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# SLIDING MODE CONTROL FOR SINGULARLY PERTURBED LINEAR CONTINUOUS TIME SYSTEMS: COMPOSITE CONTROL APPROACHES

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**Abstract.** We investigate the problem of sliding mode control for singularly perturbed systems with external disturbances. Although the system can be decoupled into two time-scales in terms of two lower dimensional state vectors, the similar type of decomposition does not hold for the control law and the disturbances. The system decoupling transformation can only decompose the control law and the disturbances into two time scales but not reduce their dimensions. Therefore, only one subsystem is designed to enter the sliding mode. Two composite control approaches are proposed to handle the stability and disturbance rejection problems: state feedback control used to stabilize slow or fast modes and discontinuous control used to deal with the remaining modes. A numerical example of a longitudinal model of an F8 aircraft is provided to illustrate the efficiency of the proposed methods.

**Keywords.** Sliding mode control, sliding surface, singularly perturbed systems, composite control, disturbance rejection.

**AMS (MOS) subject classification:** 34K26, 93B12, 93C15, 93C70.

# 1 Introduction

Singular perturbation theory is focused on studying systems whose properties are characterized by parasitic or unmodelled dynamics constituting different time-scale dynamics [16]. In general, a singularly perturbed system is decomposed into slow and fast subsystems for which a state feedback control law is synthesized. Then, the results are combined in a composite feedback control law [16]. Sliding mode control, a powerful tool dealing with uncertainty and disturbances, has been utilized for decades (see [6], [7], [18], [21], [22], [23] and references therein). However, it is not straitforward to synthesize a sliding mode control law for singularly perturbed systems due to the complication of different time-scale behavior and the discontinuous nature of switching actions.

Various attempts to apply the knowledge of sliding mode control for singularly perturbed systems have been realized in several papers [2], [3], [8], [9], [10], [13], [14], [17], [19], [20], [25]. Heck [13] proposed a composite sliding mode control method which derives from two slow and fast sliding mode