1}{2}\cdot\frac{a^2 N}{\sigma^2}\Bigg|_{a/\sigma<<1} \approx \frac{a^2}{4\sigma^4}\sum_{k=1}^{N} x_k^2 - \frac{a^4}{32\sigma^8}\sum_{k=1}^{N} x_k^4 - \frac{a^2 N}{2\sigma^2},$$

where x_k are the signal envelope readings, and N is the number of readings in the signal sample.

Assume that the amplitude of radio pulses is distributed with a certain a priori probability density $W(a) > 0$, $a \in [a_1, a_2]$. Given a known function $W(a)$, the processing algorithm makes the decision that the signal is available, if the averaged likelihood ratio functional (LRF)

$$L[\Lambda] = \ln \int_{a_1}^{a_2} \exp\{L[x_k]\} W(a)\mathrm{d}a = \ln \int_{a_1}^{a_2} \exp\left[N\left(\frac{a^2}{4\sigma^4 N}\sum_{k=1}^{N} x_k^2 - \frac{a^4}{32\sigma^8 N}\sum_{k=1}^{N} x_k^4 - \frac{a^2}{2\sigma^2}\right)\right] W(a)\mathrm{d}a \quad (1)$$

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