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SIMULTANEOUS DESIGN OF CONTROL SYSTEMS WITH INPUT SATURATION

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Abstract. *This paper considers the simultaneous design of structure and controller for control systems with input saturation. First, the mathematical model of plant and controller with input saturation is given. Secondly, the closed-loop system is described by descriptor form. Then, a sufficient condition for the control system to satisfy the specifications is introduced, and the simultaneous design problem is formulated as a bilinear matrix inequality (BMI) one. The BMI problem is solved by an iterative linear matrix inequality (LMI) algorithm. Finally, the effectiveness is confirmed by a numerical example.*
Keywords: Simultaneous design, Input saturation, Bilinear matrix inequality, Linear matrix inequality, Descriptor form.

1. **Introduction.** In the conventional control system theory, the controller is constructed for the plant which is designed in advance. However, in general, the design of the controller and that of the plant are inseparable [9]. Therefore, by designing not only the controller but also the structural parameters of the plant (e.g., mass, length, spring constant etc.) simultaneously, we may construct the control system with better performance in some sense. From this point of view, the simultaneous design problem has been paid much attention for the last two decades. In fact, the simultaneous design of structure and controller for linear systems under pole placement constraint, H_∞ constraint etc. has been vigorously investigated [4-6], and most of the simultaneous design problems are recast as bilinear matrix inequality (BMI) ones. However, the methods in [4-6] are applicable to the design of linear control systems only.

The design problem of control systems with input saturation has also been energetically studied for recent years [2, 7, 13]. However, the studies in [2, 7, 13] have never referred to the simultaneous design problem.

In this paper, the authors develop a method for simultaneous design of structure and controller for a class of control systems with input saturation by using the sector-bounded nonlinearity [3]. Then, the design problem is formulated as BMI one. It is well-known that BMI problem is NP-hard [10], and therefore, it is, in general, difficult to solve it. On the other hand, linear matrix inequality (LMI) problem is one of the convex programming problems, and can be solved efficiently by such a numerical algorithm as the interior-point method [1]. It is noted that the LMI approach has been widely used in the control systems design (e.g., [11, 12]). Hence, in this paper, an iterative LMI algorithm to minimize the objective function for the simultaneous design is introduced. The algorithm takes into consideration not only the nonlinearities but also the structural design parameters.