Preface

It is well established that the sliding mode control strategy provides an effective and robust method of controlling the deterministic system due to its well-known invariance property to a class of bounded disturbance and parameter variations. Advances in microcomputer technologies have made digital control increasingly popular among researchers worldwide. This led to the study of discrete-time sliding mode control design and its implementation. However, most of the strategies proposed are based on the state feedback approach. But, system state variables are often not fully available for many practical systems. Also some state variables may be difficult/costly to measure and sometimes have no physical meaning and cannot be measured at all. Thus, one has to resort to output feedback method or observer-based design. Sliding mode control using static output feedback is not always possible. On the other hand observer-based design requires more hardware resources and also increases the dimension of the system. Recently, there have been efforts to design the multirate output feedback-based sliding mode control (MROFSMC) where the available output is measured at a faster rate than the input actuation rate and by means of that states are obtained implicitly. It has also been shown that sliding mode control using multirate output feedback is possible for all controllable/observable systems. In general, most of the methods available for sliding surface design are based on pole placement technique or Linear Quadratic (LQ) design. It does not take care of the certain frequency component excited/introduced during the sliding mode. So to suppress certain frequency dynamics during sliding mode the frequency shaped sliding mode may be used. The frequency shaped sliding mode control based on state feedback exists in the literature.

This monograph proposes a method for multirate frequency shaped sliding mode controller design based on switching and non-switching type of reaching law. In this approach, the frequency-dependent compensator dynamics are introduced through a frequency shaped sliding surface by assigning frequency-dependent weighing matrices in a linear quadratic regulator (LQR) design procedure. In this way the undesired high frequency dynamics or certain frequency disturbance can be eliminated. The states are implicitly obtained by measuring the output at a faster rate than the control input.

The vibration control of smart structure is a challenging problem as it has several vibratory modes. The frequency shaping approach may be used to suppress the frequency dynamics excited during sliding mode in smart structure. The frequency content of the optimal sliding mode is shaped by using a frequency-dependent compensator, such that a higher gain can be obtained at the resonance frequencies. The controllers based on the proposed method are designed and implemented for vibration suppression of the intelligent structure.

The monograph also presents the design of discrete-time reduced order observer using the duality to discrete-time sliding surface design. First, the duality between the coefficients of the discrete-time reduced order observer and the sliding surface design is established and then, the design method for the observer using Riccati equation is explained. Using the proposed method, the observer for the Power System Stabilizer (PSS) for Single Machine Infinite Bus (SMIB) system is designed and simulation is carried out using the observed states. The discrete-time sliding mode controller based on the proposed reduced order observer design method is also obtained for a laboratory experimental servo system and verified with the experimental results.

The monograph is organized in the following sequence.

In Chap. 1, the background of the sliding mode control strategy along with the research contributions of the monograph is discussed.

In Chap. 2, the preliminaries and literature survey of continuous-time sliding mode control and discrete-time sliding mode control along with the multirate output measurement technique for state estimation is presented.

In Chaps. 3 and 4, design method for multirate output feedback-based frequency shaped sliding mode control for vibration suppression of the intelligent structure with switching and non-switching type control law are proposed.

Chapter 5 presents the design of discrete-time reduced order observer using the duality to discrete-time sliding surface design along with the application for reduced order observer design for the Power System Stabilizer (PSS) of Single Machine Infinite Bus (SMIB) system and Industrial Servo System.

Keywords Variable structure control, Sliding mode control, Smart structure, Uncertain system, Duality, Power system stabilizer

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