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STABILITY OF SINGULARLY PERTURBED DIFFERENTIAL-DIFFERENCE SYSTEMS: A LMI APPROACH

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Abstract. For linear singularly perturbed system with delay sufficient conditions for stability for all small enough values of singular perturbation parameter ε are obtained in the general case, when delay and ε are independent. The sufficient delay-dependent conditions are given in terms of linear matrix inequalities (LMIs) by applying an appropriate Lyapunov-Krasovskii functional. LMIs are derived by using a descriptor model transformation and Park's inequality for bounding cross terms. A memoryless state-feedback stabilizing controller is obtained. Solution is given also in the case of systems with polytopic parameter uncertainties. Numerical examples illustrate the effectiveness of the new theory.
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1 Introduction

It is well-known that if the ordinary differential system of equations is asymptotically stable, then this property is robust with respect to small delays (see e.g. [2], [12]). Examples of the systems, where small delays change the stability of the system are given in [13] (see also references therein). All these examples are infinite-dimensional systems, e.g. difference systems, neutral type systems with unstable difference operator or systems of partial differential equations. Another example of a system, sensitive to small delays, is a descriptor system [18]. Recently a new example has been given of a finite dimensional system that may be destabilized by introduction of small delay in the loop [5]. This is a singularly perturbed system. Consider the following simple example:

$$\varepsilon\dot{x}(t) = u(t), \quad u(t) = -x(t-h), \tag{1}$$

where $x(t) \in R$ and $\varepsilon > 0$ is a small parameter. Eq. (1) is stable for $h = 0$, however for small delays $h = \varepsilon g$ with $g > \pi/2$ this system becomes unstable (see e.g.[2]).

Stability of singularly perturbed systems with delays has been studied in two cases: 1) h is proportional to ε and 2) ε and h are independent. The first