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Author: Mr. Bjørn Eskildsen
Aalborg University, Denmark

Mr. Jonas Lauridsen
Aalborg University, Denmark
Mr. Kasper Worre Foged
Aalborg University, Denmark
Mr. Anders Borchersen
Aalborg University, Denmark
Prof. Jesper Abildgaard Larsen
Aalborg University, Denmark

FAULT DETECTION AND FAULT TOLERANT CONTROL FOR AAUSAT3 CUBESAT

Abstract

Purpose: AAUSAT3 is the third student cubesat satellite developed at Aalborg University. The mission objective is to evaluate the possibility of receiving AIS messages from the ships in the waters around Greenland, which, for high reliability requires an Attitude Determination and Control System (ADCS). However, due to the hostile space environment, it is likely that some sensors and actuators will fail, thus a correct identification and appropriate countermeasures are needed to be designed to ensure a successful mission.

Firstly, the design of a model based Fault Detection and Isolation (FDI) system, which can detect a faults in the ADCS is presented. Secondly, the design of an intelligent Fault Tolerant Control (FTC), which is able to reconfigure the ADCS, in case of a faulty transducer is presented.

Methodology: The procedure of designing the FDI and FTC requires expertise in several disciplines. Firstly, a Failure Mode and Effect Analysis (FMEA) is conducted in order to analyze the faults and their propagation throughout the ADCS. The FDI algorithm design is mainly based on both the dynamic and kinematic equations of the spacecraft and detailed models of the transducers used in the ADCS. The usage of an Unknown Input Observer (UIO) method is used for the residual generation, which

are afterwards filtered using a CUSUM algorithm capable of determining if the generated residuals indicates a fault. Additionally, multi-sensor redundancy methods coupled with active fault diagnosis methods are applied.

The FTC is developed around optimal controllers designed by minimizing a periodic Ricatti equation, which together with advanced observer structures, is capable of controlling the attitude of the satellite with in the presence of multiple faults.

Results: An advanced simulation model of the satellite has been used to validate the FTC prior to launch. The simulation includes sophisticated models of the ambient environment including inter alia solar radiation, atmospheric drag, earth, sun and moon gravitational field and magnetic field.

The results indicate that using the designed FDI algorithm, detection and isolation of faults is possible for both actuators and sensors of the ADCS on the AAUSAT3. The results also indicate that the designed FTC is able to control the attitude acceptable in the presence of faults.

Conclusion: It has been shown how the FDI and FTC attitude control is designed for the AAUSAT3, which have been implemented on the AAUSAT3 and is ready for launch in 2011.