

LONGITUDINAL STABILITY AUGMENTATION DESIGN WITH TWO DEGREE OF FREEDOM CONTROL STRUCTURE AND HANDLING QUALITIES REQUIREMENTS

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Keywords: Aircraft Flight Control, Robust Control, Two Degree of Freedom, Stability Augmentation

Abstract

This paper presents the design of longitudinal stability augmentation system (SAS) using a two degree of freedom control structure based on the LQR¹ technique in the frequency domain, which is robust to plant uncertainties, sensor noise and external disturbances. The design incorporates various handling quality requirements involving modal and bandwidth domain criteria. The design is done looking its use in the possible alternative mode in fly-by-wire aircraft with relaxed stability. The approach is applied throughout the flight envelope of a commercial aircraft and the first results obtained are presented.

1 Introduction

An aircraft model, characterized by its weight, center of gravity (x_{cg}) position, airspeed, altitude, flight path angle, flaps configuration, and landing gear position among others, is subject to a wide range of parameters variation. These characteristics change its dynamics and for this reason a dynamic mode that is stable and adequately damped in one flight condition may become unstable or at least inadequately damped in another flight condition. In commercial aircraft a lightly damped oscillatory mode may cause a great deal of discomfort for passengers or make it difficult for the pilot to control the aircraft. For a combat aircraft this condition may lead to a more critical

situation because the aircraft is already inherently unstable due to the maneuverability requirements and capability of attack.

These problems are overcome by using feedback control to modify the aircraft dynamics. Also aircraft's manufactures are currently developing improvements in terms of weight diminution, aerodynamic efficiency and optimization of fuel consumption. These changes are naturally leading to design of new airplanes with relaxed stability, increasing the use of feedback control laws [1]. Either a Stability Augmentation System (SAS) to increase and to change the natural frequencies of aircraft modes or a Control Augmentation System (CAS) to control the modes and to provide the pilot with a particular type of response are used as control laws. In this sense a Two Degree of Freedom (TDOF) controller [2] is normally used to project a Stability Augmentation System.

The TDOF is a robust control strategy that guarantees a better performance against uncertainties, sensor noise and external disturbances when compared with some classical techniques [3]. The structure was successfully implemented for control position problem in a SCARA manipulator robot [4] and at the present moment, a technique extension, applicable to commercial and military aircrafts, is being developed.

The project focuses on finding optimal gains to shown robustness at different flight conditions using fixed gains instead of traditional gain scheduling. The gains are calculate using a LQR

¹Linear Quadratic Regulator

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Table of Contents Longitudinal Stability Augmentation Design With Two Icas

1. Understanding the eBook Longitudinal Stability Augmentation Design With Two Icas
 - The Rise of Digital Reading Longitudinal Stability Augmentation Design With Two Icas
 - Advantages of eBooks Over Traditional Books
2. Identifying Longitudinal Stability Augmentation Design With Two Icas
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Longitudinal Stability Augmentation Design With Two Icas
 - User-Friendly Interface
4. Exploring eBook Recommendations from Longitudinal Stability Augmentation Design With Two Icas

- Personalized Recommendations
 - Longitudinal Stability Augmentation Design With Two Icas User Reviews and Ratings
 - Longitudinal Stability Augmentation Design With Two Icas and Bestseller Lists
5. Accessing Longitudinal Stability Augmentation Design With Two Icas Free and Paid eBooks
 - Longitudinal Stability Augmentation Design With Two Icas Public Domain eBooks
 - Longitudinal Stability Augmentation Design With Two Icas eBook Subscription Services
 - Longitudinal Stability Augmentation Design With Two Icas Budget-Friendly Options
 6. Navigating Longitudinal Stability Augmentation Design With Two Icas eBook Formats
 - ePub, PDF, MOBI, and More
 - Longitudinal Stability Augmentation Design With Two Icas Compatibility with Devices
 - Longitudinal Stability Augmentation Design With Two Icas Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Longitudinal Stability Augmentation Design With Two Icas
 - Highlighting and Note-Taking Longitudinal Stability Augmentation Design With Two Icas
 - Interactive Elements Longitudinal Stability Augmentation Design With Two Icas
 8. Staying Engaged with Longitudinal Stability Augmentation Design With Two Icas
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Longitudinal Stability Augmentation Design With Two Icas
 9. Balancing eBooks and Physical Books Longitudinal Stability Augmentation Design With Two Icas
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Longitudinal Stability Augmentation Design With Two Icas
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Longitudinal Stability Augmentation Design With Two Icas
 - Setting Reading Goals Longitudinal Stability Augmentation Design With Two Icas
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Longitudinal Stability Augmentation Design With Two Icas

- Fact-Checking eBook Content of Longitudinal Stability Augmentation Design With Two Icas
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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