

## Sliding Mode Controller for Electromechanical System with Chattering Attenuation

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### Abstract:

Electromechanical systems (EMS) may be considered as devices transforming electrical into mechanical energy. Every system that belongs to the electromechanical class can be decomposed in an electrical (ES) and a mechanical subsystem (MS). The motion control systems can be quite complicated because many different factors have to be considered in the design of electromechanical systems. These factors can be summarized as the nonlinearity, non-smoothness in its model, the uncertainty in system model parameters and non-satisfying matching condition.

In this paper a new sliding mode control design approach for the EMS is proposed without neglecting the inductance in the electrical part or approximating the non-smooth perturbation. The first step in the proposed controller design consists of transforming the ES to a low pass filter (LPF) and then (the second step) designing a sliding mode controller (SMC) to the MS that will reject system model uncertainty and the effect of non-smooth disturbances. With a suitable selected LPF time constant, the SMC which controls the MS is nearly the equivalent control and as a result the chattering is attenuated greater than that in the case of classical SMC which designed by ignoring the electrical subsystem and also with a smaller control effort. The simulation results, of applying the proposed sliding mode control to an electromechanical system, show its superiority compared with classical SMC designed in two effective SMC features beside forcing the state to follow the desired position where chattering amplitude is greatly reduced with a significant reduction in control action value (approximately equal to third the required input voltage with the classical SMC).

**Keywords:** Electromechanical systems, Sliding mode control, Low pass filter, Chattering attenuation

### 1. Introduction:

Electromechanical systems may be considered as devices transforming electrical into mechanical energy. They establish a very important class of

industrial components often found in current practical applications defining the ideal link between computer-based drivers and movement generators systems. From the control point of view their structure is quite interesting since they belong to the class of the so-called under actuated systems in the sense that only the electrical part is directly actuated; the mathematical models that represent their dynamical behavior are, in general, nonlinear and, in many cases, the state is not completely available for measurement [1]. The main assumption is that every system that belongs to the electromechanical class can be decomposed into an electrical and a mechanical subsystem which it can be viewed as the *interconnection* of electrical and mechanical lumped elements, respectively. For the *electrical subsystems* these elements are inductances, capacitances and resistances, while for the *mechanical subsystem* are springs, masses and dampers [1].

Motion control is concerned with manipulating power to control the movement of a mechanical system. A large amount of motion control is now performed using electric motors, so that it will be our main focus. Motion control systems can be quite complicated because many different factors have to be considered in the design. The following issues must typically be considered:

- Reduction of the influence of plant disturbances
- Attenuation of the effect of measurement noise
- Variations and uncertainties in plant behavior

It is difficult to find design methods that consider all these factors, especially for the conventional control approaches where control designs involve compromises between conflicting goals. In order to design control systems to get high performance and robustness when controlling such complicated processes, advanced controllers have been introduced.

From control design point of view there are mainly three problems for the application of many control theories which can be summarized as follows:

- 1) The nonlinearity and non-smoothness in its model due to the friction model and the nonlinear spring.

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**Mohammed Salem, Juan Julián  
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Addresses research problems in each chapter along with numerical and simulation results that reflect engineering practice and demonstrate the focus of developed analysis and synthesis approaches Contains comprehensive up to date references which play an indicative role for further study *Intelligent Manufacturing & Mechatronics* Mohd Hasnun Arif Hassan,2018-04-27 This book presents the proceedings of SympoSIMM 2018 the 1st edition of the Symposium on Intelligent Manufacturing and Mechatronics With the theme of Strengthening Innovations Towards Industry 4 0 the book comprises the studies towards the particularity of Industry 4 0 s current trends It is divided into five parts covering various scopes of manufacturing engineering and mechatronics stream namely Intelligent Manufacturing Robotics Artificial Intelligence Instrumentation and Modelling and Simulation It is hoped that this book will benefit the readers in embracing the new era of Industrial Revolution 4 0

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**Proceedings of the 2024 2nd International Conference on Image, Algorithms and Artificial Intelligence (ICIAAI 2024)** Yulin Wang,2024-10-12 This is an Open Access book 2024 2nd International Conference on Image Algorithms and Artificial Intelligence ICIAAI2024 will be held in Singapore Online Participation is acceptable during August 9 11 2024 ICIAAI aims to provide a good forum for scientists researchers engineers and industrial practitioners throughout the world to present and discuss the latest technology advancement as well as future directions and trends in image algorithms and artificial intelligence The scope of ICIAAI 2024 covers research areas such as imaging algorithms and artificial intelligence Related fields of research include computer software programming languages software engineering computer science applications artificial intelligence Intelligent data analysis deep learning high performance computing signal processing information systems computer graphics computer aided design Computer vision etc The objectives of the conference are The conference aims to provide a platform for experts scholars engineers and technicians engaged in the research of image algorithm and artificial intelligence to share scientific research results and cutting edge technologies It will be a perfect gathering to strengthen academic research and discussion promote the development and progress of relevant research and application and promote the development of disciplines and promote talent training

Sliding Mode Observers for Automotive Alternator De-Shiou Chen,1998 Abstract Estimator development for synchronous rectification of the automotive alternator is a desirable approach for estimating alternator s back electromotive forces EMFs without a direct mechanical sensor of the rotor position Recent theoretical studies show that estimation of the back EMF may be observed based on system s phase current model by sensing electrical variables AC phase currents and DC bus voltage of

the synchronous rectifier Observer design of the back EMF estimation has been developed for constant engine speed In this work we are interested in nonlinear observer design of the back EMF estimation for the real case of variable engine speed Initial back EMF estimate can be obtained from a first order sliding mode observer SMO based on the phase current model A fourth order nonlinear asymptotic observer NAO complemented by the dynamics of the back EMF with time varying frequency and amplitude is then incorporated into the observer design for chattering reduction Since the cost of required phase current sensors may be prohibitive the most applicable approach in real implementation by measuring DC current of the synchronous rectifier is carried out in the dissertation It is shown that the DC link current consists of sequential windows with partial information of the phase currents hence the cascaded NAO is responsible not only for the purpose of chattering reduction but also for necessarily accomplishing the process of estimation Stability analyses of the proposed estimators are considered for most linear and time varying cases The stability of the NAO without speed information is substantiated by both numerical and experimental results Prospective estimation algorithms for the case of battery current measurements are investigated Theoretical study indicates that the convergence of the proposed LAO may be provided by high gain inputs Since the order of the LAO NAO for the battery current case is one order higher than that of the link current measurements it is hardly to find moderate values of the input gains for the real time sampled data systems Technical difficulties in implementation of such high order discrete time nonlinear estimators have been discussed Directions of further investigations have been provided

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**1996 IEEE International Workshop on Variable Structure Systems, VSS '96** ,1996 VSS 96 was a workshop designed for control engineers working in the field of sliding mode control VSS and nonlinear systems Providing coverage of that workshop this text examines robust sliding mode VSS in power electronics time delay systems VSS theory and VSS applications **FUSION ...** ,2003

**Proceedings of the National Science Council, Republic of China** ,1996 *Colloquium on Automatic Control* Claudio Bonivento,Giovani Marro,Roberto Zanasì,1996-06 Comprising six invited lectures by recognised experts in the field of control the Colloquium on Automatic Control presents a number of well balanced theoretical and engineering oriented elements which will be accessible to many readers ranging from non specialists to experts and professionals in the field

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## **Table of Contents Chattering Attenuation Of Sliding Mode Controller Using**

1. Understanding the eBook Chattering Attenuation Of Sliding Mode Controller Using
  - The Rise of Digital Reading Chattering Attenuation Of Sliding Mode Controller Using
  - Advantages of eBooks Over Traditional Books
2. Identifying Chattering Attenuation Of Sliding Mode Controller Using
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in a Chattering Attenuation Of Sliding Mode Controller Using
  - User-Friendly Interface
4. Exploring eBook Recommendations from Chattering Attenuation Of Sliding Mode Controller Using
  - Personalized Recommendations
  - Chattering Attenuation Of Sliding Mode Controller Using User Reviews and Ratings
  - Chattering Attenuation Of Sliding Mode Controller Using and Bestseller Lists
5. Accessing Chattering Attenuation Of Sliding Mode Controller Using Free and Paid eBooks
  - Chattering Attenuation Of Sliding Mode Controller Using Public Domain eBooks
  - Chattering Attenuation Of Sliding Mode Controller Using eBook Subscription Services
  - Chattering Attenuation Of Sliding Mode Controller Using Budget-Friendly Options

6. Navigating Chattering Attenuation Of Sliding Mode Controller Using eBook Formats
  - ePub, PDF, MOBI, and More
  - Chattering Attenuation Of Sliding Mode Controller Using Compatibility with Devices
  - Chattering Attenuation Of Sliding Mode Controller Using Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Chattering Attenuation Of Sliding Mode Controller Using
  - Highlighting and Note-Taking Chattering Attenuation Of Sliding Mode Controller Using
  - Interactive Elements Chattering Attenuation Of Sliding Mode Controller Using
8. Staying Engaged with Chattering Attenuation Of Sliding Mode Controller Using
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Chattering Attenuation Of Sliding Mode Controller Using
9. Balancing eBooks and Physical Books Chattering Attenuation Of Sliding Mode Controller Using
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Chattering Attenuation Of Sliding Mode Controller Using
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine Chattering Attenuation Of Sliding Mode Controller Using
  - Setting Reading Goals Chattering Attenuation Of Sliding Mode Controller Using
  - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Chattering Attenuation Of Sliding Mode Controller Using
  - Fact-Checking eBook Content of Chattering Attenuation Of Sliding Mode Controller Using
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
  - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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