Sensorless Control of Induction Motor Drives Speed and Position Sensorless Operation


Induction motors are the most important workhorses in industry, as they are mostly used as constant-speed drives when fed from a voltage source of fixed frequency. Advent of advanced power electronic converters and powerful digital signal processors, however, has made possible the development of high-performance, adjustable-speed AC motor drives. This book aims to explore new areas of induction motor control based on artificial intelligence (AI) techniques in order to make the controller less sensitive to parameter changes. Selected AI techniques are applied for different induction motor control strategies. The book presents a practical computer simulation model of the induction motor that could be used for studying various induction motor drive operations. The control strategies explored include expert-system-based acceleration control, hybrid-fuzzy/Pt two-stage control, neural-network-based direct self-control, and genetic algorithm-based extended Kalman filter for rotor speed estimation. There are also chapters on neural-network-based parameter estimation, genetic-algorithm-based optimized random PWM strategy, and experimental investigations. A chapter is provided as a primer for readers to get started with simulation studies on various AI techniques. Presents major artificial intelligence techniques to induction motor drives. Uses a practical simulation approach to get interested readers involved in drive development. Authored by experienced scientists with over 40 years of experience in the field. Provides numerous examples and the latest research simulation programs available from the book's Companion Website. This book will be invaluable to graduate students and research engineers who specialize in electric motor drives, electric vehicles, and electric ship propulsion. Graduate students in intelligent control, applied electric motor drives, and as well as engineers in industrial electronics, automation, and electrical transportation, will also find this book helpful. Simulation materials available for download at www.wiley.com/go/chanmotor

This monograph shows the reader how to avoid the burdens of sensor cost, reduced internal physical space, and system complexity in the control of AC motors. Many applications fields—electric vehicles, wind- and wave-energy converters and robotics, among them—will benefit. Sensorless AC Electric Motor Control describes the elimination of physical sensors and their replacement with observers, i.e., software sensors. Some important problems associated with the introduction of sensorless drive systems are introduced in this book, such as motor parameters—resistance, inertia, and so on—encountered in real systems. The details of a large number of speed- and/or position-sensorless ideas for different types of permanent-magnet synchronous motors and induction motors are presented along with several novel observer designs for electrical machines. Control strategies are developed using high-order, sliding-mode and traditional observers for the estimation of back- and sliding-mode and sliding-mode observers. A new backstepping and sliding-mode observers is developed to validate the performance of these observer and controller configurations with test trajectories of significance in difficult sensorless-AC-machine problems. Control engineers working with AC motors in a variety of industrial environments will find the space and cost-saving ideas detailed in Sensorless AC Electric Motor Control of much interest. Academic researchers and graduate students in electrical and control engineering will be able to see how advanced theoretical control methods and control algorithms will be used to implement real systems. Advances in Industrial Control aims to report and encourage the transfer of technology in control engineering. The rapid development of control technology has an impact on all areas of the control discipline. The series offers an opportunity for researchers to present an extended exposition of new work in all areas of industrial control.

The two-volume set LNAI 8856 and LNAI 8857 constitutes the proceedings of the 13th Mexican International Conference on Artificial Intelligence, MICAI 2014, held in Tuxtla, Mexico, in November 2014. The total of 87 papers plus 1 invited talk presented in these proceedings were carefully reviewed and selected from 348 submissions. The first volume deals with advances in human-inspired computing and its applications. It contains 44 papers structured into seven sections: natural language processing, natural language processing applications, opinion mining, sentiment analysis, and social network applications, computer vision, image processing, logic, reasoning, and multi-agent systems, and intelligent tutoring systems. The second volume deals with also computer vision and machine learning and contains also 44 papers structured into eight sections: genetic and evolutionary algorithms, neural networks, machine learning, machine learning applications to audio and text, data mining, fuzzy logic, robotics, planning, and scheduling, and biomedical applications.

Abstract: The focus of this research is the development of novel techniques for estimation and control of sensorless induction motor drives. In a sensorless drive, the speed must be estimated from the system measurements. Depending on the objective of the control (speed or torque control), the speed estimate must be used in one or more of the areas of the control scheme. This idea and the main techniques for speed estimation are explored. The dissertation investigates the issues related to low-speed flux estimation when a Voltage Model observer is used. Pure integrators are used in an attempt to improve the low-speed flux estimation. The flux estimation is replaced by low-pass filters and an improved method is used. Improved Voltage Model observer with the correct errors is developed based on a Programmable Low Pass Filter and a Vector rotator. The method requires estimation of the stator frequency and this is done by a Phase Locked Loop synchronized with the voltage vector. The sliding mode observer is used to obtain the dynamic estimation, however, it does not provide the static estimation. Additionally, system tuning is difficult and may yield under damped responses. Two novel Sliding Mode MRAS observers are designed and implemented and their features are used for speed estimation. The d-rotational frame currents of an induction machine are not decoupled. Decoupling can be achieved by canceling the cross-coupled terms in the equations of the synchronous frame currents. This approach is both inconvenient and inaccurate. A novel approach for decoupling is presented: an integral Sliding Mode controller complements a traditional controller that acts on a simulated plant. The use of the integral SM controller guarantees that the currents in the real plant will track those of the simulated model. The additional controller compensates for the cross-terms and for variations of the machine parameters. The method is also valuable for allowing fast and efficient tuning of the current controllers.

This is a reference source for practising engineers specializing in electric power engineering and industrial electronics. It begins with the basic dynamic models of induction motors and progresses to low- and high-performance drive systems.

Complete with a tutorial introduction, this convenient anthology of the foremost technical papers on sensorless control of AC motor drives discusses the full range of methods and schemes for complete sensorless operation of induction motors—sensorless operation of PM machines, sensorless operation of synchronous motors, and switched reluctance motors.

Motor control technology continues to play a vital role in the initiative to eliminate or at least decrease petroleum dependence and greenhouse gas emissions around the world. Increased motor efficiency is a crucial aspect of this science in the global transition to clean power use in areas such as industrial applications and home appliances—but particularly in the design of vehicles. To realize the evolution of motor driving units toward high efficiency, low cost, low power density, and flexible interface with other components AC Motor Control and Electric Vehicle Applications addresses the topics mentioned in its title but also elaborates on motor design perspective, such as back EMF harmonics, loss, flux saturation, and reluctance torque, etc. Maintaining theoretical integrity in AC motor modeling and control throughout, the author focuses on the benefits and simplicity of the rotor field-oriented control, describing the basics of PWM, inverter, and sensors. He also clarifies the fundamental nature of dynamics of electric vehicles, motor issues, and battery limits. A powerful compendium of practical information, this book serves as an overall useful tool for the design and control of high-efficiency motors.

This book addresses the vector control of three-phase AC machines, in particular induction motors with squirrel-cage rotors (IM), permanent magnet synchronous machines (PMSM) and doubly fed induction machines (DFIM), from a practical design and development perspective. The main focus is on the application of IM and PMSM in electrical drive systems, where field-oriented control is becoming firmly established. This work provides an introduction to the design of DFIM, the use of advanced control methods, and the application of the integrated control concept in both static and dynamic control of DFIM. Practical insights into flatness-based nonlinear control of IM, PMSM and DFIM. The book is useful for practitioners as well as development engineers and designers in the area of electrical drives and wind-power technology. It is a valuable resource for researchers and students.

Electric drives provide a practical understanding of the subtleties involved in the operation of modern electric drives. The Third Edition of this bestselling textbook has been fully updated and greatly expanded to incorporate the latest technologies used to save energy and increase productivity, stability, and reliability. Every phrase, equation, number, and reference in the text has been revised with the necessary changes made throughout. In addition, new references to key research and development activities have been included to accurately reflect the current state of the art. Nearly 120 new pages covering recent advances, such as those made in the sensorless control of A-C motor drives, have been added; as well as have two new chapters on advanced scalar control and multiphase electric machine drives. All solved numerical examples have been retained, and the 10 MATLAB®-Simulink® programs remain online. Thus, Electric Drives, Third Edition offers an up-to-date synthesis of the basic and advanced control of electric drives, with ample material for a two-semester course at the university level.

In high - demanding AC drives as for example traction applications, usually, an encoder or speedsensor is needed on the rotor shaft. Replacing this sensor with speed estimation may result in
lower costs and maintenance demands due to one less critical component in the system. By estimating the speed instead of measuring it is called sensorless control. The topic in this book is sensorless control adopted on the induction machine (IM). Research in the area sensorless control is wide and especially control problems at low speed has been an interesting problem to solve. In this book the focusing topic is 0 Hz crossover problems, which occurs as the machine alters between motoring and regenerating drive. As sensorless control method a rotorflux estimator is adopted in a vector controlled scheme by the so - called voltage model (VM). The VM design is used for estimating the frequency by measuring stator voltages and currents. The analysis of sensorless control considers parameter variations and instability problems, which are two important reasons for control problems at low speed. The proposed final method shows good performance both by linear and nonlinear analysis methods.

The advance of variable speed drives systems (VSDs) engineering highlights the need of specific technical guidance provision by electrical machines and drives manufacturers, so that such applications can be properly designed to present advantages in terms of both energy efficiency and equipment. This book presents problems and solutions related to inverter-fed electric motors. Practically oriented, the book describes the reasons, theory and analysis of those problems. Various solutions for individual problems are presented together with the complete design of the drive. The simulation examples are solved with Matlab/Simulink and AC Drives with Inverters [BLDC and PMSM]. The book provides a comprehensive treatment of the state variables estimation and motor control structures which have to be modified according to the used solution (filter). In most control systems the structure and parameters are taken into account to make it possible for precise control of the motor. This methodology is able to include modifications and extensions depending on specific control and estimation structures. Highly accessible, this is an invaluable resource for practising R&D engineers in drive companies, power electronics & control engineers and manufacturers of electrical drives. Senior undergraduate and postgraduates students in electronics and control engineering will also find it of value.

This book introduces electrical machine modeling and control for electrical engineering and science to graduate students, undergraduate students as well as researchers. It targets electrical drives and machines. It targets electrical drives and machines. Its focus is on the induction machine (IM). Research in the area sensorless control is wide and especially control problems at low speed has been an interesting problem to solve. In this book the focusing topic is 0 Hz crossover problems, which occurs as the machine alters between motoring and regenerating drive. As sensorless control method a rotorflux estimator is adopted in a vector controlled scheme by the so - called voltage model (VM). The VM design is used for estimating the frequency by measuring stator voltages and currents. The analysis of sensorless control considers parameter variations and instability problems, which are two important reasons for control problems at low speed. The proposed final method shows good performance both by linear and nonlinear analysis methods.

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Control of Power Electronic Converters and Systems examines the theory behind power electronic converter control, including operation, modeling and control of basic converters. The book explains how to manipulate components of power electronics converters and systems to produce a desired effect by controlling system variables. Advances in power electronics enable new applications to emerge and performance improvement in existing applications. These advances rely on control effectiveness, making it essential to apply appropriate control schemes to the converter and system to obtain the desired performance. Discusses different applications and their control Explains the most important controller design methods both in analog and digital Describes different important applications to be used in future industrial products Covers voltage source converters in significant detail Demonstrates applications across a much broader context

- Provides an overall understanding of all aspects of AC electrical drives, from the motor and converter to the implemented control algorithm, with minimum mathematics needed - Demonstrates how to implement and debug electrical drive systems using a set of dedicated hardware platforms, motor setup and software tools in VisSimTM and PLECSTM - No expert programming skills required, allowing the reader to concentrate on drive development - Enables the reader to undertake real-time control of a safe (low voltage) and low cost experimental drive - This book puts the fundamental and advanced concepts behind electric drives into practice. Avoiding involved mathematics whenever practical, this book shows the reader how to implement a range of modern day electrical drive concepts, without requiring in depth programming skills. It allows the user to build and run a series of AC drive concepts, ranging from very basic drives to sophisticated sensorless drives. Hence the book is the only modern resource available that bridges the gap between simulation and the actual experimental environment. Engineers who need to implement an electrical drive, or transition from sensored to sensorless drives, as well as students who need to understand the practical aspects of working with electrical drives, will greatly benefit from this unique reference.

This book presents a holistic view of climate change by examining a number of energy and transportation technologies and their impact on the climate. High-quality technical research results from specific test-cases around the globe are presented, and developments in global warming are discussed, focusing on current emissions policies from air and maritime transport to fossil fuel applications. Novel technologies such as carbon capture and storage are investigated together with the corresponding process and systems analysis, as well as optimization for mitigating CO2 emissions. Water resources management, waste water treatment, and waste management issues are also covered. Finally, biomass, hydrogen and solar energy applications are presented along with some insights on green buildings. Energy, Transportation and Global Warming is of great interest to researchers in the field of renewable and green energy as well as professionals in climate change management, the transportation sector, and environmental policy.

The first book of its kind, Power Converters and AC Electrical Drives with Linear Neural Networks systematically explores the application of neural networks in the field of power electronics, with particular emphasis on the sensorless control of AC drives. It presents the classical theory based on space-vectors in identification, discusses control of electrical drives and power converters, and examines improvements that can be attained when using linear neural networks. The book integrates power electronics and electrical drives with artificial neural networks (ANN). Organized into four parts, it first deals with voltage source inverters and their control. It then covers AC electrical drive control, focusing on induction and permanent magnet synchronous motor drives. The third part examines theoretical aspects of linear neural networks, particularly the neural EKIN family. The fourth part highlights original applications in electrical drives and power quality, ranging from neural-based parameter estimation and sensorless control to distributed generation systems from renewable sources and active power filters. Simulation and experimental results are provided to validate the theories. Written by experts in the field, this state-of-the-art book requires basic knowledge of electrical machines and power electronics, as well as some familiarity with control systems, signal processing, linear algebra, and numerical analysis. Offering multiple paths through the material, the text is suitable for undergraduate and postgraduate students, theoreticians, practicing engineers, and researchers involved in applications of ANNs.

This book provides the most important steps and concerns in the design of estimation and control algorithms for induction motors. A single notation and modern nonlinear control terminology is used to make the book accessible, although a more theoretical control viewpoint is also given. Focusing on the induction motor with, the concepts of stability and nonlinear control theory given in appendices, this book covers: speed sensorless control; design of adaptive observers and parameter estimators; a discussion of nonlinear adaptive controls containing parameter estimation algorithms; and comparative simulations of different control algorithms. The book sets out basic assumptions, structural properties, modelling, state feedback control and estimation algorithms, then moves to more complex output feedback control algorithms, based on stator current measurements, and modelling for speed sensorless control. The induction motor exhibits many typical and unavoidable nonlinear features.

In case of induction motor, the independent control of flux and torque is achieved by resolving the motor current into two components, one contributing to flux and other to the torque. Here, rotor flux oriented vector control is presented and the implementation results are shown. To implement rotor flux oriented control, information of rotor flux is required, which is calculated using rotor flux model through speed feedback. For sensorless control, the speed and flux are estimated with the help of open loop calculation of the motor equations. Implementation of the above control algorithm requires high speed sampling of measured currents, their processing and calculations. These calculations are done with the help of software using TMS320F2812 digital signal processor. The induction motor model is first developed and tested using different reference frames. The model is then simulated for rotor flux oriented vector control and then sensorless control.