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DISTURBANCE ATTENUATION FOR UNCERTAIN NONLINEAR CASCADED SYSTEMS

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Abstract. In present paper, the disturbance attenuation problem of uncertain nonlinear cascaded systems is studied. Based on the adding one power integrator technique and recursive design, a feedback controller that solves the disturbance attenuation problem is constructed for uncertain nonlinear cascaded systems with internal stability.

Key words. Uncertain, nonlinear systems, disturbance attenuation.

1 Introduction

The problem of almost disturbance decoupling (ADD) with internal stability was originally introduced and solved for linear systems by Willems in 1981[1]. So far, the ADD problem has attracted considerable attention and some important results have been estabilished for both linear and nonlinear systems[2,3].

Recently, the result of [4] was extended to a large class of minimum-phase nonlinear systems whose zero-dynamics are not necessarily independent of the disturbance $w(t)$ [5]. And the results of [4] and [5] have been further generalized to a class of nonminimum-phase nonlinear systems. Most of the existing solutions to the ADD problem are researched on the basis of the assumptions that the controlled plants are feedback linearizable (at least partially) and affine in the control input. All results obtained so far are only applicable to those nonlinear systems in [4] that are globally diffeomorphic. When the system is inherently nonlinear, the ADD problem has not been addressed yet. Therefore, it is still unclear and open whether the common L_2-gain characterization is suitable to describe the ADD problem for high-order nonlinear systems.

In this paper, we shall address the ADD problem with internal stability for a class of high-order lower-triangular systems and present a constructive solution to the ADD problem under a set of growth conditions which are a natural generalization of the feedback linearization condition. This paper presents an explicit design of the smooth static state feedback law that solves the ADD problem of system (1). And, the result of this paper exploits a new application of the adding a power integrator technique proposed recently in [6], thus further complementing the previous work[6,7], where global robust stabilization and adaptive regulation have been studied via the adding a power integrator technique, for a class of high-order nonlinear systems that can't be controlled by the existing methods.

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Let $u_\gamma(\cdot) = u^*(\xi_1, \xi_2, \cdots, \xi_n)$ and $\beta = \gamma^2/n$.

Therefore, from (30) we have

$$\dot{V}_n(\xi_1, \xi_2, \cdots, \xi_n) + y^{2mp_1} - \gamma^2 \|w\|^{2m} \le -(\xi_1^{2mp_1} + \cdots + \xi_n^{2mp_1}) \tag{31}$$

which shows that the closed-loop system (1),(2) is uniformly globally asymptotically stabilized at the equilibrium $x = 0$ by the smooth static state feedback law (29) when $w = 0$.

Again, we know that $V_n(\cdot)$ is positive definite and proper with $V_n(0) = 0$. So, one deduces from (31) that

$$\int_0^t \|y(s)\|^{2mp_1} ds \le \gamma^2 \int_0^t \|w(s)\|^{2m} ds, \quad \forall t \ge 0, \quad \text{when } x(0) = 0.$$

This verifies the Theorem.

4 Conclusion

This paper investigates the almost disturbance decoupling problem with internal stability, for a class of high-order lower-triangular nonlinear systems (1). Meanwhile, a constructive solution to the ADD problem under growth conditions which are a natural generalization of the feedback linearization condition is presented. And the Theorem presented in this paper extends Theorem 1 in [8]. The result of this paper exploits a new application of the adding a power integrator technique developed recently in [6].

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