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Sensitivity to Parameter Variations of the Regularized Recovery Algorithm of Binary Message Masked by Chaotic Process

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Abstract—This study analyzes an impact of parameter variations of the recovery algorithm of binary message masked by the Mackay-Glass chaotic process on the quality of its recovery in the presence of noise during observation. The paper presents the numerical results of the probability of correct estimation of the recovered message and admissible variations of the algorithm parameters under conditions of maintaining the specified quality.

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Theoretical investigations and experiments performed in recent decades have shown that the use of chaotic processes as carriers proves to be efficient in covert and confidential communications systems. Among a great variety of methods using chaotic carriers in algorithms designed for data transmission, those methods deserve the attention that have been realized and feature positive experimental results, namely: 1) chaotic masking, where the information signal is summed up with a chaotic process and passed into communication channel; 2) switching of chaotic modes (symbol "1" of information signal is coded by one type of chaotic mode, while symbol "0"—by the other); 3) nonlinear mixing, when the information signal participates in formation of the complex dynamics of chaos generator in the communication channel. However, the proposed algorithms using chaotic processes feature a number of significant disadvantages, for example, high susceptibility to noises (interferences), synchronization of chaotic generators at the receiving and transmitting sides and a fairly high accuracy of parameters of the elements of systems (the spread is below 1%) [1, 2].

Earlier investigations of the recovery algorithm of a binary message masked by the chaotic process generated by the Mackay–Glass dynamic system with delay resulted in determination of admissible (from the viewpoint of the total error of recovery) values of the regularization parameter under different requirements to the noise level and also in determination of the impact of mismatched choice of the regularization parameter and the length of an element of binary message on the recovery quality. It is worthy of note that the application of the regularization method of observation derivative reduces the algorithm noise susceptibility by an order of magnitude. In addition, for the quality recovery it is necessary that the number of observation samples shall exceed the number of samples fitting the interval of determining the weight function taking part in formation of the regularized value of observation derivative [3, 4]. However, the issues dealing with susceptibility of the recovery algorithm to variations of its parameters that are important for practical realization of the algorithm were not handled in earlier investigations and it is these issues that are the subject of the present study.

Let us consider a transmission system with delay described by the Mackay–Glass nonlinear differential equation of the first order, where the mixing of information message $i(t)$ is effected by its addition to parameter b [5]

$$\dot{f}(t) = -[b + ci(t)]f(t) + \frac{af(t-\tau)}{1+\left(f(t-\tau)\right)^{10}}. \quad (1)$$

The chaotic mode of the system oscillations is realized at the following values of parameters: $a = 0.2$, $b = 0.1$, $c = -0.06$, $\tau = 100$. Message is described by a binary sequence $i(t) = r^{(p)}_{[t/T_r]}$ ($p = 1; 2$), presented in the