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EXTENDED OBSERVER AND OUTPUT FEEDBACK CONTROL FOR THE PRELIMINARY DESIGN OF TIANQIN TWO-TEST-MASSES DRAG-FREE AND ATTITUDE SYSTEM

Abstract

TianQin mission, which is proposed to detect and characterize gravitational waves in the millihertz-frequencies, relies on the spacecraft constellation with an orbital radius of 100 thousand km, it consists of three spacecrafts flying with an equilateral triangular configuration in a geocentric orbit. One core technology of TianQin mission is drag-free control technic with a high-precision requirement of residual acceleration 1×10^{-15} m/$s^2/Hz^{1/2}$ between 1 mHz and 1Hz on the test masses.

In order to achieve the mission requirement, the two-test-masses load of each of the three spacecrafts is established, and the drag-free and attitude control system is designed for several purposes. Not only does the jitter-controller for the whole system must compensate the nonconservative force acting on spacecrafts by tracking the baseline depending on free-fall test masses, but also the attitude-controller should make the optical assembly pointing meet the requirement 10 nrad/$Hz^{1/2}$ between 1 mHz and 1 Hz so that the laser-links can achieve its stabilized metrology performance, furthermore, the relative displacement between the test masses and cage in the spacecraft must be controlled to 3nm /$Hz^{1/2}$ between 1 mHz and 1Hz in order to ensure the influence of parasitic stiffness of the system can be cancelled, in addition to the residual acceleration condition on test-masses which must be isolated from external disturbances, the control force on test-masses must confirm to the requirement of residual acceleration 1×10^{-15} m/$s^2/Hz^{1/2}$ between 1 mHz and 1Hz.

In this paper, the background of TianQin mission is introduced, and the requirements, constraints and boundary conditions for the whole system is analyzed, and the drag-free and attitude control system design for one spacecraft with two-test-masses on board is given by robust and optimal theory, based on the mission requirements, this control system consists of three parts, the drag-free and attitude controller for spacecraft, the controller for test masses, the optimization and assignment for both thruster system and electrostatic suspension system. So as to make the design practicable in the engineering, the model of this system is decoupled, and the controller based on a state estimator is layout for each loop with different bandwidth. The design is proved by a non-linear time-domain simulation, and the results meet the requirements with the constraints under TianQin background.