Paper ID: 62991
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures - Dynamics and Microdynamics (3)

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SOLAR PANEL AND ATTITUDE CONTROL DESIGN FOR AN AUTONOMOUS TABLE-TOP EMULATOR (KNATTE)

Abstract

The number of small satellites launched in recent years takes up to half of the total satellite launches, this number is expected to increase in the following years. With this new space market in mind, KNATTE (Kinesthetic Node and Autonomous Table-Top Emulator) has been developed. KNATTE is a frictionless platform developed by the Onboard Space Systems group at Luleå University of Technology in cooperation with La Sapienza University of Rome. It replicates the spacecraft behaviour in orbit, the aim of the platform is to validate control algorithms, guidance strategies and different types of hardware that can be found in spacecraft. One of the challenges that both small satellites and regular satellites face is the interaction between control movement and vibration of flexible appendages such as solar arrays and antennas that can negatively affect the performance of the spacecraft. Many control algorithms can be implemented to damp the elastic vibrations, thus solving this issue. The aim of this work is to develop a numerical model of a solar panel structure for KNATTE and implement a control law that reduces the flexible vibration of the solar arrays when attitude control manoeuvres are performed. The mathematical model of the multibody system, which consists of a rigid hub and two flexible solar panels, is developed in Matlab by applying the finite element method. A finite element analysis is performed in Matlab to extract the natural frequencies and modal shapes of the system. The model is then numerically verified using a commercial software, and experimentally verified by performing testing on the frictionless platform, KNATTE, equipped with the solar panel structure and a number of sensors. Once the model has been verified, a linear quadratic regulator (LQR) controller is implemented using the results from the finite element model in order to reduce the amplitude of the vibrations of the flexible solar panel structure. The behaviour of the system is simulated when the spacecraft performs an attitude manoeuvre. The finite element model provides the modal behaviour of the multibody system, obtaining its natural frequencies and modal shapes. This model can be used by future students and researchers to develop control techniques for spacecraft with flexible appendages. The implementation of the LQR controller reduces the amplitude of the vibrations of the flexible solar panel structure.