

Preface

Differential algebraic equations arise naturally in many significant applications, for example in mechanical body motion, chemical processing, power generation, network fluid flow, aircraft guidance. Such equations also exist in economy, for instance, the famous input–output Leontief model and its several important extensions, or in ecology and growth population, for instance, the Leslie growth population model and backward population projections.

Such systems may not be regular, referred to as singular, and often considered as a generalization of conventional state-space systems. The fact that these systems include algebraic equations enables them to encompass static constraints. These constraints may be intrinsic, such as some physical or behavior constraints, or induced by the analysis and/or the control approach. It is common to call these systems *descriptor systems* since they allow keeping the physical significance of state variables. Moreover, in their irregular form, they can also model systems with an impulsive (e.g. a derivative action) or non-causal behavior.

Since the 1970s, an abundant literature has shown the advantages of the generic specificity of descriptor systems. One issue of great importance is that unique solutions to initial value problems consistent with the system may not exist and the system may not be controllable or observable. A critical aspect of control system design is therefore to ensure regularity of the system. Likewise, many research works dealt with those new aspects that are inexistent for regular state-space systems. The frequency domain and time domain approaches are both discussed to give an overall picture of the status of the theory in the 1980s.

Twenty years later a remarkable number of results have been produced particularly on some extensions of state-space control theory to descriptor systems. Many control issues are tackled, such as pole placement, optimal control, observer synthesis, filtering and fault detection, control design under H_2 or H_∞ constraints, and their LMI-based solutions. This reading key is valid even today. In the same vein, many recent papers consider the open problems in this theme associated with the discrete-time control design case or state-space controllers design for descriptor systems, fault estimation, and fault-tolerant control.

This book develops some original results about linear descriptor systems through the two following different visions. The first one is generalizing some existing results from classical state-space case to descriptor systems, such as dilated LMI characterizations and performance control under regulation constraints. This part of the book is somehow in the continuity of the work mentioned before. Second, a different contribution of descriptor systems is highlighted. A new path is taken by considering these systems as a powerful tool for conceiving new control laws, understanding and deciphering some controller's architecture or even homogenizing different existing ways to obtain some new or known results for state-space systems. To emphasize this concern, for instance, the comprehensive control problem for continuous-time descriptor systems is an example of the descriptor framework used in order to transform a nonstandard control problem with unstable and nonproper weights into a traditional stabilization control problem. In another register, an exact solution is derived for the sensitivity constrained linear optimal control also by using the descriptor framework.

On new developments for descriptor systems or on the use of the descriptor approach to solve some extended or constrained control problems, this book brings a new brick to the knowledge edifice of descriptor systems. It also represents a synthesis of a work that lasts for a decade.

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Hangzhou, China
Nantes, France

Yu Feng
Mohamed Yagoubi

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Feng, Y.; Yagoubi, M.

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