A STUDY ON SIMPLE TIME VARYING FEEDFORWARD COMPENSATOR

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Abstract

In this paper, we deal with a simple time varying feedforward compensator in order to decrease the amount of undershoots and overshoots on the step response. This compensator makes the step type input be a ramp input with saturation for $0 \le t < \alpha$. It will be shown that the system with the feedforward compensator has small amount of undershoot and overshoot at the price of rise time. Also, provided the system is properly stable, the influence of the design parameter α on the step response of the system with the feedforward compensator is investigated in the current paper.

1. Introduction

In most industrial control plants, it is difficult to track a rapidly varying reference input like a step change. Also this input usually generates a bad transient response characteristic of the plant, and it may cause the unstability of the system[1, 2]. However, if the reference input is changed smoothly unlike the rapidly varying reference input, the transient response can be improved[2, 3]. This type of reference trajectory generation is often used in servo systems, e.g., industrial robots[3].

The reference models are used in many control algorithms for improvement of transient response characteristics, e.g., overshoots, saturation, etc. They provide desired trajectories that the plant should follow. Hence the plant is to track the output of reference model, not reference input[2]. Amount of undershoots and overshoots can be reduced by tracking the smooth varying reference model output, not the rapidly varying reference input. The reference models are very important in the model reference control, but it is very difficult to select the proper reference model for a given plant[1, 2, 3].

In this paper, instead of using reference model, we propose a simple time varying feedforward compensator which makes the step type input be a ramp input with saturation for $0 \le t < \alpha$. The reference input generated by the proposed compensator improves the transient response, but it doesn't affect the stability of the system. Using this compensator, it will be shown that the system with the feedforward compensator has small amount of undershoots and overshoots at the price of rise time. But the settling time of the system may be shorter by using the compensator. Also, assuming the system is properly stable, we will investigate the influence of the design parameter α on the step response of the system with the feedforward compensator.

The layout of this paper is organized as follows : In Section 2, we define the type of undershoots for preliminaries. In Section 3, we will propose simple time varying feedforward compensator which decreases amount of undershoots or overshoots at the price of rise time. In Section 4, performances of the proposed compensator are analyzed via computer simulation to show that the ramp input with saturation $0 \le t < \alpha$ can improves the transient response compared to step changes in the reference input. The concluding remarks are given in Section 5.

2. Preliminaries

In this paper, we consider an SISO(single input single output) system with RHP(right half plane) zeros. Let us introduce the classification of the undershoot which is caused by RHP zeros[4, 5].

Definition 1 *Let $y(t)(t \ge 0)$ be a sufficiently smooth scalar time response of a dynamical system and assume that $y(0) = 0$ and the following conditions :*

a) There is a finite positive integer η that satisfies

$$y(0+) = \cdots = \left.\frac{d^{\eta-1}y(t)}{dt^{\eta-1}}\right|_{t=0+} = 0, \quad \left.\frac{d^{\eta}y(t)}{dt^{\eta}}\right|_{t=0+} \neq 0. \tag{1}$$

b) The steady state value of $y(t)$ exists and is not zero, i.e.,

$$y(\infty) = \lim_{t\to\infty} y(t) \neq 0. \tag{2}$$

Then $y(t)$ is said to have a Type A undershoot if

$$y^{(\eta)}(0+)y(\infty) < 0. \tag{3}$$

If (3) is not true and there is an open interval (a, b) such that

$$y(t)y(\infty) < 0, \quad {}^{\forall}t \in (a, b), \tag{4}$$

then $y(t)$ is said to have a Type B undershoot.