Study of Rigid Body Launch Vehicle Dynamics

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Abstract

Most launch vehicles represent a challenging flex-body problem to flight control system design, due to parameters variation, nonlinearities and etc. Many approaches have been developed to analyzing and design controllers to such systems. A common approach is split the problem at two others: rigid body, flex-body. So they are separately treated(Greensite). Under the assumption, that the time varying dynamic system can be well represented over a period of time by a transfer function, linear techniques can be used. The controller is designed to meet the time domain requirements (good tracking and fast response) and must have at the same time good stability margins, due to parametric uncertainty. The controller is generally designed considering that dynamic of launch vehicle is given by a second order transfer function, obtained after a simplification of third order transfer function (Greensite). After that, filters are projected to suppress the flex components in the errors signals at attitude controller. Traditional methodologies using linear techniques to analyze the system, offers great insights such as: the relationship between the controller and vehicle parameters with static and dynamics stability. New design methods are proposed to synthesis a robust controller and flex-filter together by a constrained optimization algorithm, that aim maximize margins gain while meeting performances requirements (Jang *et al.,* 2010). This new methods is promising but the designer lost the insight of the problem.

This paper analyzes the implications due to simplification, which obtain the second order transfer function through third order transfer function. The second order system usually comes from the dipole cancellation at low frequencies. In most cases the second order transfer function represents very well the third order system at high frequencies. However, some proprieties are lost due to the simplification, for example: the steady state gain at simplified transfer function differs significantly compare to the third order system.

It will be divided in two parts: firstly, will be discuss the closed loop systems designed with PD and PID controller, considering the second order system to the project. Then the system will be analyzed requirements at time and frequency domain considering both vehicle dynamics: second and third order.

The second part will discuss the improvements that can be achieved by projecting the controller using the third order directly instead of second order. The main objective of this paper is offers a method to designer to improve the robust and

controller performance requirements based on analyzes that will be made at this paper.

Main Bibliography

[1] Greensite, L. A. , "Analysis and Design of Space Vehicle Flight Control Systems", New York,US: Spartan Books, 1970.

[2] Jang, J.W, 2010, "Ares I Fight Control System Design.", American Institute of Aeronautics and Astronautics, AIAA-2010-8442, 2010.