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Extensive Tracking Performance Analysis of Classical feedback control for XY Stage ballscrew drive system

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Abstract. Performance analysis in term of identifying the system's transient response, stability and system's dynamical behavior in control system design is undeniably a must process. There are several ways in which a system can be analyzed. An example of well known techniques are using time domain and frequency domain approach. This paper is focused on the fundamental aspect of analysis of classical feedback controller in frequency domain of XY milling table ballscrew drive system. The controller used for the system is the basic PID controller using Matlab SISOTOOL graphical user interface. For this case, the frequency response function (FRF) of the system is used instead of using estimated model of transfer function to represent the real system. Result in simulation shows that after proper tuning of the controller, the system has been successfully being controlled accordingly. In addition, the result also fulfill the set requirement of frequency domain analysis in terms of the required gain and phase margin, the required maximum peak sensitivity and complimentary sensitivity function and the required stability.

1 Introduction

Accuracy and precision is decisive in machining process. However, the presence of disturbance forces leads to inaccuracy in positioning and tracking [3]. A good example of disturbance force that greatly affects tracking performance is cutting forces. Cutting force exist in nature of the milling process and simply cannot be avoided as it is generated from the contact between the cutting tool and the work piece. Kalpakjian and Schmid [8] mention that cutting force is influenced by the milling parameters such as the depth of cut and spindle speed. In literature, problem regarding cutting force in milling process have been studied extensively and many controllers have been proposed and validated. Quite a number of techniques have been introduced and recorded in [2], [3] and [7] using different techniques such as cascade P/PI, inverse-model-based disturbance observer and repetitive controller.

The classical PID controller is extensively known in many industrial applications such as temperature control of refrigerator [5] and air conditioning system [6]. Its flexibility allowed benefits from the advances of technology. It is the combination of PI and PD controller which can improve both steady state error and transient response [7]. This paper is organized as follows. Section 2 describes the experimental setup. Section 3 discusses the design of PID controller. Section 4 describes the performance analysis in frequency domain. Section 5 summarizes the main conclusions of this paper.

2 Experimental Setup

The considered system setup is a ball screw drive XY milling table as shown in figure 1. The XY milling table is produced by Googol Tech and it consists of two axes which are x and y axes. Both axes are driven by one Panasonic MSMD 022G1U A.C. servo motor and equipped with an incremental encoder for positioning measurement respectively. The resolution of the encoder is 0.0005 mm/ pulse. The length of the milling table for both axes is 300mm respectively. Two limit