A port-Hamiltonian Approach to Satellite Attitude Control in presence of disturbances

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1 Introduction

The rigid-body attitude control problem is inspired by aerospace systems such as atmospheric flight, spacecraft, underwater and ground vehicles, together with robotic systems, which includes attitude maneuvers and attitude stabilization, [3, 7]. Furthermore, Euler's equations of motion describe the dynamics of a rigid-body, and then attitude kinematic stabilization becomes a requirement. More specifically, attitude control of a satellite is done via attitude parametrizations due to the fact that the set of attitudes is not a Euclidean space (see [11] and its references). In addition to this, it is well-known that satellite systems are affected by external torques such as gravity gradient [8], solar pressures and norm-based disturbances [1], and the J_2 effect [2].

2 port-Hamiltonian framework

The port-Hamiltonian framework (PH) is based on the description of (physical) systems in terms of power ports, energy variables, and their interconnection structure, [6]. The transfer of energy between the physical system and the environment is given via dissipation and energy elements, together with power preserving ports. The PH method has the additional advantage of preserving the PH structure for the closed-loop system.

Recently, a PH formulation of the rigid-body attitude problem that enhances the set of tools for its modeling and control is presented in [9], and [10]. More specifically, in [9] a novel approach on both dynamics and kinematics equations is provided such that a standard energy-balancing passivity-based controller (PBC) is used for set-point control. In addition to the PBC controller, a variation of the controller designed by [4] is given. Its mayor advantage is the achievement of the set-point without velocity measurements. Nevertheless, the controller proposed by [9] becomes ineffective when nonlinear disturbances are not neglected. The disturbances are considered as external forces affecting satellite attitude control.

Here, we have proposed a novel controller inspired by [5], by which a desired attitude kinematics and a attitude dynamics configuration of a satellite system is attained. Simulation results show how an integral action via an adapted momenta attains asymptotic stability in presence of nonlinear disturbances.

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