ISSN 0735-2727, Radioelectronics and Communications Systems, 2008, Vol. 51, No. 10, pp. 565–572. © Allerton Press, Inc., 2008.
Original Russian Text © A.A. Popov, 2008, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2008, Vol. 51, No. 10, pp. 69–80.

Processing Characteristics of Harmonic Signals against Noises in Case of Their Interaction in *K*-Space

A. A. Popov
National Academy of Defence, Kyiv, Ukraine
Received in final form November 20, 2007

Abstract—In this paper it is shown that processing of harmonic signals with unknown nonrandom amplitude and phase, against noises in *K*-space allows achieving better processing characteristics than ones in linear space. It is proposed signals processing quality criteria, based on metrical properties of an estimation space.

DOI: 10.3103/S0735272708100105

The most common problem of processing of signals against noises is a problem of signals and its parameters estimation. This problem is closely related to other similar ones: signal recognition, detection and determination [1–4]. Many authors propose to process signals against noises in linear space, using signals $L(+)$. In this space resulted signal x is an additive mixture of an abelianized group of signal s and noise n: $x = s + n$.

We propose to process harmonic signals against noises in *K*-space. *K*-space properties and characteristics are well known and described in many algebraic papers, such as [5–7]. *K*-space application as a signal space allows using both algebraic lattice axiomatic and linear space axiomatic. *K*-space is defined as a linear distributive lattice $K(+,\vee,\wedge)$ above scalars ring, where axioms of algebraic distributive lattice $K(\vee,\wedge)$ with upper and lower boundaries operations: $a \vee b = \sup_K a,b$, $a \wedge b = \inf_K a,b$ and axioms of linear space L with operations of additive addition $a + b$ for abelianized group $L(+)$ can be used [5, 6]. Algebraic lattice absorption $s \wedge (s \vee n) = s$, $s \vee (s \wedge n) = s$ provides recognition of known signal in case of its interaction with noise in *K*-space without any loss caused by noises. However, this approach cannot be used in case of unknown signals. We research interaction in *K*-space of harmonic signal with unknown nonrandom amplitude and initial phase and Gaussian noise $x(t) = s(t) \oplus n(t)$, where operation $\oplus$ corresponds to one of two binary operations $\vee$, $\wedge$ of the algebraic lattice K: $s \vee n = \sup_K \{s,n\}$, $s \wedge n = \inf_K \{s,n\}$.

Received signal $s(t)$ model is:

$$s(t) = A\cos(\omega_0 t + \varphi), \quad t \in T_s = [t_0, t_0 + T],$$

where A is unknown nonrandom amplitude of useful signal s; φ is unknown nonrandom initial phase of useful signal, $\varphi \in [0, 2\pi]$; $t_0 = 0$ is known signal arrival time; T is a duration of the signal.

Narrow-band Gaussian noise $n(t)$ model is:

$$n(t) = A_n(t)\cos(\omega_0 t + \varphi_n(t)),$$

where где $A_n(t)$ is noise stochastic envelope with Rayleigh distribution, $\varphi_n(t)$ is stochastic noise phase with uniform distribution at the interval of $[0, 2\pi]$.

Processing device must fulfill Hilbert transformation of signals sum $s + n$ and create two processing channels for measuring of unknown nonrandom harmonic signal amplitude and initial phase. Let we have a device C [$+/\vee\wedge$] which can provide inter-unilateral mapping of the linear space $L(+)$ with additive sum operation "+" (sum of the signal s and the noise n) into *K*-space taking into account identity [5–7]: $s + n = (s \vee n) + (s \wedge n)$. Convectors C[$+/\vee\wedge$] provide mapping of linear space signals $L(+)$ into *K*-space signals in each cos(sin)-quadrature channel: