

ROBUST CONTROL OF TIME DELAY SYSTEMS

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Abstract

In this paper the control of delay time system is considered. Results of this paper is an attempt to develop robust process control theory without special attention which is devoted to delay time of process. For that in the paper certain shift operator induced finite-dimensional approximation of an important class of delay systems is introduced. The H_∞ error bound is given for stable delay systems. Furthermore, a multiple shift formula, generated by a second-order Pade shift is considered and an exact asymptotic H_∞ error formula is derived. Such approach provides an appealing approach for determining good finite-dimensional models of the delay systems. Finally, the design of robust controller is considered.

Keywords: robust control, time delay systems

1. INTRODUCTION

Time delays are very common in real-world control problems. When the delay dominates the response it is especially important to examine whether one can improve on the performance achievable from a simple PID controller. The solution for such kind of problem is given in [1]. But, as well known, Smith predictor is very sensitive to change of process parameters.

The well known approach for such case is the internal model controller (IMC) [2]. It is shown that for the first-order model with dead-time and the first-order Pade approximation one can find the PID controller which minimizes the L_2 norm of the tracking error due to setpoint changes. However, the method gives poor load disturbance response. One reason is that we have not explicit approximation error for the Pade approximation. Now exists new tuning approaches which can be classified into three categories:

- (i) Time domain optimization method [3] – where idea is to choose the PID control parameters to minimize an integral cost functional
- (ii) Frequency domain shaping – where is specified the gain and phase margin [4] shaping for compensated system frequency response is used [5]
- (iii) Optimal control methods – the new trend which has been motivated by the desire to incorporate several control system performance objectives

such as reference tracking, disturbance rejection and measurement noise rejection [6].

The use of optimization for industrial controller design was discussed in [7]. In this and other early works the emphasis was on criteria that admitted analytical solutions. Problem of optimization load disturbance rejection with sensitivity constraints was suggested in [8]. The idea for use a constraint on the maximum sensitivity, also, is considered in [9].

In [10] the problem is stabilizing a first-order plant with dead-time by PID controllers is considered. Using a version of the Hermite-Biehler Theorem applicable to quasipolynomials, the complete set of stabilizing PID parameters is determined for both open-loop stable and unstable plants.

The promising approach for control of process with long time-delays is application of recently introduced theory of hybrid systems. In [11] is considered switching control strategy. The switching sequence is determined by minimization of suitable defined priority function. Using concept of multiple Lyapunov function it is theoretically proved global stability of the system. Application of the philosophy of hybrid systems for general nonlinear systems with analog uncertainty is considered in [12].

In this paper we will consider application of functional analysis in the problem of approximation. For that purpose it is used theory of Hardy spaces. In the frame of Hardy spaces – we will consider certain shift

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