

## 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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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

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Hybrid Intelligent Systems Oscar Castillo, Patricia Melin, Witold Pedrycz, 2007-07-23 This volume offers a general view of recent conceptual developments of Soft Computing SC It presents successful new applications of SC to real world problems leading to better performance than traditional methods The edited volume covers a wide spectrum of applications including areas such as robotic dynamic systems non linear plants manufacturing systems and time series prediction

*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 *ASME Technical Papers* ,1999 □□□□□□ ,1998 *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 *Journal of Dynamic Systems, Measurement, and Control* ,2003 Publishes theoretical and applied original papers in dynamic systems Theoretical papers present new theoretical developments and knowledge for controls of dynamical systems together with clear engineering motivation for the new theory Applied papers include modeling simulation and corroboration of theory with emphasis on demonstrated practicality **Proceedings of the National Science Council, Republic of China** ,1996 **Control Theory and Advanced Technology** ,1993 **FUSION ...** ,2003 **Proceedings** ,1996 *Colloquium on Automatic Control* Claudio Bonivento,Giovani Marro,Roberto Zanasi,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 **Mathematical Reviews** ,2001 **Proceedings of the IEEE International Symposium on Industrial Electronics** ,1993 *Proceedings of the 1996 IEEE IECON* ,1996

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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 an 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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