Optimal nonlinear filtration of phase and amplitude of the signal passed through a random medium

V.A. Potapov

Mints Radiotechnical Institute, ul. 8 Marta, 10, Moscow, 125083 Russia, Email: alta@mail.21th.com

In this study I treat the problem of nonlinear estimation of amplitude and phase on the basis of the technique of signal optimal nonlinear processing in the presence of colored noise. This problem concerns many applications such as communications that need advanced synchronization and advanced spectrum utilization.

According to classical approach of the theory of conditional Markovian processes, I describe the signal fluctuations in the form of stochastic differential equations. We can design the optimum filter if we find the evolution equation for the conditional density functional of given continuous measurements. The conditional Markovian process technique allows us to take into account the most important information on the statistical physical characteristics of a fluctuating signal. For example, in this form we may describe the effect of propagation through a random channel with the known statistical properties, including multipath fading channel.

Until now, the closed equations for the conditional probability density functional were written only for signals received in the presence of the white Gaussian noise. Unlike the traditional methods, I use the functional approach to find the evolution equation for the conditional probability density functional in the form of the modified FokkerPlanck equation. To find this modified evolution equation I present the desired conditional (posterior) density functional in the explicit functional-integral form. Using this functional technique we may treat the wider and more practical class of signals, colored noises, and random channels. In this study on the base of this technique I propose more efficient algorithms for estimating the phase and amplitude fluctuations of the signal passed through a scattering medium. I treat a few examples of random channel in turbulent atmosphere with the known statistical properties.

I present the results of computer simulation and numerically verify the suggested algorithms. These results show that we may improve the power control and synchronization in comparing with the linear tracing device based on the Kalman filter. In addition I modify the algorithms to suite them for digital receivers. The results of hardware modeling of fully-digital tracking loops are presented.

I discuss the way of extending the suggested functional technique to the case of fluctuating wave – spatially distributed signal. In this case I may treat the signal as a random field, for which I also write the stochastic equations and the expression for posterior functional density in functional-integral form. We may consider the channel spatial characteristics (including correlation) to improve the characteristics of adaptive arrays and MIMO communication systems.