

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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