

## Comparative Study of Robust Control Techniques Using $H_\infty$ and $\mu$ -Synthesis.

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### Abstract

Rotating machinery are largely used in many industrial sectors as they present a broad range of applications, such as motors, turbines and compressors. The growing demand for efficiency requires faster, powerful and reliable rotors. For that matter, it is crucial to stabilize the system and attenuate vibrations levels. Interesting approach that has been recently applied is to use magnetic actuators to provide stiffness and damping to the system without direct contact. In this work the robust control techniques were chosen, more specifically the  $H_\infty$  and  $\mu$ -synthesis, which were considered a more appropriated choice due to the system's parameters dependence on rotational speed. Both controllers were designed aiming to stabilize and reduce the vibration amplitude of a rotor supported by two hydrodynamic bearings. The results were obtained by simulations and the controllers performances were compared.

*Key words: Rotors, Robust controllers, Vibration control.*

### Introduction

In rotor dynamics context the hydrodynamic bearings offer an interesting option as shaft support due to its high load, speed and damping capability, very low frictional coefficients and theoretically infinite life span. However, there are some critical drawbacks in its use: the bearing stiffness and damping coefficients are rotational dependent, and the occurrence of two self-exciting phenomenon, the oil-whirl and oil-whip. The first one appears as an excitation at half the rotational speed, the second near twice the critical speed, that is, the oil-whirl frequency matches the resonance, resulting in the so called fluid-induced instability. The main control goals set for the robust controllers,  $H_\infty$  and  $\mu$ -synthesis, were to stabilize the fluid-induced instability and moreover, reduce the vibrations associated to residual mass unbalance. The controllers were then compared based on their performance.

### Results and Discussion

The rotor was modeled using finite elements based on Nelson matrices<sup>1</sup>. Since robust control synthesis methods usually achieve control laws with orders equal or greater than the original plant, it was necessary to reduce the system's matrices using the Guyan method<sup>2</sup>. Both model uncertainties and frequency dependent variations were modeled as parameters uncertainties, and "pulled off", which resulted in an augmented plant. The  $H_\infty$ , designed using Ricatti's method, was based on the nominal plant. And the  $\mu$ -synthesis, designed using D-K iteration<sup>3</sup>, was based on the augmented plant. In Figure 1 the singular structured values of the uncertain plant (G), the closed-loops using  $H_\infty$

(CL-Hinf) and  $\mu$ -synthesis (CL-Kmu) are shown. Peaks above the unity means that the system is unstable under the considered uncertainties.

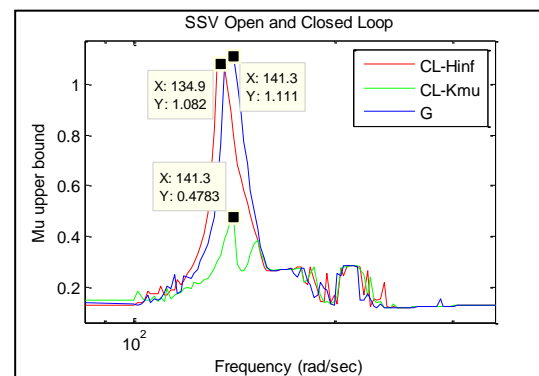


Figure 1. Singular structured value plot

### Conclusions

In this work the  $\mu$ -synthesis proved to be more robust than the  $H_\infty$ , maintaining both stability and attenuation even under uncertainties, but it required previous information about the system's uncertainties and variations, and required some expressive computational time.

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