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Characteristics of Estimating the Amplitude of Ultrawideband Quasi-Radio Signal[1]

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Abstract—The synthesis and analysis of the maximum likelihood algorithm for estimating the amplitude of ultrawideband quasi-radio signal with unknown amplitude and phase have been performed. The duration of the specified signal can amount to several periods or a fraction of the period of harmonic oscillation. The characteristics of the classical maximum likelihood estimate of the amplitude of a narrow-band radio signal were found while receiving an ultrawideband quasi-radio signal. The conditions of applicability of the model of narrow-band radio signal were defined for solving the problem of amplitude estimation with the specified accuracy.

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The problem of optimal estimation of the amplitude of a narrow-band radio signal with unknown amplitude and phase against the background of white noise has been studied in detail and can be called classical in the field of statistical radio engineering [1, 2]. By narrow-band signals are meant the signals having the relative bandwidth (i.e. the ratio of the frequency band to the central frequency of their spectra) much less than unity. From this viewpoint the so-called wideband signals (radio signals with a large time-bandwidth product) are also narrow-band. For a long period of time the narrow-band (quasi-harmonic) radio signals used to be one of the main objects of studies in radio electronics [1–3].

In recent years the so-called ultrawideband signals (carrier-free signals) have been finding the ever increasing interest and use in radio electronics and its applications [4–6]. These signals may have the relative frequency band of about unity and more. At such values of the relative bandwidth the conventional definitions of the envelope and phase lose their physical meaning that can lead to inexpediency of their application. That is why the known results on estimating the parameters of radio signals with unknown amplitude and phase that make essential use of their bandlimitedness cannot be applicable to ultrawideband signals. Among a host of ultrawideband signals [4–6] we shall single out a separate class of ultrawideband signals, the structure of which is similar to the structure of narrow-band radio signals. They shall be called ultrawideband quasi-radio signals.

As is known [1, 3], a narrow-band radio signal (without phase modulation) can be written in the form

$$s(t, a_0, \varphi_0) = a_0 f(t) \cos(\omega_0 t - \varphi_0). \quad (1)$$

If frequency band $\Delta\omega$ of signal $s(t, a_0, \varphi_0)$ and frequency ω_0 obey the condition

$$\Delta\omega << \omega_0, \quad (2)$$

signal (1) is a narrow-band radio signal. Then a_0, ω_0, and φ_0 are the amplitude, frequency, and initial phase, while $f(t)$ is the normalized ($\max f(t) = 1$) envelope of narrow-band radio signal (1). Note that a_0, ω_0, φ_0, and $f(t)$ can be found from the specified narrow-band radio signal $s(t, a_0, \varphi_0)$ [1, 3]. It is evident that the signal of form (1) can be obtained by using a simple modulator shown in Fig. 1, where the following designations are introduced: *1* is the oscillator of sine wave

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