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Adaptive Input Design for Identification of Output Error Model with Constrained Output

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Abstract ***- This paper considers the identification of output error (OE) model, for the case of constrained output variance. The constraint plays a very important role in the process industry, in the reduction of degradation of product quality. In this paper, it is shown, in the form of theorem, that the optimal input signal, with constrained output, is achieved by a minimum variance controller together with stochastic reference. The key problem is that the optimal input depends on the system parameters to be identified. In order to overcome this problem, it is the proposed two-stage adaptive procedure***

a) obtaining an initial model using PRBS as input signal

b) application of adaptive minimum variance controller together with the stochastic variable reference, in order to generate input signals for system identification

Theoretical results are illustrated by simulations.

Key words: ***System identification, adaptive input design, output error model, constrained output variance, minimum variance controller***

I. INTRODUCTION

The design of controllers is largely based on the use of mathematical models that are obtained in the process of system identification [1-3]. The main task of the theory of identification is the extraction of maximum information from the measurements that are available. This requirement is realized by optimal experiment design [4-5]. The basic approach consists in minimizing the scalar function of Fisher information matrix [4].

The key problem in the optimal input design is that the optimal input depends on the unknown system properties to be identified. Namely, the Fisher information matrix typically depends on system parameters. There are two basic approaches to overcome this problem. The first approach is based on robust optimal experiment design. In this case the procedure is slightly sensitive to the uncertainty of a priori information about the system [6-7]. The second approach is based on adaptation. One such, two-stage procedure is proposed in [8]. In the first stage, in a short time interval, the data are collected using PRBS input. Based on these data system model is identified, and that is initial model for optimal input design. In the second stage, the obtained input signal, by using minimum variance controller and stochastic reference, is used to generate a new data set. Adaptive input design for the ARX models is discussed in [9].

In many practical cases, constraints on the fluctuation of input and/or output signals are very important [10]. For example, in the industrial production, product quality must be within certain limits (constraints on the fluctuation of the output signal).

If the constraint is related to the variance of the output signal, it is shown that the experiment design is D-optimal and that the input signal is generated using a minimum variance controller together with an external stochastic signal [11-12].

In reference [13], it is discussed the robust identification of a pneumatic cylinder, which is modeled as a stochastic system with non-Gaussian noise. Input design is based on the ideas from model predictive control and a bandlimited "$1/f$" noise.

This paper considers the optimal experiment design for output error (OE) models. There is a constraint on the output power. It has been shown that the optimal input signal can be obtained by minimum variance controller whose reference is white noise sequence with known variance. In order to be able to implement the algorithm, adaptive approach was applied. It was used direct adaptive minimum variance controller. The algorithm has two stages. In the first stage, the process parameters are estimated. In the second stage, based on thus obtained parameters, it has been formed the minimum variance controller that generates the input signal of the process by which the identification is made. Because the reference signal is in the form of white noise, parameter estimation is consistent (the true values of parameters are obtained with probability 1). The paper's results are supported by simulations.

II. OPTIMAL ALGORITHM DESIGN

In this paper we consider the model

$$y(k) = \frac{b_1}{F(q^{-1})} u(k-1) + e(k) . \tag{1}$$

In this case the parameters b_1 and $f_i\,(i=1,\ldots,n)$ are estimated, where $F(q^{-1}) = 1 + f_1 q^{-1} + \ldots + f_n q^{-n}$.

Let us consider the system (1). Based on N measurements of output, the following vector can be formed