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Volume 349

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Jinpeng Yu · Peng Shi · Jiapeng Liu

Intelligent Backstepping Control for the Alternating-Current Drive Systems

Springer

Jinpeng Yu
School of Automation
Qingdao University
Qingdao, China

Jiapeng Liu
School of Automation
Qingdao University
Qingdao, China

Peng Shi
School of Electrical
and Electronic Engineering
University of Adelaide
Adelaide, SA, Australia

ISSN 2198-4182 ISSN 2198-4190 (electronic)
Studies in Systems, Decision and Control
ISBN 978-3-030-67722-0 ISBN 978-3-030-67723-7 (eBook)
https://doi.org/10.1007/978-3-030-67723-7

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To Yumei and Jingchen

—Jinpeng Yu

To Fengmei, Lisa and Michael

—Peng Shi

To my parents and Huiying

—Jiapeng Liu

Preface

Modern electrical drives based on alternating current (AC) motors are intensively used in industrial applications and agriculture productions, such as steel mills, power plants. However, it is still challenging for us to achieve the perfect dynamic performance by controlling the AC motor because of its multi-variable, coupled and highly nonlinear dynamic model. The field-oriented control (FOC) and direct-torque control (DTC) are two of the most important developments in this field. Unfortunately, these control approaches suffer from sensitivity to the motor parameter variations and load disturbances. Stochastic disturbance has always been considered as a common source of instability of the AC motor control system. When the AC motor is working in a light load condition or running at a high speed, too many iron losses will be generated, which may create a negative impact on the control performance. In addition, the problem of "explosion of complexity" in the traditional backstepping control method will be inevitably arisen because of the continuous derivation of virtual control laws. Thus, the research on the intelligent control for the AC motor with uncertainty is attractive because of both theoretical and practical values.

This book focuses on the intelligent control design for both the induction motor (IM) and the permanent magnet synchronous motor (PMSM). The first chapter of this book introduces the research background of the AC motor, as well as dynamic models of both IM and PMSM. The general layout of the presentation of this book is divided into three parts. Part I proposes the intelligent controllers for the IM via backstepping approach. Part II focuses on the intelligent control design problems for the PMSM. These methodologies provide a framework for intelligent controller design, Lyapunov stability proof and performance analysis for AC motors. The main contents of Part I include the following: Chap. 2 is concerned with the problem of position tracking control for field-oriented IM with parameter uncertainties and load torque disturbance; Chap. 3 studies neural networks approximation-based command filtered adaptive control for the IM with input saturation; Chap. 4 addresses the discrete-time command filtered adaptive position tracking control problem for the IM via backstepping; Chap. 5 investigates the stochastic disturbances and input saturation problems for the IM drive systems; and

Chap. 6 is concerned with the adaptive fuzzy dynamic surface control for IM with iron losses. The main contents of Part II include the following: Chap. 7 is concerned with the speed tracking control problem of PMSM with parameter uncertainties and load torque disturbance; Chap. 8 studies the adaptive fuzzy backstepping position tracking control for the PMSM; Chap. 9 addresses the problem of neural-networks-based adaptive dynamic surface control for the PMSM with parameter uncertainties and load torque disturbance; Chap. 10 investigates the problem of discrete-time adaptive position tracking control for the interior PMSM based on fuzzy-approximation; Chap. 11 investigates adaptive fuzzy tracking control for the chaotic PMSM drive system via backstepping; Chap. 12 focuses on the problem of position tracking control for the chaotic PMSM drive system with parameter uncertainties. Finally, Chap. 13 in Part III summarizes the results of the book and discusses some future works.

This book is a research monograph, which provides valuable reference material for researchers who wish to explore the area of AC motor. In addition, the main contents of the book are also suitable for a one-semester graduate course.

Qingdao, China — Jinpeng Yu
Adelaide, Australia — Peng Shi
Qingdao, China — Jiapeng Liu
December 2020

Acknowledgements

The authors would like to thank numerous individuals who propose constructive comments, useful suggestions and wealth of ideas. Without them, this monograph could not have been completed. Special thanks go to Prof. Wenjie Dong from the University of Texas-Pan American, Prof. Bing Chen from Qingdao University, Prof. Haisheng Yu from Qingdao University and Prof. Chong Lin from Qingdao University, for their valuable suggestions, constructive comments and support.

Next, our acknowledgements go to many colleagues, who have offered support and encouragement throughout this research effort. In particular, we would like to acknowledge the contributions of Xuewei Mao from Qingdao University and Lin Zhao from Qingdao University. We also thank our students and their commentary. Finally, we would like to thank the editors at Springer for their professional and efficient handling of this project.

This work was partially supported by the National Natural Science Foundation of China (61573204, 61573203, 61973179), the Taishan Scholar Special Project Found (TSQN20161026), the Shandong Province Outstanding Youth Fund (ZR2011FQ012, ZR2015JL022), the National Key Research and Development Plan of China (2017YFB130503), the Science and Technology Project of College and University in Shandong Province (J11LG04), and the China Postdoctoral Science Foundation (2014T70620).

Contents

Notations and Acronyms

■	End of proof
♦	End of remark
$\in$	Belongs to
$\forall$	For all
$\sum$	Sum
$\mathbb{R}$	Field of real numbers
$\mathbb{R}^n$	Space of n-dimensional real vectors
lim	Limit
max	Maximum
min	Minimun
sup	Supremum
$\lambda_i(\cdot)$	ith eigen value of a matrix
$\lambda_{\min}(\cdot)$	Minimum eigen value of a matrix
$\lambda_{\max}(\cdot)$	Maximum eigen value of a matrix
$\lvert\cdot\rvert$	Euclidean vector norm
$\lvert\lvert\cdot\rvert\rvert$	Euclidean matrix norm (spectral norm)
FLS	Fuzzy logic system
FLC	Fuzzy logic control
NNs	Neural networks
PMSM	Permanent magnet synchronous maotor
IPMSM	Interior permanent magnet synchronous motor
IM	Induction motor
SMC	Sliding mode control
CFC	Command filter control
DSC	Dynamic surface control
RBF	Radial basis function

Matrices, if their dimensions are not explicitly stated, are assumed to be compatible for algebraic operations.

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