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Research Article

Finite-Time Boundedness Control of Time-Varying Descriptor Systems

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This paper mainly studies a control problem of finite-time boundedness of time-varying descriptor systems. Firstly, a sufficient and necessary condition of finite-time stability is given, then a sufficient condition of finite-time boundedness for time-varying descriptor systems is given. Secondly, we analyze the finite-time boundedness control problem and design the finite-time state feedback controller; the controller is given based on LMIs for time-varying descriptor systems and time-varying uncertain descriptor systems, respectively. Finally, a numerical example is given to prove the effectiveness of the method.

1. Introduction

Recently, descriptor systems (which are also known as *singular systems, semistate systems, systems of differential-algebraic equations, or generalized state space systems.*) theory has been well studied since they are very important from the engineering point of view. Let the time-varying descriptor systems be described as $E(t)\dot{x}(t) = A(t)x(t) + B(t)u(t) + G(t)\omega(t)$. They arise naturally in many physical applications such as electrical networks, aircraft and robot dynamics, neutral delay and large-scale systems, economics and optimization problem, biology, constrained mechanics, as result of partial discretization of partial differential equation, and so forth. The time-varying descriptor system has the common properties of general descriptor system and some special properties. In control theory, the time-varying descriptor system stability is mainly Lyapunov stability; however, Lyapunov stability deals with the whole state performance of the system, but it does not reflect a transient performance of the system. The transient performance refers to the system stability in a short period, but it is different from Lyapunov stability. In engineering, a whole stability of the system may have a very bad transient performance, which would cause a bad effect in the engineering. Therefore, people tend to be more concerned about the transient performance of the system [1–5] than the overall steady state performance of the system.

In order to study the transient performance of the system, scholars have given the concept of finite-time stability. Finite-time stability of time-varying descriptor system is a new field; scholars have mainly studied the finite-time stability of linear system for years and also made some corresponding results. For example, [6–10] proposed the definition of finite-time stability and finite-time boundedness; [5–8] proposed the sufficient conditions for the finite-time stability of general linear system; [1, 11] studied the input and output finite-time stability for time-varying descriptor system.

In addition, a finite-time stability problem with external disturbance is called finite-time boundedness; the concept of finite-time boundedness came from finite-time stability. We have some preliminary research results about the finite-time boundedness. For example, [12–14] studied the finite-time bounded problem of the linear time-varying system with impulse; [15–18] proposed the design methods of dynamic compensators; [19–21] discussed the finite-time control problems of uncertain system with disturbance. Scholars introduced the definition of finite-time stability and have given the necessary and sufficient conditions for finite-time stability of the descriptor system, but the finite-time stability problems of time-varying descriptor system have no available research results, especially when $E(t)$ is time-variant. So, it is necessary to study finite-time stability of the time-varying uncertain descriptor system.

The paper is divided into two parts: firstly, we deals with the problem of finite-time stability of time-varying descriptor system. We give the necessary and sufficient condition of finite-time stability and finite-time boundedness of system with time-varying function matrix $E(t)$; the unstable system can be controlled by the state feedback controllers. We also make the corresponding research for time-varying uncertain descriptor system. Secondly, we design a finite-time boundedness state feedback controller for time-varying uncertain descriptor system to make the close-loop system finite-time boundedness.

The paper is organized as follows. In Section 2, we give some results of finite-time stability and boundedness for time-varying descriptor system. In Section 3, some results of time-varying uncertain descriptor system are provided. In Section 4, a numerical example is presented to illustrate the efficiency of the proposed result.

2. Finite-Time Control of Time-Varying Descriptor Systems

2.1. Finite-Time Stable of Time-Varying Descriptor Systems

Definition 1. Time-varying matrix $E(t)$ is singular on time interval $[0,T]$, if there exists a $t \in [0,T]$ such that $\operatorname{rank} E(t) < n$.

Consider the following time-varying descriptor systems

$$E(t)\dot{x}(t) = A(t)x(t), \tag{1}$$

where $x(t) \in R^n$ is the state. $A(\cdot)$ is given continuous matrix-valued function. $E(t) \in R^n$ is singular on time interval $[0,T]$.

Definition 2. The time-varying descriptor system (1) is said to be finite-time stable with respect to $(c_1, c_2, T, R(t))$ with positive definite matrix $R(t)$, and given three positive scalars c_1, c_2, T, with $c_1 < c_2$, if $x^T(0)E^T(0)R(0)E(0)x(0) \le c_1$, then $x^T(t)E^T(t)R(t)E(t)x(t) < c_2$, for all $t \in [0,T]$.

Theorem 3. *The following statements are equivalent:*

(i) *system (1) is FTS respect to $(c_1, c_2, T, R(t))$.*

(ii) *For all $t \in [0,T]$, $\Phi^T(t,0)E^T(t)R(t)E(t) < (c_2/c_1)E^T(0)R(0)E(0)$, where $\Phi(t,0)$ is the state transition matrix and $R(t)$ is positive definite matrix.*

(iii) *For all $t \in [0,T]$, the differential Lyapunov inequality, with terminal and initial conditions*

(a) $M(t) < 0$, *where*

$$\begin{aligned} M(t) &= A^T(t)P(t)E(t) + E^T(t)P(t)A(t) \\ &\quad + \dot{E}^T(t)P(t)E(t) + E^T(t)\dot{P}(t)E(t) \\ &\quad + E^T(t)P(t)\dot{E}(t), \end{aligned} \tag{2}$$

(b) $R(t) \le P(t) \le P(0) < (c_2/c_1)R(0)$, *$R(t)$ is positive definite matrix, admits a piecewise continuously differentiable symmetric solution $p(\cdot)$.*

Proof. (ii) $\Rightarrow$ (i) Let $x^T(0)E^T(0)R(0)E(0)x(0) \le c_1$; assume $x(t) = \Phi(t,0)x(0)$, have

$$\begin{aligned} &x^T(t)E^T(t)R(t)E(t)x(t) \\ &\quad = x^T(0)\Phi^T(t,0)E^T(t)R(t)E(t)x(0) \\ &\quad < \frac{c_2}{c_1}E^T(0)R(0)E(0) \\ &\quad < c_2. \end{aligned} \tag{3}$$

Therefore, system (1) is FTS.

(i) $\Rightarrow$ (ii) by contradiction. Let us assume $\exists \bar{t}, \bar{x}$

$$\begin{aligned} &\bar{x}^T(\bar{t})\Phi^T(\bar{t},0)E^T(\bar{t})R(\bar{t})E(\bar{t})\Phi(\bar{t},0)\bar{x}(\bar{t}) \\ &\quad \ge \frac{c_2}{c_1}\bar{x}^T(0)E^T(0)R(0)E(0)\bar{x}(0). \end{aligned} \tag{4}$$

Let $x^T(0)E^T(0)R(0)E(0)x(0) = c_1$, $\exists\lambda$, such that $\bar{x}(t) = \lambda x(0)$; then (4) implies that

$$x^T(0)\Phi^T(\bar{t},0)E^T(\bar{t})R(\bar{t})E(\bar{t})\Phi(\bar{t},0)x(0) \ge c_2; \tag{5}$$

therefore

$$\begin{aligned} &x^T(\bar{t})E^T(\bar{t})R(\bar{t})E(\bar{t})x(\bar{t}) \\ &\quad = x^T(0)\Phi^T(\bar{t},0)E^T(\bar{t})R(\bar{t})E(\bar{t})\Phi(\bar{t},0)x(0) \\ &\quad \ge c_2. \end{aligned} \tag{6}$$

Obviously, it contradicts the initial assumption that system (1) is FTS.

(iii) $\Rightarrow$ (i) Let $V(t,x) = x^T(t)E^T(t)P(t)E(t)x(t)$, $\dot{V}(t,x) = x^T(t)M(t)x(t)$.

Then (a) implies that $\dot{V}(t,x)$ is negative definite along the trajectories of system (1).

Now $x^T(0)E^T(0)R(0)E(0)x(0) \le c_1$, then for a generic t, such that

$$\begin{aligned} &x^T(t)E^T(t)R(t)E(t)x(t) \\ &\quad \le x^T(t)E^T(t)P(t)E(t)x(t) \\ &\quad < x^T(0)E^T(0)P(0)E(0)x(0) \\ &\quad \le \frac{c_2}{c_1}x^T(0)E^T(0)R(0)E(0)x(0) \\ &\quad \le c_2. \end{aligned} \tag{7}$$

(i) $\Rightarrow$ (iii) By contradiction. Because system (1) is FTS. Let $z = \epsilon x$ for a small $\epsilon > 0$, for all $t \in [0,T]$, such that

$$\begin{aligned} &x^T(0)E^T(0)P(0)E(0)x(0) \le c_1 \\ &\quad \Longrightarrow x^T(t)E^T(t)R(t)E(t)x(t) + \|z\|_2^2 < c_2. \end{aligned} \tag{8}$$

Let $P(\cdot)$ be the solution of

$$M(t) = \epsilon^2 I, \tag{9}$$

$$R(t) = P(t). \tag{10}$$

And assume that $\exists \overline{x}$, such that

$$\overline{x}^T(t) E^T(t) P(0) E(t) \overline{x}(t) \geq \frac{c_2}{c_1} \overline{x}^T(t) E^T(t) R(0) E(t) \overline{x}(t). \tag{11}$$

Now let $x^T(0)E^T(0)R(0)E(0)x(0) = c_1$, $\exists \lambda$, such that $\overline{x}(t) = \lambda x(0)$.

Then (11) implies

$$x^T(0) E^T(0) R(0) E(0) x(0) \geq c_2; \tag{12}$$

from (9) we obtain that

$$\frac{d}{dt} x^T(t) E^T(t) P(t) E(t) x(t) = -\epsilon^2 x^T(t) x(t). \tag{13}$$

Integrating (13) from 0 to t we have

$$\begin{aligned} &x^T(t) E^T(t) P(t) E(t) x(t) - x^T(0) E^T(0) R(0) E(0) x(0) \\ &\quad = -\epsilon^2 \|x\|_2^2. \end{aligned} \tag{14}$$

Therefore

$$\begin{aligned} &x^T(t) E^T(t) R(t) E(t) x(t) \\ &\quad \geq x^T(t) E^T(t) P(t) E(t) x(t) \\ &\quad = x^T(0) E^T(0) P(0) E(0) x(0) - \epsilon^2 \|x\|_2^2 \\ &\quad \geq c_2 - \|z\|_2^2, \end{aligned} \tag{15}$$

which contradicts (8). □

2.2. Finite-Time Boundedness of Time-Varying Descriptor Systems. Consider the following time-varying descriptor systems

$$E(t)\dot{x}(t) = A(t)x(t) + G(t)\omega(t), \tag{16}$$

where $x(t) \in R^n$ is the state and $\omega(t) \in R^l$ is exogenous input. $A(t) \in R^{n\times n}$, $G(t) \in R^{n\times l}$ are given constant matrices. $E(t) \in R^{n\times n}$ is a singular function matrix, and rank $E(t) = q < n$.

The exogenous disturbance $\omega(t)$ is time varying and satisfies the constraint

$$\int_0^T \omega^T(t)\omega(t)\,dt \leq d, \quad d \geq 0. \tag{17}$$

Definition 4. The system (16) subject to an exogenous disturbance $\omega(t)$ satisfies (17) and is said to be finite-time bounded with respect to $(c_1, c_2, T, R(t), d)$ with positive definite matrices $R(t)$, and given three positive scalars c_1, c_2, T, with $c_1 < c_2$, if $x^T(0)E^T(0)R(0)E(0)x(0) \leq c_1$, then $x^T(t)E^T(t)R(t)E(t)x(t) < c_2$.

Theorem 5. *The time-varying descriptor system* (16) *is finite-time bounded, if there exist two positive definite nonsingular matrices* $P(t) \in R^{n\times n}$, $Q \in R^{l\times l}$, *such that*

$$\begin{bmatrix} M(t) & E^T(t)P(t)G(t) \\ G^T(t)P^T(t)E(t) & Q \end{bmatrix} < 0, \tag{18}$$

$$R(t) \leq P(t) \leq P(0) \leq R(0), \tag{19}$$

$$c_1 + d\lambda_{\max}(Q) < c_2 \tag{20}$$

hold, where $\lambda_{\max}(\cdot)$ *denote the maximum eigenvalue of the argument,*

$$\begin{aligned} M(t) = {} & A^T(t)P(t)E(t) + E^T(t)P(t)A(t) \\ & + \dot{E}^T(t)P(t)E(t) + E^T(t)\dot{P}(t)E(t) \\ & + E^T(t)P(t)\dot{E}(t). \end{aligned} \tag{21}$$

Proof. Let $V(t,x) = x^T(t)E^T(t)P(t)E(t)x(t)$.

We have

$$\begin{aligned} \dot{V}(t,x) = {} & x^T(t)M(t)x(t) + \omega^T(t)G^T(t)P^T(t)E(t)x(t) \\ & + x^T(t)E^T(t)P(t)G(t)\omega(t) \\ = {} & \left(x^T(t), \omega^T(t)\right) \\ & \times \begin{bmatrix} M(t) & E^T(t)P(t)G(t) \\ G^T(t)P^T(t)E(t) & Q \end{bmatrix} \\ & \times \begin{pmatrix} x(t) \\ \omega(t) \end{pmatrix} - \omega^T(t)Q\omega(t) \\ < {} & 0. \end{aligned} \tag{22}$$

Therefore,

$$\dot{V}(t,x) < \omega^T(t)Q\omega(t); \tag{23}$$

integrating from 0 to t, with $t \in [0,T]$, we have

$$V(t,x) < V_0 + d\lambda_{\max}(Q). \tag{24}$$

From (19), we have

$$\begin{aligned} &x^T(t)E^T(t)R(t)E(t)x(t) \\ &\quad \leq V(t,x) < V(0,x) + d\lambda_{\max}(Q) \\ &\quad < x^T(0)E^T(0)R(0)E(0)x(0) + d\lambda_{\max}(Q) \\ &\quad < c_1 + d\lambda_{\max}(Q) \\ &\quad < c_2. \end{aligned} \tag{25}$$

Therefore, system (16) is FTB. The proof is completed. □

2.3. Finite-Time Bounded Control of Time-Varying Descriptor Systems. Consider the following time-varying descriptor systems

$$E(t)\dot{x}(t) = A(t)x(t) + B(t)u(t) + G(t)\omega(t), \quad (26)$$

where $x(t) \in R^n$ is the state; $u(t) \in R^m$ is control input; $\omega(t) \in R^l$ is exogenous input. $A(t) \in R^{n\times n}, B(t)) \in R^{n\times m} G(t) \in R^{n\times l}$ are given continuous matrix-valued functions. $E(t) \in R^{n\times n}$ is a singular function matrix, and rank $E(t) < n$.

Find a state feedback control law

$$u(t) = K(t)x(t), \quad (27)$$

where $K(t) \in R^{m\times n}$. Let $A_c(t) = (A(t) + B(t)K(t))$. Then the closed-loop system is given by

$$E(t)\dot{x}(t) = A_c(t)x(t) + G(t)\omega(t). \quad (28)$$

Theorem 6. *The time-varying descriptor system* (19) *is finite-time bounded, if there exist a symmetric positive definite matrix $P(t) \in R^{n\times n}$, and a nonsingular matrix $Q \in R^{l\times l}$, such that inequality* (19), (20) *and the following condition hold:*

$$\begin{bmatrix} M(t) & E^T(t)P(t)G(t) \\ G^T(t)P^T(t)E(t) & -Q^T \end{bmatrix} < 0. \quad (29)$$

Moreover, the state feedback control law is given by

$$K(t) = B^{-1}(t)G(t)Q^{-1}(t)G^T(t)P^T(t)E(t), \quad (30)$$

where $\lambda_{\max}(\cdot)$ denote the maximum eigenvalue of the argument,

$$\begin{aligned} M(t) = {} & A^T(t)P(t)E(t) + E^T(t)P(t)A(t) \\ & + \dot{E}^T(t)P(t)E(t) + E^T(t)\dot{P}(t)E(t) \\ & + E^T(t)P(t)\dot{E}(t). \end{aligned} \quad (31)$$

Proof. From Theorem 5, the conditions for FTB is that there exist a nonsingular matrix Q such that (19), (20) and the following matrix inequality hold:

$$\begin{bmatrix} \overline{M}(t) & E^T(t)P(t)G(t) \\ G^T(t)P^T(t)E(t) & Q \end{bmatrix} < 0, \quad (32)$$

where

$$\begin{aligned} \overline{M}(t) = {} & (A(t) + B(t)K(t))^T P(t)E(t) \\ & + E^T(t)P(t)(A(t) + B(t)K(t)) \\ & + \dot{E}^T(t)P(t)E(t) + E^T(t)\dot{P}(t)E(t) \\ & + E^T(t)P(t)\dot{E}(t). \end{aligned} \quad (33)$$

According to Schur's theorem, it is easy to see that (32) can be rewritten as

$$\overline{M}(t) - E^T(t)P(t)G(t)Q^{-1}(t)G^T(t)P^T(t)E(t) < 0. \quad (34)$$

Using (30), (34), we have

$$M(t) + E^T(t)P(t)G(t)Q^{-T}(t)G^T(t)P(t)E(t) < 0. \quad (35)$$

Since $P(t)$ is symmetric, then

$$M(t) + E^T(t)P(t)G(t)Q^{-T}(t)G^T(t)P^T(t)E(t) < 0. \quad (36)$$

By Schur's theorem, (36) is equivalent to (29). The proof is completed. □

2.4. Finite-Time Bounded Control of Time-Varying Uncertain Descriptor Systems. Consider the following time-varying descriptor systems

$$\begin{aligned} E(t)\dot{x}(t) = {} & (A(t) + \Delta A(t)x(t)) \\ & + (B(t) + \Delta B(t))u(t) + G(t)\omega(t), \end{aligned} \quad (37)$$

where $x(t) \in R^n$ is the state; $u(t) \in R^m$ is control input; $\omega(t) \in R^l$ is exogenous input. $A(t) \in R^{n\times n}$, $B(t) \in R^{n\times m}$, $G(t) \in R^{n\times l}$ are given continuous matrix-valued functions. $E(t) \in R^{n\times n}$ is a singular function matrix, and rank $E(t) < n$.

$$[\Delta A(t) \;\; \Delta B(t)] = HF[E_1(t) \;\; E_2(t)], \quad (38)$$

where $F \in R^{q\times s}$ is unknown and satisfies

$$F^T F \le I. \quad (39)$$

Theorem 7. *The time-varying descriptor system* (37) *is finite-time bounded, if there exist a symmetric positive definite matrix $P(t) \in R^{n\times n}$, and a nonsingular matrix $Q \in R^{l\times l}$, such that inequality* (19), (20), *and* (32) *hold, and the state feedback control law is given by*

$$\begin{aligned} K(t) = {} & (B(t) + HFE_2(t))^{-1} \\ & \times (G(t)Q^{-1}(t)G^T(t)P^T(t)E(t) - HFE_1(t)), \end{aligned} \quad (40)$$

where

$$\begin{aligned} \overline{M}(t) = {} & [A(t) + \Delta A(t) + (B(t) + \Delta B(t))K(t)]^T \\ & \times P(t)E(t) + E^T(t)P(t) \\ & \times [A(t) + \Delta A(t) + (B(t) + \Delta B(t))K(t)] \\ & + \dot{E}^T(t)P(t)E(t) + E^T(t)\dot{P}(t)E(t) \\ & + E^T(t)P(t)\dot{E}(t). \end{aligned} \quad (41)$$

Proof. Applying (40) to (34), and $P(t)$ is symmetric, then the proof is completed. □

3. Numerical Example

Consider a time-varying descriptor system (26) with

$$E = \begin{bmatrix} t & 0 \\ 0 & 0 \end{bmatrix}, \qquad A = \begin{bmatrix} t & 0 \\ 0 & -1 \end{bmatrix}, \qquad B = \begin{bmatrix} 1 & 0 \\ 0 & t \end{bmatrix},$$
$$G = \begin{bmatrix} 1 \\ -t \end{bmatrix}. \tag{42}$$

Let $R(t) = P(t)$, $Q = t$, $T = 1$. Exist $P(t) = \left[\begin{smallmatrix} -t & 0 \\ 0 & t \end{smallmatrix}\right]$, such that

$$M(t) = \begin{bmatrix} -2t^3 - 3t^2 & 0 \\ 0 & 0 \end{bmatrix}, \qquad E^T(t)P(t)G(t) = \begin{bmatrix} -t^2 \\ 0 \end{bmatrix},$$
$$G^T(t)P^T(t)E(t) = \begin{bmatrix} -t^2 & 0 \end{bmatrix}. \tag{43}$$

So, condition (29), (19), (20) hold. the system (32) is finite-time bounded and the state feedback controller with

$$K(t) = B^{-1}(t)G(t)Q^{-1}(t)G^T(t)P^T(t)E(t) = \begin{bmatrix} -t & 0 \\ 1 & 0 \end{bmatrix}. \tag{44}$$

4. Conclusions

In this paper, we have studied the finite-time stability and given a sufficient and necessary condition of the finite-time stability; the state feedback controller was designed, then we studied the finite-time boundedness of time-varying descriptor systems, and a sufficient and necessary condition of the finite-time boundedness is given and a state feedback controller was designed. In the end, a numerical example is given to prove the effectiveness of the method.

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References

[1] J. Yao, Z.-H. Guan, G. Chen, and D. W. C. Ho, "Stability, robust stabilization and H_∞ control of singular-impulsive systems via switching control," *Systems & Control Letters*, vol. 55, no. 11, pp. 879–886, 2006.

[2] X. Lin, H. Du, and S. Li, "Finite-time boundedness and L_2-gain analysis for switched delay systems with norm-bounded disturbance," *Applied Mathematics and Computation*, vol. 217, no. 12, pp. 5982–5993, 2011.

[3] G. Garcia, S. Tarbouriech, and J. Bernussou, "Finite-time stabilization of linear time-varying continuous systems," *IEEE Transactions on Automatic Control*, vol. 54, no. 2, pp. 364–369, 2009.

[4] Z.-H. Guan, C. W. Chan, A. Y. T. Leung, and G. Chen, "Robust stabilization of singular-impulsive-delayed systems with non-linear perturbations," *IEEE Transactions on Circuits and Systems*, vol. 48, no. 8, pp. 1011–1019, 2001.

[5] Y. Tong, B. Wu, and F. Huang, "Finite-time bound and LL_2-gain analysis for linear time-varying singular impulsive systems," in *Proceedings of the Chinese Control and Decision Conference (CCDC '12)*, no. 24, 2012.

[6] E. Moulay, M. Dambrine, N. Yeganefar, and W. Perruquetti, "Finite-time stability and stabilization of time-delay systems," *Systems & Control Letters*, vol. 57, no. 7, pp. 561–566, 2008.

[7] J. Yao, J.-e. Feng, L. Sun, and Y. Zheng, "Input-output finite-time stability of time-varying linear singular systems," *Journal of Control Theory and Applications*, vol. 10, no. 3, pp. 287–291, 2012.

[8] F. Amato, R. Ambrosino, C. Cosentino, and G. DeTommasi, "Input-output finite-time stability of linear systems," in *Proceedings of the 17th Mediterranean Conference on Control and Automation*, pp. 342–346, Hessaloniki, Greece, June 2009.

[9] F. Amato, M. Ariola, C. Cosentino, C. T. Abdallah, and P. Dorato, "Necessary and sufficient conditions for finite-time stability of linear systems," in *Proceedings of the American Control Conference*, pp. 4452–4456, Denver, Colo, USA, June 2003.

[10] N. A. Kablar and D. L. Debeljkovic, "Finite-time stability of time-varying linear singular systems," in *Proceedings of the 37th IEEE Conference on Decision and Control (CDC '98)*, pp. 3831–3836, Tampa, Fla, USA, December 1998.

[11] J. Xu and J. Sun, "Finite-time stability of linear time-varying singular impulsive systems," *IET Control Theory & Applications*, vol. 4, no. 10, pp. 2239–2244, 2010.

[12] S. Zhao, J. Sun, and L. Liu, "Finite-time stability of linear time-varying singular systems with impulsive effects," *International Journal of Control*, vol. 81, no. 11, pp. 1824–1829, 2008.

[13] F. Amato, M. Ariola, and C. Cosentino, "Finite-time stability of linear time-varying systems: analysis and controller design," *IEEE Transactions on Automatic Control*, vol. 55, no. 4, pp. 1003–1008, 2010.

[14] F. Amato, R. Ambrosino, M. Ariola, and C. Cosentino, "Finite-time stability of linear time-varying systems with jumps," *Automatica A*, vol. 45, no. 5, pp. 1354–1358, 2009.

[15] F. Amato, M. Ariola, and C. Cosentino, "Finite-time stabilization via dynamic output feedback," *Automatica A*, vol. 42, no. 2, pp. 337–342, 2006.

[16] F. Amato, M. Ariola, M. Carbone, and C. Cosentino, "Finite-time output feedback control of linear systems via differential linear matrix conditions," in *Proceedings of the 45th IEEE Conference on Decision and Control (CDC '06)*, pp. 5371–5375, San Diego, Calif, USA, December 2006.

[17] P. Dorato, "Short time stability in linear time-varying systems," in *Proceedings of the IRE International Convention Record*, pp. 83–87, 1961.

[18] J. Sun and Z. Cheng, "Finite-time control for one kind of uncertain linear singular systems subject to norm bounded uncertainties," in *Proceedings of the 5th World Congress on Intelligent Control and Automation*, pp. 980–984, Hangzhou, Chin, June 2004.

[19] F. Amato, M. Ariola, and P. Dorato, "Finite-time control of linear systems subject to parametric uncertainties and disturbances," *Automatica*, vol. 37, no. 9, pp. 1459–1463, 2001.

[20] J.-E. Feng, Z. Wu, and J.-B. Sun, "Finite-time control of linear singular systems with parametric uncertainties and disturbances," *Acta Automatica Sinica*, vol. 31, no. 4, pp. 634–637, 2005.

[21] R. Ambrosino, F. Calabrese, C. Cosentino, and G. de Tommasi, "Sufficient conditions for finite-time stability of impulsive dynamical systems," *IEEE Transactions on Automatic Control*, vol. 54, no. 4, pp. 861–865, 2009.

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