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REQUIREMENT ANALYSIS AND PRELIMINARY DESIGN OF CONTROL SYSTEM FOR ATP PHASE OF TIANQIN MISSION

Abstract

TianQin is a space-borne gravitational wave detector. The TianQin Mission will enable scientists to detect and characterize gravitational waves in the millihertz (mhz) range (i.e., $0.1mhz$-$1hz$) emitted by different sources and events in our universe. TianQin consists of three spacecraft flying in a triangular constellation with an arm-length about $1.7 \times 10^5 km$ in a geocentric orbit that the orbit altitude is about $1 \times 10^5 km$. One core technology required in order to achieve the mission requirements is the establishment of three bidirectional laser link which can form an interferometer between the three spacecraft. The objective of the ATP (acquirement, tracking and pointing) phase which is pretty critical technology for the TianQin mission is to establish the laser link between the three spacecraft of the TianQin constellation and keep them stable so that the interferometric measurements for the science experiment can commence. The ATP phase for TianQin is extremely challenging given the $1.7 \times 10^5 km$ distance between the spacecraft, the inherent limits of the attitude sensors accuracy, the orbit determination accuracy issues and the time required to phase-lock the incoming and outgoing laser signals. This paper presents the requirement analysis and preliminary design of control system of the ATP phase of TianQin Mission on the basis of the ATP phase system concept. Firstly, a methodology is developed to derive requirements for all control loops from system level requirements, such as we can get the requirement of the pointing error is less than 10 $nrad$ and the jitter level is no more than 10 $nrad/\sqrt{Hz}$ between $o.1mhz$ and $1hz$. The final tracking accuracy need to be ensured in the order of a few $nrad/\sqrt{Hz}$ so that the science experiment can be performed. Then, based on the requirements for each individual control loop, a preliminary control system is designed for the ATP phase combine with the dynamic model to achieved the requirement. Finally, a constellation-wide non-linear simulation is developed to verify the system and the result indicates that ATP phase of TianQin Mission is feasible by means of the proposed control strategy.