INTEGRATED DESIGN OF HIGH-PERFORMANCE SERVOMECHANISMS USING A DISTURBANCE OBSERVER

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ABSTRACT
This paper proposes a systematic design methodology for high-speed/high-precision servomechanisms by using a disturbance observer. A multiplicative uncertainty model and a two degree-of-freedom controller composed of a disturbance observer (DOB) and a PD controller are considered as subsystems. The tradeoff relationship between disturbance suppression and measurement noise rejection of the DOB is studied through the design process. It is confirmed that the proposed design methodology performs excellent disturbance suppression performance.

INTRODUCTION
Accurate tracking at high speed is required in many servomechanisms used in the manufacturing, IT, and FPD (flat panel display) industries. To design a high-speed/high-precision servomechanism with smooth velocity, a disturbance rejection method suppressing effects of cutting force variation, friction, vibration, etc. is required [1]. Two degree-of-freedom controllers composed of an internal-loop controller for improving robustness and an external-loop controller for satisfying tracking performance are used to design high-performance servomechanisms. DOBs have been used as internal-loop controllers to design robust servomechanisms [1–3].

In this paper, a previously developed integrated design methodology [4–7] for high-speed/high-precision servomechanisms is applied to develop a robust servomechanism equipped with a DOB. A mechanical subsystem is modeled as a multiplicative uncertainty model. A two degree-of-freedom controller composed of a DOB and a PD controller is considered for the integrated design. Optimal parameters of the DOB and the PD controller, as well as the mechanical parameters of the servomechanism are obtained through the minimization of the multi-objective function constructed with Abbe offset, circular tracking error and bandwidth. To verify the developed design methodology, an xy-table is selected as a case study. Optimally designed results with lower Abbe offset, larger bandwidth and minimized contour error are obtained through the integrated design. It is confirmed that internal stability and excellent disturbance suppression are accomplished as well.

FIGURE 1. XY-table as a case study.

FIGURE 2. Schematic diagram of the mechanical subsystem.

FIGURE 3. Block diagram of the mechanical subsystem.

MODELING OF SERVOMECHANISMS

Mechanical subsystem