66th International Astronautical Congress 2015

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (3) (9)

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A MIXED H-INFINITY-GUARDIAN MAPS DESIGN APPROACH FOR THE AUTOMATIC FLIGHT CONTROL SYSTEM OF LAUNCH VEHICLES

Abstract

article amsmath The design methods of automatic flight control systems for launch vehicles received much attention over the last two decades. Among them, the H_∞-norm minimisation based approaches have been widely investigated due to their potential to handle simultaneously key design requirements as robust stability with respect to modeling uncertainty, tracking performances, disturbance attenuation, reduced sensitivity to measurement noises. An important issue arising when using the H_∞-type methods is the complexity and the structure of the resulting controller. Due to the gain scheduling of the control law parameters during the flight, controllers with reduced complexity are desired, having the same order and structure at all flight instances.

The aim of this paper is to present a design approach for the control system of launchers, able to achieve both *frequency-domain* requirements specific to the H_∞-synthesis and *time-domain* performances expressed as pole placement objectives. The proposed method consists in the following three stages.

Stage I. Determine the existence conditions of a fixed structure and order H_∞ controller such that the stability and the frequency–domain requirements are accomplished. These conditions are expressed in terms of the feasibility of a matrix inequality of form $Z + P^T \Omega Q + Q^T \Omega^T P < 0$ where the elements of the matrix Ω are the unknown parameters of the control law;

Stage II. Parametrise the set of all solutions $\Omega(L)$ of the above inequality with respect to the arbitrary matrix L such that $\|L\| < 1$;

Stage III. Using the *guardian maps* procedure one determines the elements of L such that the poles of the closed-loop system are inside a prescribed set $D \subset \mathbf{C}^-$. The advantage of using the guardian maps approach is that it is not conservative, allowing to determine the whole set of uncertain parameters for which the pole placement requirements are achieved.

The paper is organised as follows: after an introductory section, some preliminaries and useful results including the Bounded Real Lemma and the guardian maps procedure are presented in Section 2. The proposed design methodology is detailed in the third section and it is illustrated in the next section for the pitch/yaw motion of the VEGA launcher. The paper ends with some concluding remarks and future developments.