CHATTERING PROBLEM IN SLIDING MODE CONTROL SYSTEMS

Vadim Utkin * **Hoon Lee** *

* *Dept. of Electrical Engineering,*
The Ohio State University, USA
2015 Neil Avenue Columbus, OH 43210 USA

ABSTRACT

In practical applications of sliding mode control, engineers may experience undesirable phenomenon of oscillations having finite frequency and amplitude, which is known as 'chattering'. At the first stage of sliding mode control theory development the chattering was the main obstacle for its implementation. Chattering is a harmful phenomenon because it leads to low control accuracy, high wear of moving mechanical parts, and high heat losses in power circuits. There are two reasons which can lead to chattering.

- The chattering can be caused by fast dynamics which were neglected in the ideal model. These 'unmodeled' dynamics with small time constants are usually disregarded in models of servomechanisms, sensors and data processors.
- The second reason of chattering is utilization of digital controllers with finite sampling rate, which causes so called 'discretization chatter'. Theoretically the ideal sliding mode implies infinite switching frequency. Since the control is constant within a sampling interval, switching frequency can not exceed that of sampling, which lead to chattering as well.

Mechanism of chattering generating is demonstrated for control of inverted an pendulum with unmodeled actuator dynamics.

The efficient recipe for chattering suppression is use of asymptotic observers. The main idea of using an asymptotic observer to prevent chattering is to generate ideal sliding mode in the auxiliary loop including the observer. In the observer loop, sliding mode is generated in the control software; therefore, any unmodeled dynamics which cause chattering can be excluded.

As follows from analysis, based on the describing function method, the amplitude of chattering is proportional to magnitude of discontinuous control. Therefore the methods of chattering suppression can be developed such that the magnitude is decreased properly holding the establishment of sliding mode. First option is to decrease the magnitude along with the system states. The second one implies that the magnitude is the function of an equivalent control derived by a low-pass filter u_{eq}. The method can be applied for the plants subjected to unknown disturbances.

"Discretization chattering" in discrete-time systems is caused by discontinuities in control. Increasing a sampling frequency to decrease the chattering amplitude seems unjustified, since using a computer is adequate to control system dynamics if a sampling frequency corresponds to average, slow system motion rather than to a high frequency component.

First the definition of sliding mode is introduced embracing both discrete- and continuous-time systems. Then free of chattering design methodology is proposed for discrete-time systems. The fundamental difference is that the control should be a continuous function of the state.

Experimental results for sliding mode control of inductions motors with observers are discussed.