OPTIMAL TUNING OF BIAXIAL SERVOMECHANISMS
USING A CROSS-COUPLED CONTROLLER

Ho-Kyu Bae and Sung-Chong Chung
Hybrid Systems Design and Control LABoratory
School of Mechanical Engineering
Hanyang University, Seoul 133-791, Korea

KEYWORDS
Contour error, Cross-coupled control, Kharitonov’s theorem, Optimal tuning

ABSTRACT
In order to improve contouring accuracy of a biaxial servomechanism, a cross-coupled controller is adopted and an optimal tuning procedure based on an integrated design concept is proposed. Strict mathematical modeling and identification process of a servomechanism are performed. An optimal tuning problem is formulated as a nonlinear constrained optimization problem including the relevant controller parameters of the servomechanism. The objective of the optimal tuning procedure is to minimize both the contour error and the settling time while satisfying constraints such as the relative stability and maximum overshoot conditions, etc. The effectiveness of the proposed optimal tuning procedure is verified through experiments.

INTRODUCTION
Precision servomechanisms are widely used in the machine tool, semiconductor, and aerospace industries. It is important to improve contouring accuracy in high-precision servomechanisms. In order to improve the contouring accuracy, cross-coupled control systems have been proposed (Koren 1980, Koren and Lo 1991, Srinivasan and Kulkarni 1990). The objective of the cross-coupled control is to reduce contour errors, defined as the shortest distance between the desired and actual contours, by coupling two axes and controlling the relative movements, rather than to reduce position errors by controlling each axis independently. It has been shown that cross-coupled controllers have better contouring accuracy than conventional uncoupled controllers. However, it is very difficult to select the controller parameters because cross-coupled control systems are multivariable, nonlinear and time-varying systems. Tarng et al. (1997) proposed an optimization approach to cross-coupled control systems by using a genetic algorithm. However, information about mathematical modeling and stability of the servomechanism was not considered.

In this paper, the optimal tuning procedure of cross-coupled control systems is studied to reduce contour errors of a biaxial servomechanism based on the integrated design concept (Kim and Chung 2004, Kim and Chung...