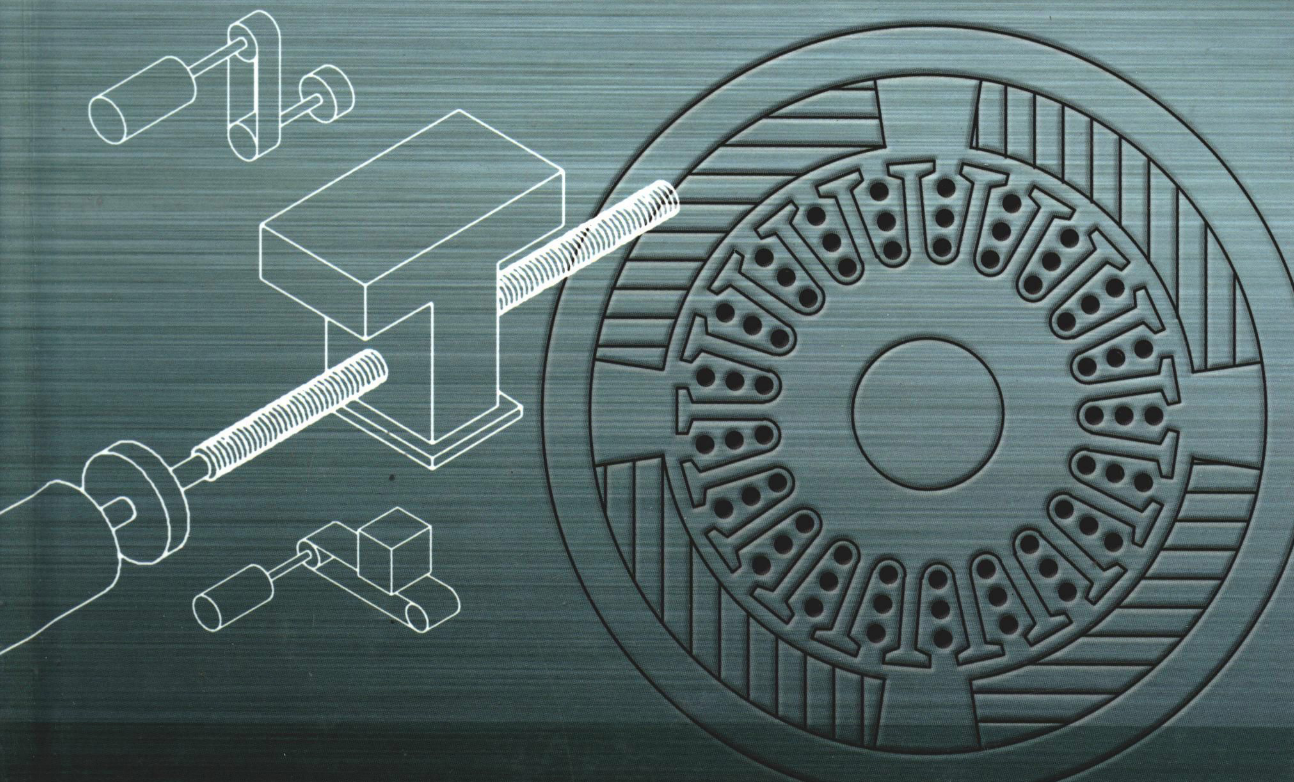
Electromechanical Motion Systems - Design and Simulation

Frederick G. Moritz



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DESIGN AND SIMULATION

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ELECTROMECHANICAL MOTION SYSTEMS

To my wife,

Louise,

For her enthusiastic support and encouragement

Acknowledgements

To Roger Mosciatti and Thomas Foley, my partners for over 25 years at MFM Technology; the two most inventive and dedicated engineers it has been my pleasure to know. Our efforts individually and together led to over 20 US patents and a highly successful manufacturer of motion control products and systems.

To Hans Waagen, an engineer who combines an in-depth knowledge of motion control with an ability to concisely analyze and interpret a customers' product requirements.

To Avi Telyas, founder of the Bayside Motion Group, an entrepreneur who understands and supports the engineers' contribution to the success of high tech business ventures.

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To my wife Louise and son Peter for their able participation in checking the manuscript and proofs of the complete book.

Contents

1

Introduction

Having spent the first half of my engineering career in the design of motion control systems in computer peripheral equipment (digital tape recorders, disc memories and high speed line printers) and the second half in the design, manufacture and application of brushless motors, gearheads and slides, I have been both a user and a supplier of the various components used in high performance servo/control systems.

Time restraints in a typical one or two semester motion control/servo system course require that the text and class time devote a majority of their content to topics such as pertinent mathematics, LaPlace transform, linear system analysis, closed loop control theory and stabilization techniques. Little time can be devoted to a detailed presentation of the system components, which are typically presented in a cursory fashion only as needed to aid in the discussion of the system theory.

This book will extend such course work by providing an introduction to the technology of the major components that are used in every motion system.

A website is available (www.wiley.com/go/moritz) which will allow you to access a number of the figures in this book. You will be able to activate them, observe simulation activity, modify system parameters to observe the effect on system performance and print out the results. For example, in Figure 4.13 you can change the motor parameters (*R*, *L*, torque constant, etc.) or the load torque or the PI values to observe the effect on performance and stability. The figures that are accessible are identified throughout the book with (available at www.wiley.com/go/moritz) appended to their captions.

A system designer cannot become an expert in the design of system components. He will never fabricate his own motor or encoder, but he must understand the basics of those components in order to properly apply them and have successful discussions with his component suppliers.

I have found that one of the best sources of information about component technology is from the well written and timely application notes and white papers from component suppliers. Over the years I have accumulated a valuable file of such information and encourage everyone engaged in system design to do the same.

Electromechanical Motion Systems: Design and Simulation, First Edition. Frederick G. Moritz.

Companion Website: www.wiley.com/go/moritz

Since the time I used a Bendix G15 computer in the 1960s there have been amazing advances in computer technology and application software that now allow simulation of complete electromechanical systems, including both linear and nonlinear characteristics of all the components. Throughout this book, component and system simulation is used to demonstrate the use of this technology to display system operation. A number of programs, such as MATLAB® and Simulink® by The Mathworks, MapleSim by Maplesoft, Ansys by Ansoft and VisSim by Visual Solutions are available to perform such simulations. The simulations in this book have been created with VisSim.

The book consists of the following chapters:

Chapter 2 – A brief review of servo/motion control theory, including an introduction to the use of simulation for root solving and a review of sampled data technology.

Chapter 3 – Detailed descriptions of the main components used in the fabrication of electromechanical motion control systems.

Chapter 4 – A review of the various system characteristic functions showing how they can be described and analyzed by the use of computer simulation techniques. It also contains a summary of the dynamic equations describing eight basic building blocks, which form the foundation of most motion systems.

Chapter 5 – Contains design notes and simulations of five of the many systems I helped create.

1.1 Targeted Readership

This book will be useful to:

- Students at the senior undergraduate or graduate school level to supplement their standard systems text to provide detailed component and simulation information as an aid in the design and analysis of prototype systems.
- As a reference text for graduate school students in advanced system courses involved in detailed system design and component selection.
- Practicing engineers initiating a system design requiring background information about components unfamiliar to them and/or an introduction in the use of simulation techniques.

1.2 Motion System History

A detailed and complete history of the motion control field would alone require a book larger than this one. Therefore the following just covers some highlights in the field and some of the pioneers and their accomplishments and contributions to motion control.

Since the late 1800s mathematical analysis and design of motion control has been limited to modeling the system in terms of its classical Newtonian differential equations with constant coefficients since no method existed to model nonlinearites (saturation, dead band, hysteresis, etc.) At best, linear approximations of nonlinearities have been made and designs modified once prototype test results are obtained.