

Preface

The motivation for writing this book can be ascribed chiefly to the usual struggle of an average reader to understand and utilize controls concepts, without getting lost in the mathematics. Many textbooks are available on modern control, which do a fine job of presenting the control theory. However, an introductory text on modern control usually stops short of the really useful concepts – such as optimal control and Kalman filters – while an advanced text which covers these topics assumes too much mathematical background of the reader. Furthermore, the examples and exercises contained in many control theory textbooks are too simple to represent modern control applications, because of the computational complexity involved in solving practical problems. This book aims at introducing the reader to the basic concepts and applications of modern control theory in an easy to read manner, while covering in detail what may be normally considered advanced topics, such as multivariable state-space design, solutions to time-varying and nonlinear state-equations, optimal control, Kalman filters, robust control, and digital control. An effort is made to explain the underlying principles behind many controls concepts. The numerical examples and exercises are chosen to represent practical problems in modern control. Perhaps the greatest distinguishing feature of this book is the ready and extensive use of MATLAB (with its *Control System Toolbox*) and SIMULINK®, as practical computational tools to solve problems across the spectrum of modern control. MATLAB/SIMULINK combination has become the single most common – and industry-wide standard – software in the analysis and design of modern control systems. In giving the reader a *hands-on* experience with the MATLAB/SIMULINK and the *Control System Toolbox* as applied to some practical design problems, the book is useful for a practicing engineer, apart from being an introductory text for the beginner.

This book can be used as a textbook in an introductory course on control systems at the third, or fourth year undergraduate level. As stated above, another objective of the book is to make it readable by a practicing engineer *without* a formal controls background. Many modern control applications are *interdisciplinary* in nature, and people from a variety of disciplines are interested in applying control theory to solve practical problems in their own respective fields. Bearing this in mind, the examples and exercises are taken to cover as many different areas as possible, such as aerospace, chemical, electrical and mechanical applications. Continuity in reading is preserved, without frequently referring to an appendix, or other distractions. At the end of each chapter, readers are

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given a number of exercises, in order to consolidate their grasp of the material presented in the chapter. Answers to selected numerical exercises are provided near the end of the book.

While the main focus of the material presented in the book is on the state-space methods applied to linear, time-invariant control – which forms a majority of modern control applications – the classical frequency domain control design and analysis is not neglected, and large parts of Chapters 2 and 8 cover classical control. Most of the example problems are solved with MATLAB/SIMULINK, using MATLAB *command lines*, and SIMULINK block-diagrams immediately followed by their resulting outputs. The reader can directly reproduce the MATLAB statements and SIMULINK blocks presented in the text to obtain the same results. Also presented are a number of computer programs in the form of *new* MATLAB M-files (i.e. the M-files which are *not* included with MATLAB, or the *Control System Toolbox*) to solve a variety of problems ranging from *step* and *impulse* responses of single-input, single-output systems, to the solution of the *matrix Riccati equation* for the terminal-time weighted, multivariable, optimal control design. This is perhaps the only available controls textbook which gives ready computer programs to solve such a wide range of problems. The reader becomes aware of the power of MATLAB/SIMULINK in going through the examples presented in the book, and gets a good exposure to programming in MATLAB/SIMULINK. The numerical examples presented require MATLAB 6.0, SIMULINK 4.0, and *Control System Toolbox 5.0*. Older versions of this software can also be adapted to run the examples and models presented in the book, with some modifications (refer to the respective *Users' Manuals*).

The numerical examples in the book through MATLAB/SIMULINK and the *Control System Toolbox* have been designed to prevent the use of the software as a *black box*, or by rote. The theoretical background and numerical techniques behind the software commands are explained in the text, so that readers can write their own programs in MATLAB, or another language. Many of the examples contain instructions on programming. It is also explained how many of the important *Control System Toolbox* commands can be replaced by a set of intrinsic MATLAB commands. This is to avoid over-dependence on a particular version of the *Control System Toolbox*, which is frequently updated with new features. After going through the book, readers are better equipped to learn the advanced features of the software for design applications.

Readers are introduced to advanced topics such as H_∞ -robust optimal control, structured singular value synthesis, input shaping, rate-weighted optimal control, and nonlinear control in the final chapter of the book. Since the book is intended to be of introductory rather than exhaustive nature, the reader is referred to other articles that cover these advanced topics in detail.

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Ashish Tewari

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