Preface

Automatic control encroaches upon many of the defined engineering and mathematics university courses in terms of both theory and practice. In common with most engineering disciplines it is a topic which is constantly changing in order to keep pace with modern day application requirements. In the 1960s control engineers were predominantly concerned with analog design procedures, the analog computer being a fundamental building block. Things have changed considerably since that period.

Many new techniques have risen to prominence in the area of control systems during the last decade. Significantly, the increasing influence of microcomputers has led to a much greater need for an emphasis to be placed on digital aspects of control. Many control ideologies that were once thought to be unrealizable, except in a few extreme cases, because of hardware limitations, have now become everyday realities in practical industrial applications due to the transference of complex algorithms to a software base. With the advent of VLSI design in association with special-purpose machines, higher speed and greater memory capacity computers are becoming available, allowing further control schemes to be considered.

The undergraduate students of engineering taking an introductory control course as part of their overall degree must necessarily become aware of the developments in digital control which have now become standard practice in many industrial applications and are fundamental to any further degree courses or research in control. This book treats digital control as one of the basic ingredients to an introductory control course, including the more regularly found topics with equal weight.

Organization of the book is as follows. A general overview of the field called control systems is introduced in Chapter 1. This includes a brief history of control and points out many of the standard definitions and terms used. In Chapter 2 it is shown how mathematical models can be formed in order that they may be representative of a system. Basic handling rules for these models are given and the model's relationship with everyday engineering tools and apparatus is stressed.

Differential equations are examined in Chapter 3 and in Chapter 4 system stability and performance, important aspects of control systems design, are considered. These two chapters, in effect, detail the necessary mathematical tools used in the analysis of a system and give an indication as to how the system responds to a particular set of conditions. Chapter 4 concentrates mainly on the Routh–Hurwitz criterion in terms of stability and root-locus techniques for performance by investigating the effect of parameter variations on the roots of the system characteristic equation.

Chapter 5 looks into the frequency response methods due to Bode and Nyquist. Details are given with emphasis placed on how to design compensation networks using the methods described. The same approach is then taken in the discussion based on the Nichols chart which is used in obtaining the system closed-loop frequency response. It is considered that Chapters 3, 4 and 5 cover what is now termed classical control techniques; the rest of the book is therefore devoted to more recently devised methods.

Design philosophies and system descriptions based on the state space are brought together in Chapters 6 and 7. The use and variety of state equations and their relationship to system transfer functions is found in Chapter 6, whereas Chapter 7 is devoted more to system control using state feedback, subject to this being possible. Realization of the state variables when these are not measurable or physically obtainable is also considered.

Digital control uses the z operator and is closely linked with computer control via sampled-data systems. Computers, however, are also used for control design in terms of system simulations and modeling. Chapters 8 and 9 include the important topics of digital and computer control, computer-aided control system design being highlighted. The final chapter looks in depth at the most widely used control scheme, the PID controller, and includes details of its implementation in both continuous and discrete time.

The book is intended to be used in relation to an introductory course on control systems, for which students need a mathematical background such that Laplace transforms, solutions to differential equations and complex numbers have been taught.

This text has been put together with the help of several people. I would particularly like to thank John Westcott, John Finch, Mohammed Farsi and Keith Godfrey for their technical appraisal, and numerous former students who have provided valuable feedback on the material presented. I would also like to acknowledge the assistance of Sukie Clarke and Karen Smart in preparing the text and correcting my tewible English. Finally, I am immeasurably grateful for the support I have received from my family during the writing of this book, including practical help from my daughter Madeline: I hope the reader concludes that it has been worth it.

Preface to the Second Edition

One of the reviewer's comments on the first edition was that the section on Analog Computers was rather dated. In the second edition, apart from a brief mention, this section has been completely removed, to be replaced by a completely new section on Fuzzy Logic Controllers, which is very much of interest both from an academic and industrial viewpoint.

I am delighted that World Scientific Publishing Co. have decided to publish this second edition, following the first edition selling out very quickly. My thanks go to Liz Lucas for all her help in putting together this edition, her husband Rodney for helping with the figures and Barbara Griffin at World Scientific for her patience.