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Digital Self-tuning Controllers: Algorithms, Implementation and Applications

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Preface

The field of adaptive control has undergone significant development in recent years. The aim of this approach is to solve the problem of controller design, for instance where the characteristics of the process to be controlled are not sufficiently known or change over time. Several approaches to solving this problem have arisen. One showing great potential and success is the so-called self-tuning controller (STC).

The basic philosophy behind STCs is the recursive identification of the best model for the controlled process and the subsequent synthesis of the controller. A number of academics from universities and other institutes have worked intensively on this approach to adaptive control; K. J. Åström (Department of Automatic Control, Lund Institute of Technology), D. W. Clarke (Department of Engineering Science, University of Oxford), P. A. Wellstead (Institute of Science and Technology, University of Manchester), R. Isermann (Department of Control Engineering, Technical University of Darmstadt), I. D. Landau (Institut National Polytechnique de Grenoble), H. Unbehauen (Control Engineering Laboratory, Ruhr University Bochum) and also V. Peterka (Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic, Prague) can be considered as pioneers in this field.

Although during research much effort has been devoted to meeting specific practical requirements it cannot be said that the above approach has been widely applied. On the other hand, many projects have been successfully put into practice. The characteristic common to all these projects was that there was a sufficiently qualified operator available who was both well acquainted with the technology in the field and able to take on board the scientific aspects of the work.

At this current stage of development in adaptive controllers there is a slight growth of interest in both the simpler and more sophisticated types of controller, particularly among universities and companies that deal with control design. It can be seen, however, that the lack of suitable literature in this field imposes a barrier to those who might otherwise be interested. We are referring especially to literature which can be read by the widest possible

audience, where the theoretical aspects of the problem are relegated to the background and the main text is devoted to practical issues and helping to solve real problems. In comparison with the most recent publications on this subject, this book leans towards practical aspects, aiming to exploit the wide and unique experience of the authors. An important part of this publication is the detailed documentary and experimental material used to underline the elements in the design approach using characteristics in the field of time or frequency, dealing with typical problems and principles which guide the introduction of individual methods into practice. We should like to note that all the suggested control algorithms have been tested under laboratory conditions in controlling real processes in real time and some have also been used under semi-industrial conditions.

The book is organized in the following way. Chapter 1 gives a brief view of the historical evolution of adaptive control systems. The reader is introduced to problems of adaptive control and is acquainted with a classification of adaptive control systems in Chapter 2. Modelling and process identification for use in self-tuning controllers is the content of Chapter 3. Chapter 4 discusses self-tuning PID (Proportional-Integral-Derivative) controllers. Algebraic methods used for adaptive controller design are described in Chapter 5. Chapter 6 is dedicated to controller synthesis based on the minimization of the linear quadratic (LQ) criterion. Toolboxes have been created for the MATLAB®/SIMULINK® programming system. They serve to demonstrate designed controller properties and help in applications of controllers in user-specific cases. They are described in Chapter 7. Chapter 8 is devoted to practical and application problems. This chapter is based on the rich practical experience of the authors with implementation of self-tuning controllers in real-time conditions.

Although this book is the product of four workplaces (two universities, academia and industry), the authors have tried to take a unified approach. Of course, this has not always been possible. The original work is followed by a list of literature treating the problem under discussion. We assume the reader knows mathematics to technical university level.

This book was created by a team of authors. Chapter 2 was written by V. Bobál, Chapter 3 by V. Bobál together with J. Böhm. V. Bobál and J. Fessl created Chapter 4 as follows: Sections 4.1 and 4.2 they wrote together, Sections 4.3, 4.4, and 4.5 are by J. Fessl, and Sections 4.6, 4.7, 4.8, and 4.9 are by V. Bobál. J. Macháček and V. Bobál wrote Chapter 5. Chapter 6 was written by J. Böhm and Chapter 7 by V. Bobál and J. Böhm. Finally Chapter 8 is a corporate work by all authors.

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