

Sensorless Control Of Ac Motor Drives Speed And Position Sensorless Operation

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 expenditure. This book presents problems and solutions related to inverter-fed electrical motors. Practically orientated, the book describes the reasons, theory and analysis of those problems. Various solutions for individual problems are presented together with the complete design process, modelling and simulation examples with MATLAB/Simulink on the companion website. A key focus of Variable Speed AC Drives with Inverter Output Filters is to examine 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 postgraduate students in electronics and control engineering will also find it of value. 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 cost-effective speed sensorless operation of induction motors, position sensorless operation of PM motors, sensorless operation of synchronous motors, and switched reluctance motors.

The complexity of AC motor control lies in the multivariable and nonlinear nature of AC machine dynamics. Recent advancements in control theory now make it possible to deal with long-standing problems in AC motors control. This text expertly draws on these developments to apply a wide range of model-based control design methods to a variety of AC motors. Contributions from over thirty top researchers explain how modern control design methods can be used to achieve tight speed regulation, optimal energetic efficiency, and operation reliability and safety, by considering online state variable estimation in the absence of mechanical sensors, power factor correction, machine flux optimization, fault detection and isolation, and fault tolerant control. Describing the complete control approach, both controller and observer designs are demonstrated using advanced nonlinear methods, stability and performance are analysed using powerful techniques, including implementation considerations using digital computing means. Other key features:

- Covers the

main types of AC motors including triphase, multiphase, and doubly fed induction motors, wound rotor, permanent magnet, and interior PM synchronous motors • Illustrates the usefulness of the advanced control methods via industrial applications including electric vehicles, high speed trains, steel mills, and more • Includes special focus on sensorless nonlinear observers, adaptive and robust nonlinear controllers, output-feedback controllers, fault detection and isolation algorithms, and fault tolerant controllers This comprehensive volume provides researchers and designers and R&D engineers with a single-source reference on AC motor system drives in the automotive and transportation industry. It will also appeal to advanced students in automatic control, electrical, power systems, mechanical engineering and robotics, as well as mechatronic, process, and applied control system engineers.

Advanced Techniques in Computing Sciences and Software Engineering includes a set of rigorously reviewed world-class manuscripts addressing and detailing state-of-the-art research projects in the areas of Computer Science, Software Engineering, Computer Engineering, and Systems Engineering and Sciences. Advanced Techniques in Computing Sciences and Software Engineering includes selected papers from the conference proceedings of the International Conference on Systems, Computing Sciences and Software Engineering (SCSS 2008) which was part of the International Joint Conferences on Computer, Information and Systems Sciences and Engineering (CISSE 2008).

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 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 integration cannot be implemented due to offsets in the measured signals and integrators must be replaced by low pass filters. At low speed, the flux estimates are incorrect in both magnitude and angle; consequently, the rotor position obtained by the DFO method is incorrect. An improved Voltage Model observer that corrects the 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 traditional rotor flux MRAS method can be used for speed estimation, however, under non-ideal integration the dynamics of the speed estimate exhibits right-hand side plane zeros. 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-q 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.

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 EXIN 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 addresses the vector control of three-phase AC machines, in particular induction motors with squirrel-cage rotors (IM), permanent magnet synchronous motors (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-orientated control has been successfully established in practice. It also discusses the use of grid-voltage oriented control of DFIMs in wind power plants. This second, enlarged edition includes new 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.

This volume of *Advances in Intelligent and Soft Computing* contains accepted papers presented at SOCO 2014, CISIS 2014 and ICEUTE 2014, all conferences held in the beautiful and historic city of Bilbao (Spain), in June 2014. Soft computing represents a collection or set of computational techniques in machine learning, computer science and some engineering disciplines, which investigate, simulate, and analyze very complex issues and phenomena. After a thorough peer-review process, the 9th SOCO 2014 International Program Committee selected 31 papers which are published in these conference proceedings. In this relevant edition a special emphasis was put on the organization of special sessions. One special session was organized related to relevant topics as: *Soft Computing Methods in Manufacturing and Management Systems*. The aim of the 7th CISIS 2014 conference is to offer a

meeting opportunity for academic and industry-related researchers belonging to the various, vast communities of Computational Intelligence, Information Security, and Data Mining. The need for intelligent, flexible behaviour by large, complex systems, especially in mission-critical domains, is intended to be the catalyst and the aggregation stimulus for the overall event. After a thorough peer-review process, the CISIS 2014 International Program Committee selected 23 papers and the 5th ICEUTE 2014 International Program Committee selected 2 papers which are published in these conference proceedings as well.

Sliding Mode Control (SMC) is gaining increasing importance as a universal design tool for the robust control of linear and nonlinear systems. The strengths of sliding mode controllers result from the ease and flexibility of the methodology for their design and implementation. They provide inherent order reduction, direct incorporation of robustness against system uncertainties and disturbances, and an implicit stability proof. They also allow for the design of high performance control systems at low costs. SMC is particularly useful for electro-mechanical systems because of its discontinuous structure. In fact, since the hardware of many electro-mechanical systems (such as electric motors) prescribes discontinuous inputs, SMC has become the natural choice for direct implementation. The book is intended primarily for engineers and establishes an interdisciplinary bridge between control science, electrical and mechanical engineering.

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.

In high - demanding ac drives as for example traction applications, usually, an encoder or speedsensor is needed on the rotorshaft. 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 measured stator voltages and currents. The analysis here mainly 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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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. Induction motors are the most important workhorses in industry. 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/PI 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 started on drive development Authored by experienced scientists with over 20 years of experience in the field Provides numerous examples and the latest research results 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 motion, and energy, 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

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 advances in

nature-inspired computation 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.

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Institute of Electrical & Electronics Engineers (IEEE)

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.

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. Robustness is introduced to overcome problems associated with the unavoidable imperfection of knowledge of machine 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 quasi-continuous-sliding-mode techniques and two types of observer-controller schemes based on backstepping and sliding-mode techniques are described. Experimental results 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 from electrical, mechanical and control-engineering backgrounds will be able to see how advanced theoretical control can be applied in meaningful real systems.

This book constitutes the refereed proceedings of the 16th International Conference on Engineering Applications of Neural Networks, EANN 2015, held in Rhodes, Greece, in September 2015. The 36 revised full papers presented together with the abstracts of three invited talks and two tutorials were carefully reviewed and selected from 84 submissions. The papers are

organized in topical sections on industrial-engineering applications of ANN; bioinformatics; intelligent medical modeling; life-earth sciences intelligent modeling; learning-algorithms; intelligent telecommunications modeling; fuzzy modeling; robotics and control; smart cameras; pattern recognition-facial mapping; classification; financial intelligent modeling; echo state networks.

Electric drives are everywhere, and with the looming promise of electric vehicles and renewable energy, they will become more complex and the demands on their capabilities will continue to increase. To keep up with these trends, students require hands-on knowledge and a keen understanding of the subtleties involved in the operation of modern electr

The book focuses on position sensorless control for PMSM drives, addressing both basic principles and experimental evaluation. It provides an in-depth study on a number of major topics, such as model-based sensorless control, saliency-based sensorless control, position estimation error ripple elimination and acoustic noise reduction. Offering a comprehensive and systematic overview of position sensorless control and practical issues it is particularly suitable for readers interested in the sensorless control techniques for PMSM drives. The book is also a valuable resource for researchers, engineers, and graduate students in fields of ac motor drives and sensorless control.

This book is the result of inspirations and contributions from many researchers, a collection of 9 works, which are, in majority, focalised around the Direct Torque Control and may be comprised of three sections: different techniques for the control of asynchronous motors and double feed or double star induction machines, oriented approach of recent developments relating to the control of the Permanent Magnet Synchronous Motors, and special controller design and torque control of switched reluctance machine.

The authors were originally brought together to share research and applications through the international Danfoss Professor Programme at Aalborg University in Denmark. Personal computers would be unwieldy and inefficient without power electronic dc supplies. Portable communication devices and computers would also be impractical. High-performance lighting systems, motor controls, and a wide range of industrial controls depend on power electronics. In the near future we can expect strong growth in automotive applications, dc power supplies for communication systems, portable applications, and high-end converters. We are approaching a time when all electrical energy will be processed and controlled through power electronics somewhere in the path from generation to end use. The most up-to-date information available is presented in the text Written by a world renowned leader in the field

Motor control technology continues to play a vital role in the initiative to eliminate or at least decrease petroleum dependency 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.

Summarizes the evolution of motor driving units toward high efficiency, low cost, high 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.

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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 fundamentals of electric vehicles and their associated dynamics, 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 volume provides practicing engineers with new solutions to demanding real-world problems. It presents applications of soft computing to the field of industrial electronics in two categories, electric power applications and emerging applications.

The proceedings covers advanced and multi-disciplinary research on design of smart computing and informatics. The theme of the book broadly focuses on various innovation paradigms in system knowledge, intelligence and sustainability that may be applied to provide realistic solution to varied problems in society, environment and industries. The volume publishes quality work pertaining to the scope of the conference which is extended towards deployment of emerging computational and knowledge transfer approaches, optimizing solutions in varied disciplines of science, technology and healthcare.

Variable speed is one of the important requirements in most of the electric drives. Earlier dc motors were the only drives that were used in industries requiring - eration over a wide range of speed with step less variation, or requiring fine accuracy of speed control. Such drives are known as high performance drives. AC - tors because of being highly coupled non-linear devices can not provide fast dynamic response with normal controls. However, recently, because of ready availability of power electronic devices, and digital signal processors ac motors are beginning to be used for high performance drives. Field oriented control or vector control has made a fundamental change with regard to dynamic performance of ac machines. Vector control makes it possible to control induction or s- chronous motor in a manner similar to control scheme used for the separately - cited dc motor. Recent advances in artificial intelligence techniques have also contributed in the improvement in performance of electric drives. This book presents a comprehensive view of high performance ac drives. It may be considered as both a text book for graduate students and as an up-to-date monograph. It may also be used by R & D professionals involved in the impro- ment of performance of drives in the industries. The book will also be beneficial to the researchers pursuing work on sensorless and direct torque control of electric drives as up-to date references in these topics are provided.

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