

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

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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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systems with only unfavorable interactions addressed The question How to design these two systems in such a way that the airframe needs the propulsion and the propulsion needs the airframe is the fundamental issue addressed in this paper Successful solutions to this issue depend on appropriate technology ideas This paper first details some ten technologies that have yet to make it to commercial products with limited exceptions and that could be utilized in a synergistic manner Then these technologies either alone or in combination are applied to both a conventional two engine transonic transport and to an unconventional transport the Blended Wing Body Lastly combinations of these technologies are applied to configuration concepts to assess the possibilities of success relative to five of the ten NASA aeronautics goals These assessments are subjective but they point the way in which the applied technologies could work together for some break through benefits

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