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Author: Ms. Ai Noumi
Keio University, Japan

Mr. Takuya Kanzawa
Japan Aerospace Exploration Agency (JAXA), Japan
Ms. Misuzu Haruki
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Masaki Takahashi
Keio University, Japan

DESIGN OF ATTITUDE CONTROL SYSTEM BY MULTI-OBJECTIVE OPTIMIZATION CONSIDERING PRACTICAL OPERATION OF SPACECRAFT EQUIPPED WITH CONTROL MOMENT GYROS

Abstract

Recently, spacecraft requires rapid maneuverability in order to deal with properly diversity and complexity of mission. The techniques of rapid rotational agility as well as precision steady and attitudinal state are required for attitude control of spacecraft. In order to both quickly and accurately control the attitude of a spacecraft, Control Moment Gyros (CMGs) are used as an actuator of spacecraft. The pyramid type of 4-CMGs system is commonly used with a skew angle set to 54.74 degrees. Drive of motors is needed for rapid maneuverability and negatively affects for lifetime of motors. Therefore, achievement of rapid maneuverability and long lifetime by reducing drive of motors are conflicting objectives. Moreover fault-tolerance is also required for CMGs because it has been reported that CMGs have failed while operating . Consequently the design method for fault-tolerant attitude control system considering c achievement of rapid maneuverability and long lifetime is needed for spacecraft with CMGs. This study proposes a design method for attitude control system by multi-objective optimization of the hardware and software parameters considering fault-tolerance and conflicting objectives such as achievement of rapid maneuverability and long lifetime by reducing drive of motors. The parameters which are a skew angle of 4-CMGs system from hardware point of view, and the feedback gains and the parameters of the singularity-avoidance steering logic from software point of view are designed considering these objectives. It is needed to design the hardware and software parameters simultaneously because the applicable software parameters are different to achieve these objectives by changing the skew angle. The full search method or trial and error method are considered for this design method but calculation cost of these methods increases exponentially in case of that there are several design parameters. Furthermore it is commonly difficult to find an optimal solution in case of that there are several evaluation function because evaluation criteria compete with each other. Therefore Pareto solutions are obtained by multi-objective genetic algorithm which can consider several objectives. The design of fault-tolerant attitude control system for spacecraft with CMGs which is able to achieve the mission in the settling time to the desired attitude angle and considered the lifetime of CMGs by multi-objective optimization is proposed. As one of design methods, the settling time and motion of gimbal axis are evaluation criteria considering shortening of mission time and life time of CMGs. Pareto solutions are obtained by multi-objective optimization with constrained conditions.