REAL-TIME H_2 AND H_∞ CONTROL OF A GYROSCOPE USING A POLYNOMIAL APPROACH

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***Abstract*– In this paper H_2 and H_∞ control techniques are applied to the real-time control of a gyroscope with two degrees of freedom. The controllers are designed based on a polynomial approach and using routines from the Polynomial Toolbox for MATLAB. Real-time results are presented, showing a good performance of the controllers.**

***Keywords*– Control system design, Optimization H_2, Optimization H_∞, Polynomial approach, Gyroscope, Polynomial Toolbox.**

I. INTRODUCTION

Practical applications of modern control techniques to physical systems are fundamental in control engineering. These modern techniques allow controlling complex dynamic systems satisfying particular design objectives. The efficiency of the control schemes is tested and verified in the application process.

Computational routines and software, on the other hand, are important tools for the application of control schemes. The analysis of dynamic systems and the design of controllers, usually involving complex computations, can be easily carried out using computer programs.

The aim of this work is to apply H_2 and H_∞ optimization techniques to the control of a gyroscope with two degrees of freedom. The controllers are designed using routines from the Polynomial Toolbox 2.5 for MATLAB[1], which are based on a polynomial approach. One of the advantages of the polynomial approach is that the controllers for the linear model of the system can be designed directly from a transfer function description, which can be usually obtained from input-output information, avoiding the need for a state-space model of the system.

The main contribution of this paper is the application of modern optimization control techniques to the control of a gyroscope in real time. To this end, we obtain a suitable description of the system, and explain with detail the design of the corresponding controllers. Real-time results are presented, showing a good performance of the controllers. Also, the application proposed in this paper can serve very well as a lab for students. Indeed, the polynomial approach is relatively simple to apply, and the analysis and design can be easily carried out using routines from the Polynomial Toolbox.

Roughly speaking, H_2-optimization consists in finding a controller which minimizes the H_2 norm of the closed-loop transfer function and internally stabilizes the system. The closed-loop transfer function to be minimized is located between the external signal and the control error signal, where the external signal comprises external inputs, including perturbations, measuring noise and reference inputs.

The standard H_2 problem was solved by Doyle *et al.* (1989), and the authors present a solution to this problem considering a state-space description of a linear multivariable system. In Hunt *et al.* (1994), a solution is presented to the standard H_2 problem based on the polynomial solution to the LQG problem from Kučera (1979). The proposed polynomial solution is based on square complements and Diophantine equations. Another polynomial solution to the standard H_2 problem is given in Meinsma (2000), which is based on factorizations over polynomials and stable matrices. Later on, Kwakernaak (2000) presents another solution based on factorizations over polynomial matrices and Diophantine equations. This solution uses a generalized plant as a starting point, which allows to solve a number of problems, for example the mixed sensitivity

[1]For more information on the Polynomial Toolbox, see www.polyx.com. MATLAB is a trademark of The MathWorks Inc.