PLC Motion Control:

An Emphasis on Design and Application

Kelvin T. Erickson

Missouri University of Science and Technology

Esther A. Erickson

NTI AG - LinMot & MagSpring

Dogwood Valley Press, LLC

This book was set in Times New Roman and printed on acid-free paper.

Printed in the United States of America

ISBN 978-0-9766259-8-8

Dogwood Valley Press, LLC
1604 Lincoln Lane
Rolla, MO 65401
1-573-426-3507

http://www.DogwoodValleyPress.com

10 9 8 7 6 5 4 3 2 1

Dedicated to Fran, David, Amanda, Ezra, and Elijah

CONTENTS

PREFACE

Many modern automation systems, such as robotics, packaging, assembly, and machining require precise control of the motion. This book presents the subject of servo motion control using programmable logic controllers (PLCs) as the implementation platform with an emphasis on the design and application. This book uses the PackML standard as the framework for the implementation.

The text focuses on the implementation with Rockwell Automation ControlLogix and CompactLogix processors and with Siemens S7-1500 processors. These processor families integrate the motion control and safety functions with the other programming into the processor. The primary language is ladder logic, though structured text (Rockwell) and structured control language (Siemens) are used for equations as needed.

Throughout, the book contains example applications demonstrating good design and implementation practice. In addition, these applications are implemented for both Rockwell and Siemens PLCs. The text culminates in a case study where a packaging system illustrates an application of the motion concepts.

This book takes a practical approach to the design of PLC-based motion control systems. There are some mathematical concepts in the material about servo loop tuning (Chapter 6) and in the material about motor and drive sizing (Chapter 7).

Most chapters begin with a scenario that reflects the experience of the authors and their colleagues in the challenging world of factory automation. These scenarios present a small problem and the solution and are intended to illustrate troubleshooting techniques..

Objectives

The main objectives of this text are to teach:

- Basic motion control concepts for Rockwell Automation and Siemens PLCs
- Multi-axis coordinated motion control
- PackML approach to motion control implementation
- Servo loop tuning
- Sizing motors and drives
- Machine safety functions
- Implementation on Rockwell Automation and Siemens processors

Content Overview

The book starts by describing the structure of a motion control system and its major components. Chapter 2 covers the fundamental concepts of a project involving motion control for Rockwell and Siemens: project organization, networking, and installation. The motion blocks (instructions) for Rockwell PLCs are described in Chapter 3 and for Siemens

PLCs are described in Chapter 4. Chapter 5 describes the PackML standard and its implementation on Rockwell and Siemens PLCs. The solution to a simple two-axis motion scenario illustrates the concepts and implementation. Chapter 6 is concerned with the tuning of the servo loops, an important part of initial commissioning of the system. How one determines the mechanical system properties and then selects an appropriate servo motor and servo drive is the subject of Chapter 7. Variable-frequency drives are considered in Chapter 8. Coordinated multi-axis motion is covered in Chapter 9. This chapter covers applications of cam motion, fully coordinated muti-axis motion, and virtual axes. Other motion scenarios, namely, wind/rewind tension control and vertical loads are covered in Chapter 10. Machine safety and its incorporation into the PackML implementation is discussed in Chapter 11. Chapter 12 describes the units of a typical packaging system, illustrating typical motion applications with the types of motion and the blocks that implement the motion.

The Audience

This book primarily serves professional automation engineers – those that are already experienced control engineers and skilled PLC programmers that want to add to their skillset. Those that successfully implement and commission a servo motion control system are generally considered “a level above” other control engineers.

This text also serves the academic market in electrical, mechanical, or industrial engineering degree programs. The material is at the senior undergraduate level for engineering or engineering technology or graduate engineering level. A comprehensive prerequisite course in PLC programming is essential.

Online Content

Supplementary online content for the text is posted at **www.dogwoodvalleypress.com** and includes PLC project files and print-outs for the text examples..

Acknowledgements

Portions of this material were taught in a university course for multiple years and the students are acknowledged for their help in pointing out errors in the text and where the presentation was unclear.

NFPA 79, NEC, and National Electrical Code are registered trademarks of the National Fire Protection Association.

Disclaimer

Information furnished herein is believed to be accurate and reliable; however no responsibility is assumed for any errors. The user assumes full responsibility for the accuracy and appropriateness of this information.

The ladder logic portrayed in this text is an approximation of what appears on a Rockwell Automation Studio 5000 report or a Siemens TIA Portal Step 7 print-out.

About the Authors

Kelvin T. Erickson is a professor of electrical and computer engineering at the Missouri University of Science and Technology (Missouri S&T) in Rolla, Missouri, USA. He has taught university courses in factory automation and PLC programming since 1991 and PLC motion control since 2015. Prior to joining Missouri S&T, he worked as a design engineer at Fisher Controls. He spent a sabbatical year working for Magnum Technologies, a consulting firm, programming PLCs. He authored *Programmable Logic Controllers: An Emphasis on Design and Application*, 4th Ed. published in 2023 by Dogwood Valley Press, and *Allen-Bradley PLCs: An Emphasis on Design and Application*, 2nd Ed., also published in 2023 by Dogwood Valley Press. He also co-authored *Plantwide Process Control* with John Hedrick, published in 1999 by Wiley and Sons. Dr. Erickson received his BSEE and his MSEE from the University of Missouri-Rolla (now Missouri S&T) and received his PhD in EE from Iowa State University.

Esther A. Erickson is a senior application engineer with NTI AG - LinMot & MagSpring in Spreitenbach, Switzerland. Prior to joining LinMot, she had 19 years experience as a field service engineer and a senior application engineer with Rockwell Automation in Aarau, Switzerland with primary responsibility in motion control, PLC programming, and machine networks. She also was a control system integrator engineer with Alstom, working in their power plant gas turbine division. She received her BSEE degree from University of Missouri-Rolla.