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# Analytical Synthesis of a Functional Observer of the State of a Bilinear Dynamic System

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**Abstract**—The problem of asymptotic estimation of a linear combination of the state variables of a bilinear dynamic system using a minimum-order observer is considered. An algorithm for calculating the matrix coefficients of a functional observer using the technology of canonization of matrices is proposed, and solvability conditions for synthesis problem are derived..

*Keywords*: bilinear system, functional observer, synthesis algorithm, canonization of matrices.

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## INTRODUCTION

Estimation of the state vector of a dynamic system from measurements of its input and output is one of the classical problems of control theory. For linear finite-dimensional completely defined systems, the construction of minimal observers of the total phase vector was first described by Luenberger [1], who constructed an observer with order equal to the difference of the order of the system and the number of linearly independent outputs.

In some cases (for example, in solving problems of modal control or diagnostics), information on the total state vector of the system is not required, and it is only necessary to obtain data on its some functional. In this connection, the problem arises of constructing a functional observer [2] of the dynamic system which provides an asymptotic estimate of the required functional. Since the dimension of this observer can be lower than the dimension of the Luenberger observer, the problem of designing a functional observer seems very attractive. It is known that designing functional observers to estimate unmeasurable external perturbations, which is a specific extension of the theory of observers to systems with signal perturbations, makes it possible to efficiently solve problems of adaptive [3–5] and robust controls [6, 7] and identification and diagnostic problems [8, 9].

Many aspects of the problem of analytical synthesis of functional observers for a multiply connected dynamic system have been considered. Thus, an algorithm for the analytical synthesis of a functional observer for a multidimensional system was proposed in [10]. A functional observer in the problem of estimating directly unmeasurable external perturbations is designed in [11]. An algorithm for the analytical synthesis of functional observers for dynamic systems with signal perturbations is given in [12]. An algorithm for the synthesis of functional observers based on linear matrix inequalities is presented in [13].

In this paper, the above-mentioned algorithms for the analytical synthesis of functional observers is extended to bilinear dynamic systems.