Faculty of Engineering

Robust Control of Inertia Mismatch in Industrial Servos

A thesis submitted in partial fulfillment of the requirements for the degree of

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in

MECHANICAL ENGINEERING

By

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Statement

This thesis is submitted in the partial fulfillment of master degree in Mechanical Engineering to Ain Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university.

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ABSTRACT

There are a number of challenging factors that influence the performance of the industrial servo systems. One of these factors is the inertia mismatch between the motor and the load. Another problem is the variable-inertia load. This thesis applies a robust control tool called μ-synthesis to design a controller which deals with the uncertainty of the inertia in the load.

Different practical experiments are presented to investigate the effect of some parameters in the synthesis process on the performance of the synthesized controller. Also simulations are included to introduce different values of inertia mismatch and study the effect of increasing inertia mismatch on the servo system performance.

Keywords

Inertia mismatch, variable inertia, servo system, robust control, μ-synthesis, PMSM

SUMMARY

The inertia mismatch between the motor and the load in the industrial servo system plays a vital role in the performance of the servo system. It has to be within a certain range defined by the manufacturer of the servo motor. One of the problems facing the end user of the industrial servo system is having a variable-inertia load. The classic control supplied by the manufacturer doesn't overcome this problem; since it's designed for a constant-inertia load. An additive problem is having the variable-inertia load not determined specifically over one revolution of the motor.

Chapter 1 presents a survey of previous work. Inertia mismatch problem and inertia uncertainty have been addressed by many researchers who used many different ways to find out a suitable controller. The proposed controllers have been designed using feed-forward control, nonlinear control, optimal control, adaptive control, or robust control. Most of the work was done on lab servo systems, not an industrial one. Also, the historic development of automatic control theories starting from classical control until robust control has been presented.

The objective of this work is to design and implement a robust controller to enhance the performance of the industrial servo system with variable inertia load, and also achieve system stability and taking into account that the variation of the load inertia doesn't exceed the maximum limit that is determined by the manufacturer.

In chapter 2, in order to achieve this objective, the controller has been built using μ-synthesis. A mathematical model has been built on a modeling environment, taking into account the uncertainty of the inertia in the model. One of the classical, ready-made controllers on the servo system has been overridden by the proposed controller.

In chapter 3, the modeling of the servo system (motor and inverter) has been introduced in order to use the mathematical model in the synthesis of the robust controller.

Simulating the servo system has been discussed in chapter 4 by using the mathematical model from chapter 3. Then a simplified model has been proposed for faster and less effort simulations. The simplified model has been used to test the system with both classical and robust controllers and with three different values of inertia mismatch to control speed and position.

Practical implementation has been discussed in chapter 5, starting from the proposed mechanism which acts as a variable inertia load, the motor with attachments, the inverter and finally the real-time control board on a PC. Groups of experiments have been done using classical and robust controllers for comparing both.

The results of these experiments have been listed in chapter 6. Also comparative discussion based on root mean square error has been presented.

Based on this work, some recommendations and future research have been introduced in chapter 7.

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