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Ahmed A. Zaki Diab
Abo-Hashima M. Al-Sayed
Hossam Hefnawy Abbas Mohammed
Yehia Sayed Mohammed

Development of Adaptive Speed Observers for Induction Machine System Stabilization

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Ahmed A. Zaki Diab
Electrical Engineering Department
Faculty of Engineering
Minia University
Minia, Egypt

Department of Electrical
and Electronic Engineering
Kyushu University
Fukuoka, Japan

Hossam Hefnawy Abbas Mohammed
Electricity and Water Authority
Manama, Kingdom of Bahrain

Electrical Engineering Department
Faculty of Engineering
Minia University
Minia, Egypt

Abo-Hashima M. Al-Sayed
Electrical Engineering Department
Faculty of Engineering
Minia University
Minia, Egypt

Yehia Sayed Mohammed
Electrical Engineering Department
Faculty of Engineering
Minia University
Minia, Egypt

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About This Book

The book presents a comprehensive design of the adaptive state observers for induction machines drives. Experimental and simulation results have been introduced to demonstrate the effectiveness of the presented control schemes. The book objectives are summarized as follows:

1. Development of the mathematical model of an adaptive state observer based on the induction motor model taking the parameter variations into consideration to achieve high performance for sensorless induction motor drives.
2. Derive an expression for a modified gain rotor flux observer with a parameter adaptive scheme based on the machine model. This observer is used to estimate the motor speed accurately and improve the stability and performance of sensorless vector control induction motor drives.
3. Implementation of a sensorless vector control scheme to control the VSI fed from PV array for the induction motor water pumping system. An adaptive full order state observer utilized to estimate the motor speed for increasing the overall system reliability. The proposed control scheme has been simulated under different operating condition of varying irradiation and temperature.
4. Designing of a robust vector-controlled induction motor drives based on H_infinty theory for speed estimation using MRAS to achieve specific design requirement. The effectiveness of this controller is assessed by comparing the calculated results with the PI controller.

Introduction

The speed sensorless vector control techniques of induction motor drives are used in high performance applications. These techniques generally require an accurate determination of the machine parameters, rotor flux and motor speed. It uses a full order-type adaptive rotor flux observer that takes parameters variation into account to achieve high steady state performance without spoiling the dynamic response.

In this book, an adaptive state observer is derived based on the induction machine model. A modified gain rotor flux observer with a parameter adaptive scheme has been proposed for sensorless vector control induction motor drives. The optimal value of the observer gain has been proved by minimizing the error between the measured and estimated states. Also, the stability of the proposed observer with the parameter adaptation scheme is proved by the Lyapunov's theorem.

The application of sensorless vector control drives to control a photovoltaic (PV) motor pumping system has been presented in this book. The principle of vector control has been applied to control the single stage of voltage source inverter (VSI) feeding the three-phase induction motor. The main objective of this work is to design and analyze a single stage maximum power point tracking (MPPT) from PV module and eliminate the speed encoder. Elimination of the speed encoder aims to increase the reliability of the PV motor pumping system. Therefore, a full order adaptive state observer has been designed to estimate the rotor speed of the motor pumping system. Moreover, the incremental conductance method is used for achieving MPPT of the PV system. The control scheme with full order adaptive state observer has been investigated under different operating conditions of varying natures of solar radiation and air temperature. The simulation results show that the response of the PV motor pumping system with the adaptive speed observer has a good dynamic performance under different operating conditions.

In order to improve the dynamic response and to overcome the problems of the classical speed controller (such as overshoot, long settling time and oscillations of motor speed and torque), a robust controller design based on the H_∞ theory for high performance sensorless induction motor drives is implemented. The proposed controller is robust against system parameter variations and achieves good dynamic performance. In addition, it rejects disturbances well and can minimize system noise. The H_∞ controller design has a standard form that emphasizes the selection of the weighting functions that achieve the robustness and performance goals of motor drives in a wide range of operating conditions. The model reference adaptive system (MRAS) is used to estimate the motor speed based on the measurement of stator voltages and currents. In this work, the stability of the estimator scheme is discussed and proved based on Popov's criterion. To investigate the effectiveness of the proposed control scheme at different operating conditions (such as a sudden change of the speed command/load torque disturbance), its performance is compared with those of the classical control one. Experimental and simulation results demonstrate that the presented control scheme with the H_∞ controller and MRAS speed estimator has an accurate estimated motor speed and a good dynamic performance.

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