Kokotović, Petar; **Khalil, Hassan K.**; **O'Reilly, John**
Singular perturbation methods in control: analysis and design. (English) Zbl 0989.93001
Classics in Applied Mathematics. 25. Philadelphia, PA: SIAM, Society for Industrial and Applied Mathematics. xvi, 371 p. (1999).

The present book is a new edition of the book of the same title, published by Academic Press, London, 1986; see the review in Zbl 0646.93001.

It is well known that systems of singularly perturbed equations model a large number of processes that have components with much faster evolution than others.

For the control engineer, singular perturbations legitimize an ad hoc simplification of dynamic models. One of them is the neglect of "small" time constants, masses, capacitances, and similar "parasitic" parameters that increase the dynamic order of a model. However, a design based on a simplified model may result in a system far from its desired performance, or even in an unstable system. If this happens, the control engineer needs a tool that will help him to improve his oversimplified design. What is required is to treat the simplified design as a first step, which captures the dominant phenomena; then the disregarded phenomena, if important, are treated in the second step.

It turns out that asymptotic expansions into reduced ("outer") and boundary-layer ("inner") series, which are the main characteristics of singular perturbation techniques, coincide with the outlined design stages. Because most control systems are dynamic, the decomposition into stages is dictated by a separation of time scales. Typically, the reduced model represents the slowest (average) phenomena, which in most applications are dominant. Boundary layer (a sublayer) models evolve in faster time scales and represent deviations from the predicted slow behavior. The goal of the second, third and later design stages is to make the boundary layers and sublayers asymptotically stable so that the deviations rapidly decay. The separation of time scales also eliminates stiffness difficulties and prepares for a more efficient hardware and software implementation of the controller.

A clarification of all these aspects is made in the seven chapters of the book. In the first chapter, some of the basic concepts of singular perturbation asymptotics and time-scale modeling are introduced by way of illustrative examples. So as to develop a more intuitive feel for time-scale phenomena, technical details and proofs are postponed to subsequent chapters. Since the rest of the book is design-oriented, some of the modeling examples developed in this chapter are later used to illustrate various analysis and design results.

Chapter 2 presents the main results concerning linear time-invariant control systems.

Chapter 3 deals with the problem of designing a stabilizing composite linear feedback and the problem of near optimal regulators, high gain feedback stabilization and robust output-feedback design.

Aspects of singular perturbation techniques in the presence of white-noise perturbations are investigated in Chapter 4.

Chapter 5 deals with singularly perturbed linear time-varying systems. Chapter 6 discusses some singularly perturbed optimal control problems. Chapter 7 considers several aspects concerning the stability problem with applications to synchronous machines, adaptive systems, etc.

The purpose of this book is to provide such a natural theoretical framework that is understandable with little mathematical background. The book is of interest to all graduates, researchers and professionals in applied mathematics, control engineering and aerospace engineering who work with fundamental stabilization problems in systems and control theory.

Reviewer: V.Dragan (Bucureşti)

MSC:

93-01	Introductory exposition (textbooks, tutorial papers, etc.) pertaining to systems and control theory	Cited in **1** Review Cited in **41** Documents
93C70	Time-scale analysis and singular perturbations in control/observation systems	
93C15	Control/observation systems governed by ordinary differential equations	
93E11	Filtering in stochastic control theory	
34D15	Singular perturbations of ordinary differential equations	
93E10	Estimation and detection in stochastic control theory	
34E15	Singular perturbations, general theory for ordinary differential equations	

Keywords:

boundary-layer series; time-scale; composite linear feedback; high gain feedback stabilization; robust output-feedback; singular perturbation; optimal control problems