Lecture Notes in Control and Information Sciences 435

For further volumes:
http://www.springer.com/series/642

Chunyu Yang, Qingling Zhang, and Linna Zhou

Stability Analysis and Design for Nonlinear Singular Systems

Springer

Authors
Chunyu Yang
School of Information and Electrical Engineering
China University of Mining and Technology
Xuzhou
P.R. China

Linna Zhou
School of Information and Electrical Engineering
China University of Mining and Technology
Xuzhou
P.R. China

Qingling Zhang
Institute of Systems Science
Northeastern University
Shenyang
P.R. China

ISSN 0170-8643
e-ISSN 1610-7411
ISBN 978-3-642-32143-6
e-ISBN 978-3-642-32144-3
DOI 10.1007/978-3-642-32144-3
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2012942952

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

In the past several decades, singular systems have been one of the major research fields of control theory because of their extensive applications in the Leontief dynamic model, electrical and mechanical models, etc. Depending on the area of applications, these models are also called descriptor systems, semi-state systems, differential-algebraic systems or generalized state-space systems. On the stability of linear time-invariant singular systems, many necessary and sufficient conditions have been reported. However, the stability problem for nonlinear singular systems has not been thoroughly investigated. This monograph aims to present up-to-date research developments and references on stability analysis and design of nonlinear singular systems. It investigates the problems of practical stability, strongly absolute stability, input-state stability and observer design for nonlinear singular systems and the problems of absolute stability and multi-objective control for nonlinear singularly perturbed systems by using Lyapunov stability theory, comparison principle, S-procedure and linear matrix inequality (LMI) etc.. It contains valuable reference material for researchers wishing to explore the area of singular systems, and its contents are also suitable for a one-semester graduate course.

In this monograph, practical stability of nonlinear singular systems is firstly studied. The basic concepts and results on practical stability for standard state-space systems are generalized to singular systems. Then, strongly absolute stability of Lur'e singular systems is defined. Circle criterion and Popov criterion are derived. The notion of input-state stability (ISS) for nonlinear singular systems is defined based on the concept of ISS for standard state-space systems and the characteristics of singular systems. LMI-based sufficient conditions for ISS of Lur'e singular systems are proposed. Furthermore, observer design for nonlinear singular systems is studied and some observer design methods are proposed by the obtained stability results and convex optimization algorithms. Finally, absolute stability and multi-objective control of nonlinear singularly perturbed systems are studied. Using ε-dependent Lyapunov functions, absolute stability criteria of Lur'e singularly perturbed systems are derived and multi-objective control of T-S fuzzy singularly perturbed systems is achieved. Compared with the existing results, the obtained methods do not depend on the decomposition of the original system and can produce a determinate upper bound for the singular perturbation parameter.

The work was partially supported by the National Natural Science Foundation of China (60904009, 60904079, 60974004, 61020106003), the Fundamental Research Funds for the Central Universities (N110408001, N100406010), the National Basic Research Program of China (2009CB320601) and the 111 project (B08015).

Xuzhou, China
June, 2012

Chunyu Yang
Qingling Zhang
Linna Zhou

Contents

Acronyms

PR	positive real
SPR	strictly positive real
ESPR	extended strictly positive real
LMI	linear matrix inequality
KYP	Kalman-Yakukobovich-Popov
SPS	singularly perturbed system
ISS	input-to-state stability
GLLF	generalized Lur'e Lyaponov function
SISO	single-input-single-output
MIMO	multiple-input-multiple-output