Radioelectronics and Communications Systems
Vol. 47, No. 8, pp. 27–31, 2004

Izvestiya VUZ. Radioelektronika
Vol. 47, No. 8, pp. 38–44, 2004
UDC 621.39

PARAMETRIC REPRESENTATION OF SAMPLED SIGNALS AND ESTIMATION OF THEIR PARAMETERS

V. L. Seletkov

National Academy of Security Service, Kiev, Ukraine

The paper considers algebraic and exponential forms of parametric representation of sampled signals over the field of real numbers making it possible to facilitate considerably the treatment of the problem of statistical estimation of envelope parameters and full phases of signals. Analysis of properties of the matrix operator of the discrete finite-dimensional Hilbert transform is carried out.

In radio-engineering applications an arbitrary analog signal $s(t)$ is often represented in the form $s(t) = a(t)\cos q(t)$, where unambiguously defined functions of the envelope $a(t)$ and full phase $q(t)$ are introduced with the aid of the following relations:

$$a(t) = [s^2(t) + \hat{s}^2(t)]^{1/2};\; q(t) = \arctan(\hat{s}(t)/s(t)),$$

and where $\hat{s}(t) = a(t)\sin q(t)$ is the signal conjugate to $s(t)$ after Hilbert [1].

Using digital signal processing techniques, we perform sampling of the signal $s(t)$ on a finite observation interval $T = l\tau$. That is, the signal $s(t)$ is represented as a vector $S = [s_i] = [s(t_i)]$, $i = 1,..., l$ of samples $s_i = s(t_i)$, $i = 1,..., l$, in some fixed time instants t_i (where $t_{i+1} - t_i = \tau$).

For the sample vectors $S = [s_i] = [s(t_i)]$, $i = 1,..., l$, the "samples" of envelopes A and full phases of Q-signals are also introduced in the form of vectors

$$A = [a_i] = [(s_i^2 + \hat{s}_i^2)^{1/2}];\quad Q = [q_i] = [\arctan(\hat{s}_i / s_i)],$$

where $\hat{s}_i$ are samples of the signal $\hat{s}(t_i)$ [1, 2].

In the problems of statistical synthesis and analysis of measurers of signal parameters, representation of signals in discrete form is more appropriate. The reason is that for the majority of the additive noise and measurement error models we always can set up the expression of a many-dimensional likelihood function (likelihood ratio). However, the expressions for many-dimensional likelihood functions of samples of envelopes and full phases are difficult to obtain in the explicit form, which complicates substantially the statistical analysis of multichannel amplitude measurers [1, 2]. Because of this, we suggest an approach to parametric representation of envelopes and full phases of sampled signals, which permits us to avoid the difficulties of their statistical description inherent in methods of the theory of statistical solutions.

In the majority of practically important cases of signal processing we are interested not in absolute values of parameters but in their increments (changes) with respect to the same parameters of the likely (to be modulated) known signal $s_0(t) = a_0(t)\cos q_0(t)$ (reference, testing, pilot signal. etc.). In this case the signal $s(t) = a(t)\cos q(t)$ can be represented in the form

$$s(t) = m(t)a_0(t)\cos[q(t) - q_0(t) + q_0(t)] = m(t)[\cos g(t)s_0(t) - \sin g(t)\hat{s}_0(t)], \qquad (1)$$

where $a(t) = m(t)a_0(t); g(t) = q(t) - q_0(t)$.

REFERENCES

1. I. N. Amiantov, Selected Issues of Statistical Theory of Communications [in Russian], Sov. Radio, Moscow, 1971.
2. V. G. Gusev, Radiotekhnika i Elektronika, Vol. 28, No. 1, pp. 88–94, 1983.
3. J. Bendat and A. Piersol, Applied Analysis of Random Data [Russian translation], Mir, Moscow, 1989.
4. L. M. Soroko, The Hilbert Optics [in Russian], Nauka, Moscow, 1961.

21 November 2002