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Estimation of Ultrawideband Quasi-Radio Signal Duration[1]

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Abstract—Quasi-likelihood and maximum likelihood algorithms of duration estimation for ultra-wideband quasi-radio signal of arbitrary shape with unknown amplitude and initial phase, influenced by additive Gaussian white noise, are synthesized. It was considered that conditions of relatively narrow band of received signal are not satisfied and its duration can constitute only several periods or a fraction of period of harmonic oscillation. It is shown that the structure of the algorithm for duration estimation of ultra-wideband quasi-radio signal is significantly different from the structure of duration estimation algorithm for narrowband radio signal. Relative bias and variance are determined as the statistical characteristics of synthesized duration estimates. The influence of unknown amplitude and initial phase on the accuracy of duration estimation is investigated. Quantitative limits for relation of signal bandwidth to its center frequency are formulated, such that the classical solution of the problem of duration estimation for narrowband radio signal possesses the required accuracy.

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Ultra-wideband (UWB) signals finds ever broader applications in many practical cases of modern radioelectronics, which are evidenced by large number of publications, including considerable number of monographs [1–6]. Implementation of UWB signal into telecommunication systems allows increasing the information transfer rate due to large spectral width. Application of UWB signals in measurement systems, radars and positioning devices unveils the possibilities of enhancement of measurement accuracy and resolution.

The problems of processing of UWB signals with unknown time of arrival are studied in detail in modern literature [1]. This is related to the necessity of signal delay measurement in radars and also to the active utilization of temporal-impulse modulation in the UWB systems. At the same time, there are plenty of applications that require processing of UWB signals with unknown duration. In this case duration can serve both as an informative signal parameter and as a non-informative parameter, which is undefined at the receiving side due to specifics of UWB signal propagation.

The meaning of UWB signals is wide and includes large number of various mathematical models [1–6]. Obtaining of constructive results from processing algorithms of UWB signals of any type poses significant difficulties. Therefore among UWB signals we separate a sub-type of such signals that have structure similar to narrowband signals, but the narrowband conditions are not satisfied. Such signals are termed as UWB quasi-radio signals (QRS) [1]. This paper investigates algorithms for duration estimation of UWB QRS. Such narrowing of the type of signals under consideration allows more in-depth and informative results of synthesis and analysis of the duration estimation algorithms.

The problem of signal duration estimation in the noise background for different signal types has been considered multiple times [7–13], but for UWB signals this problem remains mainly unsolved. Algorithms for duration estimation of video impulses of rectangular [7], arbitrary shape [8] and signals of arbitrary shape and unknown amplitude [9] have been investigated previously. It has been shown that accuracy of maximum likelihood (ML) duration estimation asymptotically does not depend on signal shape in case of large signal to noise ratio (SNR), but is determined only by the magnitude of back front of the signal. In addition, synthesis and analysis of the duration estimation algorithms for narrowband radio impulse with an arbitrary envelope shape having unknown initial phase [10] and simultaneously unknown amplitude and initial phase [11] have been performed. The accuracy of ML estimation of radio signal duration is asymptotically defined

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