ISSN 0735-2727, Radioelectronics and Communications Systems, 2011, Vol. 54, No. 10, pp. 536–545. © Allerton Press, Inc., 2011.
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Methods for Estimating the ADC Jitter in Noncoherent Systems

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Received in final form August 22, 2011

Abstract—The paper presents the method of estimating the jitter dispersion developed for the case when the clock pulse generator of ADC and the generator of input test signal are not time synchronized. The generalization of the method was carried out for the following cases: input signal represents a sum of harmonic components; ADC system has several channels with equal values of the jitter and additive noise dispersions. The results of numerical simulation are also presented.

DOI: 10.3103/S0735272711100037

The methods considered in literature for jitter estimation in systems with analog-to-digital converters (ADC), as a rule, imply (in explicit or implicit form) that the device generating a test signal and the clock pulse generator of ADC are time synchronized and so ensure the repetition of events (for example, [1, 2]). This ensures the formation of statistical characteristics of samples (for example, dispersion and mathematical expectation) that are obtained under the equal conditions. However, in practice, the high-quality clocked generators (synthesizers) are not always available due to their high cost. At the same time, the price of high-quality free-running generators for fixed frequencies is much lower. In addition, the methods using the clocked generators (synthesizers) as sources of a test signal cannot be always applied when the tested system represents a complete device and the in-built generator cannot be used as the master generator of the test system (for example due to its low quality).

The purpose of this study is to develop the methods for estimating the jitter dispersion in systems with ADC under an assumption that the signal source is not synchronized with the clock generator of ADC and also to analyze the usability conditions of the specified methods.

Let the following harmonic signal be present at the input of jitter ADC:

$$u(t) = A\sin(2\pi Ft + \varphi), \tag{1}$$

where A, φ, and F are the amplitude, initial phase, and frequency of the input signal, respectively.

Let us write down the results of signal sampling at the ADC output in the form of expansion into the Taylor series in the neighborhoods of the sampling instants with preservation of terms of the first order of smallness assuming the jitter is small:

$$u_i \approx A\sin(2\pi fi + \varphi) + 2\pi F\tau_i A\cos(2\pi fi + \varphi) + \eta_i, \tag{2}$$

where i is the sample number, f is the ratio of the input signal frequency to the sampling frequency, τ_i is the jitter during the generation of the ith sample, η_i is the value of additive noise during the generation of the ith sample. Next we shall assume that the jitter and additive noise samples are independent and have the average values equal to zero and dispersions σ_τ^2 and σ_η^2, respectively. We shall also assume that during the entire duration of observations dispersions σ_τ^2 and σ_η^2 remain constant.

Let M samplings be observed, and each of them contains N samples. In this case it is assumed that the amplitude and frequency of the input signal do not vary from sampling to sampling, while the initial phase of samplings is a random quantity due to the absence of synchronization of the input signal generator and clock