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Intelligent Backstepping Control for the Alternating-Current Drive Systems

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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.

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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
$\min$	Minimum
$\sup$	Supremum
$\lambda_i(\cdot)$	i th eigen value of a matrix
$\lambda_{\min}(\cdot)$	Minimum eigen value of a matrix
$\lambda_{\max}(\cdot)$	Maximum eigen value of a matrix
$ \cdot $	Euclidean vector norm
$\ \cdot\ $	Euclidean matrix norm (spectral norm)
FLS	Fuzzy logic system
FLC	Fuzzy logic control
NNs	Neural networks
PMSM	Permanent magnet synchronous motor
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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