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OPTIMAL CONTROL FOR LINEAR SYSTEMS WITH EQUAL DELAYS IN STATE AND INPUT

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Abstract. This paper presents the optimal regulator for a linear system with equal delays in state and input and a quadratic criterion. The optimal regulator equations are obtained using the maximum principle. Performance of the obtained optimal regulator is verified in the illustrative example against the best linear regulator available for linear systems without delays. Simulation graphs demonstrating better performance of the obtained optimal regulator are included.

Keywords. optimal control, linear system, time delay
AMS (MOS) subject classification: 49K25, 34K35

1 Introduction

Although the optimal control (regulator) problem for linear system states was solved, as well as the filtering one, in 1960s [12, 8], the optimal control problem for linear systems with delays is still open, depending on the delay type, specific system equations, criterion, etc. Such complete reference books in the area as [10, 11, 14, 4, 2] note, discussing the maximum principle [9] or the dynamic programming method [16] for systems with delays, that finding a particular explicit form of the optimal control function might still remain difficult. A specific form of the criterion must also be taken into account: the studies mostly focused on the time-optimal criterion (see the paper [15] for linear systems) or the quadratic one [6, 1, 3, 18]. There also exists a considerable bibliography related to the robust control problem for time delay systems (such as [5, 13]).

This paper concentrates on the solution of the optimal control problem for a linear system with equal delays in state and input and a quadratic criterion. Using the maximum principle [17, 9], the solution to the stated optimal control problem is obtained in a closed form, i.e., it is represented as a linear in state control law, whose gain matrix satisfies an ordinary differential (quasi-Riccati) equation, which does not contain time-advanced or delayed arguments and does not depend on the state variables. The obtained optimal regulator makes an advance with respect to general optimality results for time delay systems (such as given in [1, 14, 10, 11]), since (a) the optimal control law is given explicitly and not as a solution of a system of integro-differential or PDE equations, and (b) the quasi-Riccati equation for