RELIABLE STATE FEEDBACK CONTROL SYNTHESIS FOR
UNCERTAIN LINEAR SYSTEMS

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ABSTRACT

This paper is concerned with the problem of designing reliable state-feedback control for a class of uncertain linear systems with norm bounded uncertainty. A procedure for designing reliable state-feedback control is presented for the case of actuator faults that can be modeled by a scaling factor. In the design, the performance of the normal system (without fault) is optimized, as the considered system operates under the normal condition most of the time. In addition, when actuator faults occur, the closed-loop system retains robust stability and satisfies a known quadratic performance bound. A numerical example is provided to illustrate the effectiveness of the proposed design method.

KeyWords: Linear systems, reliable control, quadratic performance, actuator fault, quadratic stability, LMI.

I. INTRODUCTION

In the area of designing reliable control systems, there have been several approaches for achieving various reliability goals [1,5-8,12-19]. In particular, for linear controller designs that guarantee reliable $H_{\infty}$ performance, Veillette et al. [15] presented a methodology for designing reliable linear control systems to achieve the following reliability goal: The resulting designs guarantee closed-loop stability and $H_{\infty}$ performance not only when all control components are operational, but also in case of some admissible control component outages. This reliability goal is also achieved in [17] by using redundant controllers. Medanic [8] investigated the single contingency reliable control problem by providing redundant control elements/channels into an existing control structure. Leland et al [6] presented a reliable design by using duplicated sensors. For the state-feedback control design to guarantee reliable quadratic performance, Veillette [14] developed a procedure for designing reliable linear quadratic state-feedback control that guarantees closed-loop stability and a known quadratic performance bound despite any outages within a selected subset of actuators (i.e. primary contingency reliable control).

Although the nominal performance is sacrificed for the reliability (stability) goal in the above reliable design approaches, the optimization of nominal performance is not addressed. Obviously, in addition to guaranteeing stability, the reliable design should also optimize the nominal performance as systems operate under the normal conditions most of the time.

In this paper, the problem of designing reliable guaranteed cost control (RGCC) laws is studied for a class of uncertain linear systems with norm bounded uncertainties. Actuator faults are modeled by a scaling factor, which covers the case of outages [15], which has been used in [14,19,21]. This paper is organized as follows. In Section 2, the model of actuator faults is given, together with the formulation of RGCC problem, which is modeled as a multiobjective control problem for multiple models. In Section 3, a procedure for designing RGCC is presented for the primary contingency case. The single contingency case is studied in Section 4. Section 5 presents a numerical example to illustrate the proposed design methods. Finally, some concluding remarks are given in Section 6.