Industrial Engineering
& Management Systems
Vol 17, No 1, March 2018, pp.62-71
ISSN 1598-7248 | EISSN 2234-6473 |
https://doi.org/10.7232/iems.2018.17.1.062

Optimization of Super Twisting Sliding Mode Control Gains using Taguchi Method

Chiew Tsung Heng, Zamberi Jamaludin*, Ahmad Yusairi Bani Hashim, Nur Aidawaty Rafan, Lokman Abdullah
Department of Robotics and Automation, Faculty of Manufacturing Engineering,
Universiti Teknikal Malaysia Melaka, Malaysia

(Received: June 23, 2016 / Revised: December 31, 2016 ; March 10, 2017 ; July 06, 2017 ; October 02, 2017 ; January 04, 2018 / Accepted: January 31, 2018)

ABSTRACT

This paper focuses on optimization of super twisting controller gains using Taguchi method with objective to minimize tracking error and the chattering effect. Two gain parameters in super twisting algorithm, that is *L* and *W* were identified as two factors with three levels respectively. The optimization method applied a L_9 orthogonal array and the performance index used was root mean square of tracking error and Fast Fourier Transform of control inputs. The optimized super twisting controller with traditional sliding surface and the continuous control action laws was validated on a single axis direct driven linear motor. Analyses of variance and main effect plots were performed on the effect of gains variation on performance index. Values of *L* and *W* were chosen as 0.00002 and 0.08 respectively and were confirmed through confirmation test based on calculated confidence interval. Experimental results with 95% confidence level identified gain *L* as the significant factor in minimizing chattering effect while both gains *L* and *W* were responsible in minimizing tracking error in optimum condition. Optimized algorithm achieved 9.3% of reduction in root mean square of tracking error and 38.4% of reduction in chattering experimentally.

Keywords: Chattering, Taguchi Method, Super Twisting, Optimization, Machine Tools

* Corresponding Author, E-mail: zamberi@utem.edu.my

1. INTRODUCTION

High demand on accuracy and precision in machine tool applications associated with high degree of development in technologies induced great challenge towards control engineers and machine tools developer. A comprehensive controller design is desired to ensure good performances in accuracy and precision of machine tool applications. A robust nonlinear controller, known as sliding mode control (SMC) was introduced by Utkin (1977) to meet this high demand as classical controllers such as cascade controllers are no longer able to meet. SMC was attractive due to its high disturbance rejection and robustness properties that enforced good tracking performances on motion drive system. A geometrical locus with boundaries known as sliding surface is defined as switching function in SMC where the desired response is achieved when the system is slides on the surface. Control laws which typically consist of signum function are set to attract system states (error) towards the sliding surface and to ensure the states slides along the surface. However, the SMC comes with a critical drawback known as chattering effect which might reduce the life-span of drive system due to the high frequency oscillation occurred in signum function. In fact, chattering is an undesired phenomenon especially for machine tool applications such as computer numerical control (CNC) machine that commonly used in manufacturing field. The occurrence of chattering effect greatly affects the performances of drive system in terms of accuracy and precision as well as the outcome of pro-