Attitude Control System of an Earth Observation Satellite

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Abstract:

The objective of the research was to develop an Attitude Control System algorithm to be implemented in the Earth Observation Satellite System Concept created and being analyzed at the Division of Automation and Aeronautical Systems at Warsaw University of Technology. [1] [3] The system is composed of a formation of two nanosatellites cooperating in acquiring imagery of Earth. [1] The first satellite acquires coarse image of Earth's surface, from which an area is selected for a high-resolution image acquisition to be performed by the second satellite. In terms of a spacecraft control in such formation flight, satellites perform image acquisition in a similar manner. The main difference is the resolution of their imagery equipment, which influences the length of the part of the orbit suitable for image acquisition. Determination of this part of the orbit referred to as acquisition segment within this paper was the preliminary part of the research and is not discussed here.

The main task of the developed Attitude Control System is to execute attitude change maneuvers required for pointing the axis of the image acquisition sensor to the fixed target on the Earth's [2] surface within the acquisition segment, and to maintain a nadir orientation otherwise. The objective is realized first by defining the high-level operational modes and control laws to manage the attitude control actuators, for which magnetorquer and reaction wheel systems are used. The reaction wheels are used for rapid, precision attitude control during image acquisition, and the magnetorquers are used as a low-power stabilization system during the desaturation of the reaction wheels and may be applied also for detumbling after satellite deployment [3].

The operational modes were defined for issuing the commanded direction of the image sensor axis, and the actuators' actions were assigned to attain these commanded directions. Despite the nonlinearity of the system PID controllers are designed for each of actuator. The system also monitors the status of the reaction wheels and automatically commands desaturation when necessary.

A six-degree-of-freedom satellite model was obtained by customizing the Matlab Cubesat Simulation Environment. [4] The spacecraft simulation model incorporates realistic models of actuators. [2] This simulation environment was used to validate that the developed attitude control system performs attitude control in line with the requirements of the Earth Observation System Concept.

The tests and simulations at component and system-levels proved that the attitude control system performs the mission objectives with sufficient accuracy for a variety of combinations of orbital parameters and surface target positions.

References:

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