Journal of Process Control 21 (2011) 678–681

Contents lists available at ScienceDirect

Journal of Process Control

journal homepage: www.elsevier.com/locate/jprocont

Short communication

Assessment minimum output variance with PID controllers

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ARTICLE INFO

Article history:
Received 17 May 2010
Received in revised form 6 January 2011
Accepted 7 January 2011
Available online 2 February 2011

Keywords:
Achievable performance
Minimum output variance
PID controller
SISO system
Time delay

ABSTRACT

In this paper, a simple method to find the minimum output variance (MOV) with proportional–integral-derivative (PID) controller is proposed. An assessment of improved achievable PID performance is important as PID controllers are the most commonly used in industries. The restriction on the controller structure e.g. PID (the case in this paper) results worst output variance compared to minimum variance (MV) benchmark. The problem in assessing the PID-MOV rises a non-convex problem and for non-convex problem, no direct and simple solution is possible. In this paper the non-convex problem is solved with simple ring of iterations. Several simulation examples are incorporated to show the usefulness of proposal algorithm.

1. Introduction

In the last two decades, an assessment of control loop performance has become topic of interest for many researchers and academicians; see e.g. [1,5,7,8,10]. The performance assessment is mainly used to verify healthy working of the controller, and to decide the certainty between the current performance and best achievable performance. In assessment of control loop performance, delay time, disturbance and process models, and structural constraints of the controller affect the output variance. In the literature, for linear discrete time system with additive disturbances, the best achievable output variance is realized when a minimum variance (MV) controller is implemented for a process, and reported, MV as a standard benchmark to assess the control loop performance [5]. Even though there are agreeable properties in using MV control as performance benchmark, but this controller does not usually give desired control action in general application due to its demand of excessive control effort (clearly reduced control effort means less maintenance) and poor robustness [9]. The PID controllers have wide acceptance in process industries and hence it is important to assess minimum output variance with PID (PID-MOV). The problem of assessing the PID-MOV rises a non-convex problem and global optimal solution cannot be guaranteed [6]. In the literature, a non-convex problem is solved by many convex methods. A gradient base method was used by Ko and Edgar [2], an analytical lower bound method presented by Kariwala [3] obtains an achievable PID performance by selecting the first $2d-1$ impulse response coefficients of the closed loop transfer function between disturbance and output, where d is process delay time. The solution of the non-convex problem by obtaining one answer from two bounds, upper and lower, is reported in the work of Sendjaja and Kariwala [4].

In this paper, a method to solve the non-convex problem is proposed. This method minimizes the polynomial that is obtained from the impulse response coefficients of the closed loop transfer function between disturbance and output. It is worth to say that, finding the PID-MOV is the first step to obtain the achievable performance for PID controllers. The organization of the paper is as follows: Section 2 includes the overview of the output variance. Section 3 consists of the proposed method. Section 4 presents PID design procedure while 10 simulation examples are included in Section 5. Section 6 reports some remarkable conclusions.

2. Problem overview

The typical single-input–single-output (SISO) feedback control system is shown in Fig. 1, with plant output $y(t)$, manipulated variable $u(t)$, and disturbance $a(t)$, where t is the sampling interval. The process output can be written as

$$y(t)=g(q^{-1})u(t)+n(q^{-1})a(t) \tag{1}$$

where, $g(q^{-1})$ and $n(q^{-1})$ represent process and disturbance transfer function respectively and q^{-1} is the backward shift operator. For simplicity in the writing, the terms t and q^{-1} are omitted in the

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doi:10.1016/j.jprocont.2011.01.003