

**Master thesis and internship[BR]- Master's thesis : H-infinity robust controller development for seismic isolation of Gravitational-Wave Detectors : Implementation on the E-TEST prototype[BR]- Integration internship**

**Auteur :** Magain, Gilles

**Promoteur(s) :** Sacré, Pierre; Collette, Christophe

**Faculté :** Faculté des Sciences appliquées

**Diplôme :** Master en ingénieur civil en aérospatiale, à finalité spécialisée en "aerospace engineering"

**Année académique :** 2024-2025

**URI/URL :** <http://hdl.handle.net/2268.2/23384>

---

*Avertissement à l'attention des usagers :*

*Tous les documents placés en accès ouvert sur le site le site MatheO sont protégés par le droit d'auteur. Conformément aux principes énoncés par la "Budapest Open Access Initiative"(BOAI, 2002), l'utilisateur du site peut lire, télécharger, copier, transmettre, imprimer, chercher ou faire un lien vers le texte intégral de ces documents, les disséquer pour les indexer, s'en servir de données pour un logiciel, ou s'en servir à toute autre fin légale (ou prévue par la réglementation relative au droit d'auteur). Toute utilisation du document à des fins commerciales est strictement interdite.*

*Par ailleurs, l'utilisateur s'engage à respecter les droits moraux de l'auteur, principalement le droit à l'intégrité de l'oeuvre et le droit de paternité et ce dans toute utilisation que l'utilisateur entreprend. Ainsi, à titre d'exemple, lorsqu'il reproduira un document par extrait ou dans son intégralité, l'utilisateur citera de manière complète les sources telles que mentionnées ci-dessus. Toute utilisation non explicitement autorisée ci-avant (telle que par exemple, la modification du document ou son résumé) nécessite l'autorisation préalable et expresse des auteurs ou de leurs ayants droit.*

---

# H-infinity robust controller development for seismic isolation of Gravitational-Wave Detectors : Implementation on the E-TEST prototype.

Gilles Magain - Aerospace engineering - Colette Christophe - Sacré Pierre

Academic year: 2024 - 2025

## 1 Abstract

Gravitational wave astronomy is the most recent branch of the universe observation. It will widen our spectrum of analysis due to the new information brought by those waves. However, their detection is a technical challenge since their magnitude is minimal when reaching the earth. Designs based on Michelson interferometers are used to detect them. It is mandatory to reduce any perturbation applied to those detectors since they need to have an extraordinary degree of precision. One of the main noise limiting their resolution is the ground motion. Multiple systems, active or passive, are then employed to reduce its impact on the interferometers.

This thesis addresses the challenge of seismic noise. The goal is the implementation of a robust control strategy, called H infinity, on the E-TEST prototype, which is a precursor of the Einstein Telescope. The objective is to obtain a controller, which is rarely done for such complex system using this method. This work explores the isolation of this structure, especially below  $10\text{ Hz}$ , where ground motion is most pronounced. After reviewing the gravitational waves, their detectors, the major noise sources and the current isolation technologies, this thesis introduces the required knowledge of Control Theory necessary to the understanding of the implementation of such method. The core of the work is the use of two different models representing the dynamics of the active platform constituting the base of the prototype. Indeed, the H infinity procedure requires a system to produce the controllers. Those systems are meticulously defined in terms of inputs and outputs signals. This allows for the method to minimize the desired outputs using the other signals as given information to the controllers. Weights are also defined to shape the desired performances given by the method. The results of both controllers applied to their corresponding model are analyzed.

The first model, being more basic, allows for a robustness study, demonstrating the interest of such method when the system is subject to uncertainties. The second model, more complex, allows for the implementation of its controller on the prototype for damping. The performances have been validated experimentally and the limitation of the controller application have been proved to be due to the model, the latter being not precise enough. However, this experiment has proven that the implementation of controllers produced with robust control methods is possible on complex structures as the E-TEST prototype. This contributes to the ongoing development of the Einstein telescope and the technologies required for the implementation of high-resolution gravitational waves detectors.