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An Estimation of Temporal Parameters of Signals Sequence with Pseudo-Random Frequency Tuning at the Output of Digital Panoramic Radio Receiving Device

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Abstract—An algorithm for adaptive estimation of delay time and period of signal sequence with pseudo-random frequency tuning is developed. This algorithm is based on detection and frequency measurements results processing at the panoramic receiver output. Algorithm is created according to separation method, where a priori uncertainty range of signal period and time delay is divided into elementary parts. Precision parameters of the algorithm are analyzed.

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Signals with pseudo-random frequency tuning (PRFT) are widely spread in radio communication systems now. These signals have switching interval with fixed duration (about 10% of each frequency radiation) [1], useful information does not transmit during this interval. Frequency modification process is guided by pulse sequence, whose period and delay time are unknown and must be estimated for typical radiomonitoring of radio radiation sources. In radiomonitoring systems, based on digital panoramic radio receiving devices (RRD), the decision about signal detection in general case is made using several elements (samples) of input realization. In case of threshold overcoming, signal parameters are measured in RRD and these parameters can be used together with decision about signal presence data for estimation of temporal parameters of sequence with PRFT. At that, it is necessary to take into account operating specificity of panoramic RRD, which is a possibility of detection and measurement of signals with PRFT parameters in case of coincidence of their temporal-frequency parameters with corresponding parameters of receiver frequency adjustment. Moreover, this problem is complicated by existing probability of detection threshold overcoming by noises and abnormal measurements obtaining, that do not correspond to real signals. The same problem of binary pulse sequence estimation according to timewise detection results of input realization elements are considered in paper [2], by they do not take into account specificity of panoramic RRD operation in some elements of input signal realization accumulation mode, and also possibility of abnormal observation appearing in case of small signal to noise ratio. In this connection, the purpose of this work is solution of problem of analysis and synthesis of optimal algorithm for temporal parameters estimation of pulse sequences of signals with PRFT using detection and measurements results, obtaining by digital panoramic RRD. For synthesis carrying out we use methods of non-linear filtration in discrete time [3] theory.

Now we consider a case of detection in frequency band of radio electronic system (RES) signal with PRFT, analyzed by RRD. A priori frequency density distribution of the signal $f(f_{\text{cur}})$ is a composition of two uniform distributions on the intervals of $[f_{\text{c}} - F_{\text{c}}/2, f_{\text{c}} + F_{\text{c}}/2]$ and $[-F_{\text{cur}}/2, F_{\text{cur}}/2]$, where f_{c} is mathematical expectation of central frequency at PRFT, F_{c} is uncertainty region of central frequency, F_{cur} is bandwidth of current signal frequency tuning range with regard to central frequency. One of this distribution laws defines uncertainty with regard to central frequency of irradiation with PRFT in whole analyzed frequency band, the second distribution law defines random behavior of current frequency tuning of signal pulse sequence.

We assume unknown parameters vector a-priory distribution $\boldsymbol{\alpha} = (T, \tau)^T$, including period and pulse sequence delay time as:

$$f(\boldsymbol{\alpha}) = f(T) f\left(\tau / T\right) = \frac{1}{((T_{\max} - T_{\min})T)}, \quad T_{\min} \le T \le T_{\max}, \quad -\frac{T}{2} \le \tau < \frac{T}{2}, \tag{1}$$