

# Preface

Almost all control systems are realized using discretized (discrete-time and discrete-value, i.e., digital) signals. However, analysis and design methods for discretized/quantized control systems are not always established. The analytical treatment of linear discrete-time (sampled-data) control systems was developed in the 1950s and the 1960s, and is covered in several classical textbooks. Nevertheless, since the characteristics of control systems with discrete-value (discretized) signals become nonlinear, the analysis and design of these discrete control systems has not been elucidated. The aim of this book is to establish a basis for the analysis and design of discretized/quantized control systems for continuous physical systems.

Chapter 1 surveys the mathematical descriptions of discrete-time and also “discrete-value” systems. In Chap. 2, beginning with the necessary mathematical foundations and system model descriptions, the analysis in function spaces for these discretized (nonlinear) control systems is developed. Chapter 3 analyzes the robust stability of discretized nonlinear feedback systems in the frequency domain based on the input-output stability concept. In order to keep a practical perspective on the uncertain physical systems, most of the methods are carried out in the frequency domain. As part of the design procedure, modified Nyquist-Hall and Nichols diagrams are presented. In Chap. 4, first, a discretized version of traditional proportional-integral-derivative (PID) control schemes is reconsidered. Next, schemes for a model reference feedback that corresponds to a discrete observer feedback are proposed. It is shown that the model reference feedback approximately becomes a PID control scheme.

Although single-loop feedback systems form the core of the text, in Chap. 5, some considerations are given to multiple loops and nonlinearities. Furthermore, Chap. 6 discusses the robust control performance and stability of discrete interval systems (with multiple uncertainties) from the viewpoint of the characteristic roots area based on Sturm’s theorem. Finally, in Chap. 7, the relationship between feedback control and discrete event systems is outlined. The nonlinear phenomena associated with practically important event-driven systems are elucidated, and the dynamics and stability of finite state and discrete event systems are defined.

The author’s thoughts on recent control theory are as follows.

- (1) The state-space representation is useful for the analysis and simulation of control systems in the time domain. However, the method is not always appropriate for the design of control systems.
- (2) To keep a practical perspective on uncertain physical systems, modeling/identification and control should be carried out in a limited frequency range.
- (3) There will be a large difference in time scale for feedback control systems (transient responses) and adaptive control loops. Therefore, adaptive and learning control processes should be discussed separately.
- (4) This book treats discrete signals; therefore, differential and integral techniques are not used in principle.

I would like to thank Mr. Oliver Jackson and Ms. Charlotte Cross at Springer UK for giving me the opportunity to write this book and for helping me to complete it.

Tokushima, Japan  
October 2013

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<http://www.springer.com/978-1-4471-5666-6>

Discrete Control Systems

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2014, XII, 251 p. 165 illus., 100 illus. in color.,

Hardcover

ISBN: 978-1-4471-5666-6