

ROBUST SWITCHING CONTROLLERS IN THE PRESENCE OF MODEL UNCERTAINTY AND SATURATION

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Abstract. This paper considers the control of uncertain dynamic system in the presence of input saturation. The uncertainties satisfy the matching conditions. Robust controller is based on combination of switching (piecewise linear LQ controller with prescribed degree of stability), low gain and high-gain (which is incorporated by multiplying the gains of switching controller with a scaling factor) and over-saturation. It is shown, using piecewise quadratic Lyapunov function, that the uncertain system can be exponentially stabilized with prescribed exponential rate.

Key Words. Actuator saturation, low-and-high gain feedback, piecewise control, over-saturation, robust stability.

1. Introduction

Recently there has been increased research interest in the study of the hybrid dynamical systems [14]. In general, these systems consist of a logical discrete event decision-making system interacting with a continuous time process. Very important class of hybrid system is a switched controllers systems [11]. In this paper we will consider the application of switching controllers when in the system exists actuator saturation. That is the most frequent nonlinearity encountered in practice [7].

The design of switching controllers having guaranteed stability, known as the piecewise linear LQ control (PLC), is first considered in [15]. The piecewise linear systems are systems that have different linear dynamics in different regions of the continuous state space [6]. The PLC control has the associated switching surfaces in form of positively invariant sets and yields a relatively low-gain controller. In the LHG (low-and-high gain) design a low gain feedback law is first design in such a way that the actuator does not saturate in magnitude and the closed-loop system remains linear. The low gain enlarge the region in which the closed-loop system remains linear and enlarge the basin of attraction of the closed-loop systems [9]. After that, using appropriate Lyapunov function for the closed-loop system, under this low gain feedback control law, a linear high gain feedback law is designed and added to the low gain feedback control. Combination of LHG and PLC gives the robust controllers with fast transience. The key feature of PLC/LHG controllers is that the saturation level is avoided. But, it has been recognized in references [8] and [4] that the performance of closed-loop system can be further improved by forcing the control into saturation. Such controller increases the value of the switching regions so that each linear controller is able to act in a region where a degree of over-saturation is reached. The over-saturation means that the controller demands for input level is greater than the available range.

