Stabilization for Multirate Sampled-data Control Systems in case of Open-loop Unstable Plant

°Seok Bo Son*, Young Baek Kim**, Chansik Park***, Sang Jeong Lee****

*Department of Electronics Engineering, Chungnam National University, Daejeon, Korea
(Tel : 82-42-825-3991; Fax : 82-42-823-4494 ; E-mail:s_sbson@hanbat.chungnam.ac.kr)
**Navicom Co., Ltd., Daejeon, Korea
(Tel : 82-42-483-4072; Fax : 82-42-483-4074 ; E-mail:ybkim@navicom.co.kr)
***School of Electronics and Electrical Engineering, Chungbuk National University, Cheongju, Korea
(Tel : 82-43-261-3259; Fax : 82-43-268-2386 ; E-mail:chansp@cbucc.chungbuk.ac.kr)
****Department of Electronics Engineering, Chungnam National University, Daejeon, Korea
(Tel : 82-42-821-6285; Fax : 82-42-823-4494 ; E-mail:eesjl@cslab.chungnam.ac.kr)

Abstract

This paper proposes a stabilizing controller for multirate sampled-data systems which have a periodic output. The proposed controller has IMC structure, and can be decomposed into a pre-stabilizing controller, an output estimator, a filtered disturbance estimator and the inverse of the fast pre-stabilized plant model. We assume that the plant is open-loop unstable and the disturbance consists of a sum of finite number of sinusoids with different frequencies. A sufficient condition for maintaining observability in the multirate sampled-data system is derived and a design strategy for filtered disturbance rejection is proposed. In addition, we propose a design method for the plant output estimator. The simulation results show that the proposed stabilizing controllers can stabilize the plant.

1. Instruction

Recently much work on a stabilizing controller for periodic or multirate systems has been carried out[1],[4]. And some stabilizing controller parameterization methods[3],[4], which expand Youla parameterization method using the lifting technique[1],[2], has been derived for multirate or periodic sampled-data systems. These methods transform the given time varying system into the shift-invariant equivalent using the lifting technique. The control algorithms for time-invariant systems can be applied to the transformed one. IMC controller can be used to implement the stabilizing controller for the lifted system. However, adopting lifting technique to periodic or multirate sampled-data systems causes the singularity problem because of the sampling scheme. It is not always possible to design a controller with general IMC structure. To overcome this situation, it has been proposed a stabilizing controller design method with IMC structure which has a disturbance rejection property for the open-loop stable plant[5].

In this paper, we expand this result to the open-loop unstable plant. In section 2, we describe the design problem for multirate sampled-data systems which will be treated in this paper. It is shown that the pre-stabilizing controller does not work well under the given zigzag measurement scheme in IMC controller form. In section 3, we propose a design procedure for stabilizing controller which has IMC structure and good disturbance rejection properties for the open-loop unstable plants and some examples will be given to evaluate the performance. In section 4, some concluding remarks are given.

2. Problem description

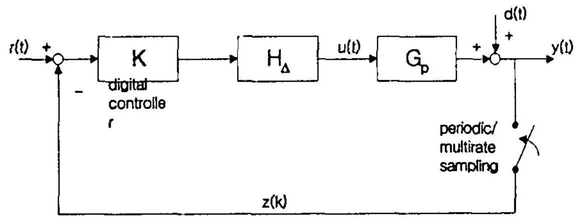

Fig. 1. Sampled-data feedback system with periodic measurement.

Figure 1 shows the sampled-data feedback system with a periodic measurement scheme, where G_p is an unstable time invariant continuous time plant, K is a digital controller, $u(t) \in R^m$ is a control input, $y(t) \in R^m$ is an output, $d(t) \in R^m$ is a disturbance, $r(t) \in R^m$ is a reference input, H_Δ is a zero-order holder with Δ period. It is assumed that disturbances consist of a sum of finite number of sinusoids with difference frequencies.

The periodic output measurement scheme which will be treated in this paper is as follows.

$$z(k) = \begin{cases} y_1(k\Delta) & \text{if } k=0,\ 2m-1,\ 2m,\ 4m-1,\ \ldots \\ y_2(k\Delta) & \text{if } k=1,\ 2m-2,\ 2m+1,\ 4m-2,\ldots \\ \vdots & \\ y_m(k\Delta) & \text{if } k=m-1,\ m,\ 3m-1,\ 3m,\ldots \end{cases}$$

The ZOH equivalent state space model of $G_p(s)$ is given by

$$x(k+1) = Ax(k) + Bu(k), \quad (1)$$

$$y(k) = Cx(k) + d(k). \quad (2)$$