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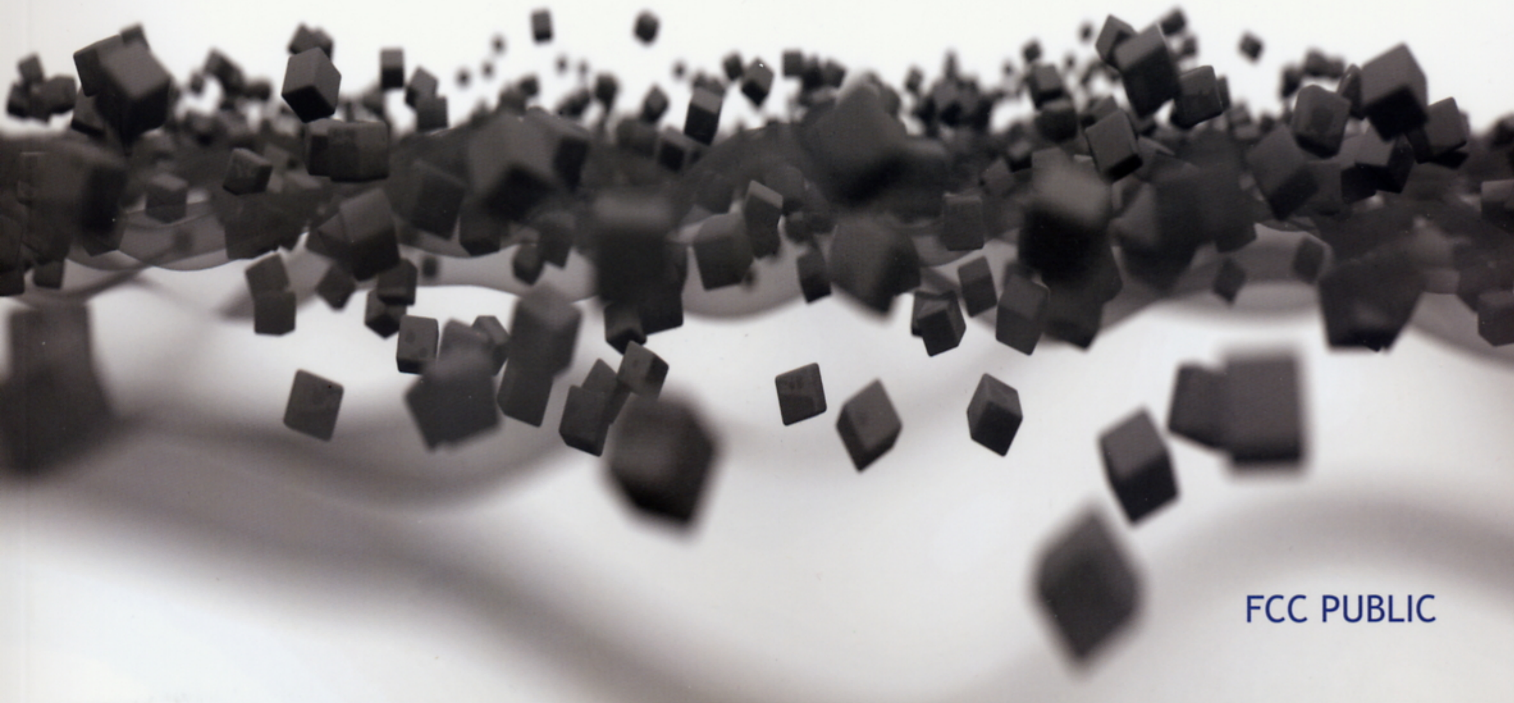

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Process Control is a basic essence in this digital age that helps to keep industries competitive. This book is a detailed guide through the fundamentals of understanding, designing, and practicing control systems. Although an introductory nature of the text, it covers the major elements of process control applicable for students studying automatic control courses, as well as for professionals looking for proven guidance usable in day–to–day operations.

Unique features of the text include succinctly comprehensive presentation, complete teaching environment, sensitive selection of methods and techniques, piece of the newest original research, introduction of concepts which are untypical in current process control books, introduction to the modern concepts versus classical concepts and serious effort to emphasize readable language with using acceptable mathematics.

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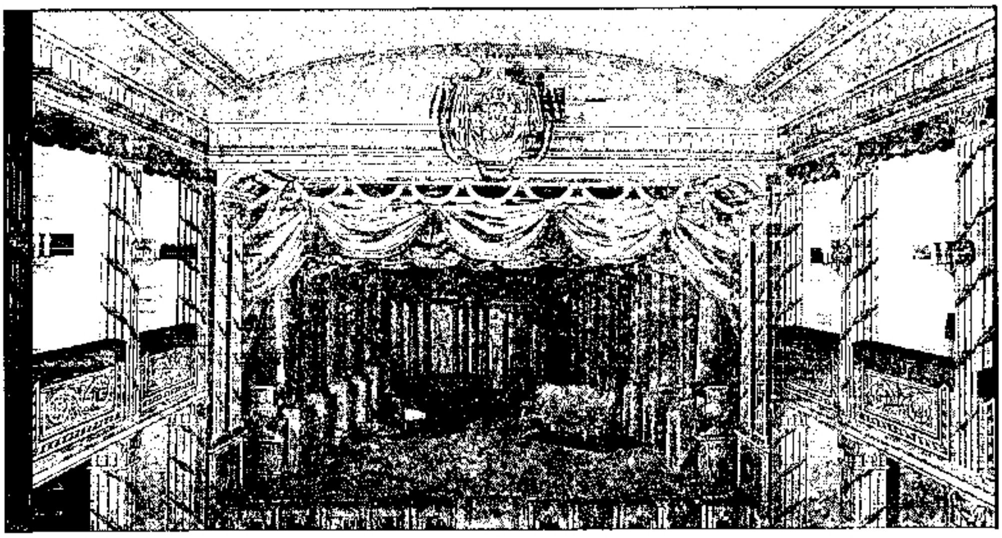
Preface

 [1]

It is widely recognized that process control is a key element for keeping industries competitive in a world wide market. Therefore, the major objective of this book is to teach students to analyze the dynamics of processes and to develop automatic control strategies with a view to a robust, safe and economical process operation. This text was developed for the process control engineering courses offered to engineering students of technical universities as well as a starting textbook for control engineers or instructors. It emphasizes the interdisciplinary nature and the effort to transform complex tasks such as dynamics described by differential equations to easier forms of algebraic equations and to computer simulation tools. The first eight chapters introduce the theory of continuous–time analog process control and its application for a basic course; the ninth chapter deals with two–valued logic control systems. Note that this book assumes that the reader does not know much about process control.

There is a variety of books in process control theory and practice. Therefore, it was not possible to stay uninspired by some of them as well as by a standard form of presentation of these topics. On the other hand, the authors of this book present their own view and experience from their long–term process control teaching and from many related applications and projects including new control tuning strategies, the development of industrial versatile digital controllers and the design of control strategies for various laboratory and industrial processes.

The unique features of this book include:

- a succinctly comprehensive presentation and integration of basic theoretical and application concepts ;
- a complete teaching environment that includes a solution for many concrete problems of "how to make" type ;
- a sensitive selection of methods and techniques which are really needed ;
- a piece of newest original contributing research results of the authors such as balanced control, measure of aggressiveness, process identification or monitoring of performance ;

[1]This small theater in the castle of Litomyšl is from the end of 18th century. It is considered as a jewel of the baroque style in Bohemia, the painters have played with optical illusions and perspective effects to create unique *trompe l'oeil* decorations. Here the widely open stage symbolizes the opening to the theory and applications of automatic control. Source: Pavel Vopálka and city hall of Litomyšl with permission.

- an introduction of concepts which are untypical in current process control books such as logic control together with continuous control, a view to the control history, a solution of oscillation problems, problems with non–linearities etc ;
- an introduction to the modern concepts versus classical concepts ;
- a serious effort to emphasize readable language with using an acceptable "polynomial" mathematics, the meaning and significance of every term used, what the term is related to the process, to the controller, or to the control performance.

Accordingly, Chapter 1 presents the very basic concepts and techniques of process control. The main goals of this chapter are to explain why process control is needed, to present the basic components of a control system, to define very common terms and to present the concept for feedback control and feedforward control with their advantages, disadvantages, and limitations. A couple of historical aspects of the control theory is added to illustrate the field development.

To achieve a good process control system there are at least five things to know and fully understand: the process, the process, the process, the controller, the controller tuning. Chapter 2 presents a discussion of processes from a very complex point of view. Most common characteristics of processes as well as processes from a non–mathematical viewpoint are discussed here. Everything presented in this chapter is used extensively in the followings.

Chapter 3 introduces processes from the common mathematical point of view of control engineers. Some processes are introduced here from a very physical point of view and after they are described with transfer functions. Process dynamics, time delays, modelling techniques and their mathematical fundamentals are introduced including the Laplace transform and the resulting block algebra. It is not necessary to have specific mathematical skills about the integrals in Laplace transform, the latter is possible to understand and to handle using a "vocabulary" with derivatives and integrals in the left–hand side and simple algebraic calculus in the right–hand side. Tools for the practical identification of mathematical models are also described.

Chapter 4 presents a detailed discussion of the analysis of feedback control systems, techniques for developing feedback systems, methods for analyzing the stability of a closed–loop system, and the presentation of basic feedback controllers such as proportional, integral, derivative controllers and their combinations and their properties in feedback control systems. A significant effort is made to introduce the PID controller, the workhorse in the process control industry. The kind reader will see the charming and understandable algebraic manipulations in studying feedback control. The role of each controller parameter and the results of its tuning are explained in details as well as the different types of controllers with their advantages and disadvantages. Stability is presented from a practical point of view without dealing much with mathematics. It is important to understand how each term in the control system affects the stability of the system. The detrimental effect of time delays on the stability of a control system is also presented in Chapter 4 and it is summarized in Chapter 6.

Chapter 5 shows how to tune, adjust or adapt controllers for the process to be controlled. The importance of a good controller tuning is emphasized. Analytical as well as experimental methods for controller tuning are described in this chapter including the effects of each tuning parameter. For example, it presents the "ancient" Ziegler–Nichols closed–loop oscillation method as a method giving a very practical point of view to the controller tuning. On the other hand, it also presents the so–called *balanced tuning* technique as an example of a good controller tuning for the response to controller set–point changes.

In Chapter 6 some particular and improved strategies as well as improved common control configurations are presented. It includes cascade or feedforward control systems as well as control systems based on models such as internal model control. The common factor for all the methods in this chapter is that the control has lead to improved performance. As it can be seen, the improved performance can be reached not only via a good tuning of the controller, it can be combined by an appropriate structure of the control system and by measuring the control performance or by an indication of possible oscillations. Feedback control is never removed. Although the PID controller remains the most widely used controller, in this chapter it is shown how to convert classical PID controllers for a better performance or for meeting more complex control requirements (MIMO systems for example). Notice that some control systems suffer of poor performance, either because originally the controller tuning was not good, or because the controlled process is nonlinear and the parameters of a linearized model may change with the process operating conditions. Methods of dealing with these problems are also presented in Chapter 6.

Chapter 7 deals with the analysis and design of control systems in the frequency domain. The classical techniques based on Nyquist plots and Bode diagrams are presented. Frequency analysis is important for determining control system robustness.

Chapter 8 provides a cursory introduction to some methods of control which belong to the so–called "modern control theory". It describes some methods based on linear state–space models and design techniques using these models. This chapter also introduces to the optimal control theory, the controller design by a pole placement technique, and model predictive control. Some algebraic consequences are also given.

Chapter 9 is a comprehensive introduction to logic control and to the use of programmable logic controllers. It is presented from a very practical point of view with using a "daily" mathematics to understand how to design and to implement logic controllers. They often are a substantial part of continuous control applications providing protection against the limits of the process operating conditions and of the actuators, as also other boundary conditions and that of auxiliary variables.

Raymond Gorez is since 1999 professor emeritus from the Polytechnic School of the University of Louvain (Louvain-la-Neuve) in Belgium. He was primarily interested in the automatic control of mechanical systems.

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