

Flexible Broom Balancing

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Abstract

Low structural vibration frequencies may occur within (or near) rigid body modes influencing the angle of attack and lead to possible cross coupling in case of large rockets, like satellite launch vehicles (SLV). SLV, during boost-flight, is highly unstable and its structure is very flexible. A robust control design is a logical solution to a control problem of plants of known dynamics. However faulty (or unnecessarily approximated) plant model may lead to unstable response of the control loop in practice. In this paper mathematical model for both rigid-body and flexible body are developed and a generalized robust controller topology is designed which can be employed for the similar plants. Simulation and practical results validated the mathematical models, and proved not only that the designed control loop is robust to plant nonlinearities and other uncertainties, but also the structural vibrations do not pose any instability problem.

Key words

Flexible Inverted Pendulum, Nonlinear & Unstable System, Effective-Integral-Control, Robust Controller, Flexible Structure Mathematical Model.

1. Introduction

One should not be a control engineer to realize that an inverted broomstick pivoted at bottom is bound to go down by even a slightest disturbance. This problem becomes more difficult when the broom is pivoted on a cart and the broom is to be stabilized by its to-and-fro linear motion. The problem is further aggravated if the broomstick is flexible. Dynamics of a flexible inverted pendulum is similar to the SLV dynamics during vertical lift-off. Thus balancing of flexible inverted broom on cart is used in this study as benchmark problem, so that results could easily be practically verified in laboratory.

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