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Iterative Operator Method of Nonlinear Compensation in Recursive Systems

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Abstract—The iterative operator method of "blind" linearization was used for the compensation of nonlinear distortions of signals in recursive systems. A nonlinear compensator was synthesized for the suppression of signal distortions in electrodynamic loudspeaker. The iterative operator method was shown to surpass in terms of accuracy the fixed point method.

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Nonlinear compensation is an effective tool in combating the nonlinear distortions in electronic, telecommunications, electric, and radio systems. Among the known compensation methods we can separate a large class of methods of "blind' linearization for models of nonlinear devices where the linearization is performed without the compensator "learning" that is typical for adaptive linearization [1, 2]. The initial nonlinear device is presented in the form of a "black box". The input-output relationship of the object is described by nonlinear operator equation. The convenience of the operator form of the mathematical model is explained by the fact that it reflects the nonlinear effects caused by different physical phenomena. Polynomial approximators of the nonlinear operator of device include the Volterra functional series and polynomial [3, 4], the polynomial of split signals [5], recursive multinomial [6], and NARMAX-model [7].

"Blind" linearization within the framework of the "black box" concept is implemented by the known methods: the high order inversion [6, 8], fixed point [9], the roots of Volterra's equation [10], and the iterative operator method [11, 12].

This paper presents the generalization of the iterative operator method of linearization for the case of compensating the nonlinear distortions of signals in recursive distorting systems. The convergence condition of the iteration procedure is presented, and the techniques for reducing the computational costs of the specified procedure are considered under conditions of maintaining the accuracy of compensation. The compensation of nonlinear distortions of signals is performed in the recursive model of electrodynamic loudspeaker, and the uniform and root-mean-square compensation errors are estimated and compared with appropriate errors obtained by the fixed point method.

THE SYNTHESIS OF NONLINEAR OPERATOR EQUATION OF THE COMPENSATOR

Let us assume that the initial device can be described by the following nonlinear recursive equation:

$$B(q)y(n) = A(q)x(n) + N[x(n), y(n)] - N_y[y(n)], \tag{1}$$

where $x(n)$ and $y(n)$ are the device input and output signals, respectively, n is the normalized discrete time, q is the shift operator.

Linear polynomial operators in equation (1) have the form:

$$B(q) = 1 + \sum_{i=1}^{I_b} b_i q^{-i}, \quad A(q) = \sum_{i=0}^{I_a - 1} a_i q^{-i},$$

while the nonlinear operators can be presented as follows: