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Definition of Parameters Values of Sinusoidal Signal, Distorted by Unknown Pulses

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Abstract—In this paper a problem of definition of sinusoidal signals parameters distorted by unknown pulses is considered. It is supposed that shape, quantity and other parameters of pulses a priori unknown, but their total duration is less then an observation interval. It is given a criterion that this problem solution is achieved at the point of a minimum of a functional "duration residual" between known data and mathematical model.

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Traditional approach of signal parameters definition is based on least-squares procedure (LSP) application. But LSP using to definition of parameters of the sinusoidal signal that distorted by unknown pulses results in low accuracy. This restriction can be eliminated by cutting pulse distorted part from sinusoidal signal and LSP application for other signal part. Nevertheless if distorting pulse start time and duration are a priori unknown, then cutting of distorted signal part can be done at random and hence with random result. In this case an idea of the minimum duration method [1–3] can be used as a basis of a robust algorithm which is invariant in the limit to pulses durations and disposition.

Further we consider a model of the additive superposition of distorting pulses and sinusoidal signal. We suppose distorting pulses are definitely finite in time, their quantity, shape and parameters are previously unknown, but they cannot occupy the entire observation interval. This consideration results in following problem definition: we suppose that on time cell $[-T/2, T/2]$ there is an additive superposition $g(t)$ of the sinusoidal signal and unknown finite pulses. Quantity of these pulses is previously unknown, but their total duration is less then T. It is necessary to define sinusoidal signal parameters using known function $g(t)$.

Now we define more precisely the problem definition using formulated description of the sinusoidal and pulse signals. A mathematical model of the sinusoidal signal is expressed by following formula:

$$f(t) = A\sin(\omega t + \varphi);\, |t| < \infty, \tag{1}$$

where A, φ, ω are nonrandom parameters, and $0 < A < \infty$, $0 \le \varphi < 2\pi$, $0 < \omega < \infty$. Unknown finite pulses set can be written as:

$$p(t) = \sum_{i=1}^{n} p_i(t); \quad p_i(t) = \begin{cases} p_i(t); & t \in T_i \\ 0; & t \notin T_i \end{cases}; \quad T_i \in [-T/2, T/2]; \quad |t| \le T/2, \tag{2}$$

where n is unknown pulses quantity, $p_i(t)$ is unknown finite function of i pulse on time cell T_i. We consider that pulses are not overlapping (i.e. $T_i \cap T_j = \varnothing; i \ne j$), total sum of all time cells T_i must be less than T. Using (1)and (2) we can formalize our problem in form of:

$$g(t) = A_{\text{tr}} \sin(\omega_{\text{tr}} t + \varphi_{\text{tr}}) + p(t); \quad |t| \le T/2, \tag{3}$$

where $g(t)$ is known observed signal; A_{tr}, φ_{tr}, ω_{tr} are unknown "true" values of sinusoidal signal parameters; $p(t)$ is a priory unknown finite pulses set. It is obvious that solution of the problem (3) with regard to unknown parameters of the sinusoidal signal allows separation of the distorting pulse sequence by subtraction.