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Time-Sharing Multirate Sample-Hold Controllers and Their Application to Reliable Stabilization

Yoshimichi Ito[†], Tomomichi Hagiwara[‡], Hajime Maeda[†], and Mituhiko Araki[‡]

[†]Department of Communications Engineering, Osaka University,
2-1, Yamada-oka Suita, Osaka 565-0871, Japan
[‡]Department of Electrical Engineering, Kyoto University,
Yoshida, Sakyo-ku, Kyoto 606-8501, Japan

Abstract. In this paper, we propose a new control scheme for sampled-data systems: time-sharing multirate sample-hold control. It is a special kind of control with a multirate hold and a multirate sampler, in which the manipulation of the plant input and the detection of the plant output work on separate time intervals. It is shown that this control scheme is very powerful because it can attain an arbitrary discrete-time state transition matrix (rather than merely its eigenvalues) of the closed-loop system by a suitable choice of a multirate hold and a multirate sampler. Next, we apply the above control scheme to the reliable stabilization problem, in which we are to find a set of controllers that stabilize a given plant when they act altogether, as well as when any one of them fails. It is known that when linear time-invariant controllers are used, the stabilizability condition is very hard to derive in a general setting; it has been derived only under the 2-controller configuration, in which case the strong stabilizability of the plant is required. If the time-sharing multirate sample-hold scheme is used, however, we show that reliable stabilization is always possible under the general N-controller configuration for any given integer N (≥ 2).
Keywords. digital control, time-sharing multirate sample-hold scheme, generalized hold, generalized sampler, orthogonality condition, reliable stabilization

1 Introduction

In the implementation of digital control laws, engineers sometimes face the following problems due to some physical constraints of the plant: manipulating all the inputs, and/or detecting all the outputs, of the plant with the same period is impossible or impractical. In order to overcome such difficulties, multirate controllers and generalized holds/samplers were introduced. These days, such controllers are used in many applications, not only for the above reason but also because of their variety of ability achieving, for example, equivalent state feedback, pole/zero assignment, simultaneous stabilization, exact linearization, and adaptive control under weak assumptions [1]–[5],[10]–[12],[15],[16],[18],[19],[21].