50th STUDENT CONFERENCE (E2)
Student Team Competition (3-GTS.4)

Author: Mr. Nadim Maraqten
KSat e.V., Germany

Mr. Paul Jannik Haufe
KSat e.V., Germany
Mr. Martin Zietz
KSat e.V., Germany
Mr. Alexander Wagner
KSat e.V., Germany
Mr. Christopher Vogt
KSat e.V., Germany
Mr. Luc Lauer
KSat e.V., Germany
Mr. Steffen Gaisser
Institute of Space Systems, University of Stuttgart, Germany
Mr. Robin Schweigert
KSat e.V., Germany

LOW-COST ATTITUDE DETERMINATION AND CONTROL SYSTEM OF THE STUDENT-BUILT 3U+ CUBESAT SOURCE

Abstract

Due to a substantial decrease in cost within the past decades, the realm of space has become accessible to a myriad of satellite missions. To contribute to this trend and make space more affordable, this paper presents the low-cost Attitude Determination and Control System (ADCS) of the student-built 3U+ CubeSat SOURCE "Stuttgart Operated University Research CubeSat for Evaluation and Education". The system can be used as a blueprint for a low-cost ADCS design and development of future missions. The ADCS on-board SOURCE is vital for the success of its scientific missions: meteor and Earth observation, in-situ demise analysis and space-verification of COTS components. SOURCE is a collaborative project between the Small Satellite Student Society (KSat e.V.) and the Institute of Space Systems of the University of Stuttgart. It is supported by the Fly Your Satellite! 3 programme of the European Space Agency (ESA).

SOURCE relies on its ADCS primarily for sun-pointing of the solar panels and precise attitude determination for the scientific payloads. The CubeSat conducts measurements of atomic oxygen, pressure and the heat flux into it. These are especially important during the final mission phase: the re-entry.

The satellite's attitude determination is provided by photodiodes used as sun sensors, magnetometers, GPS receivers and gyroscopes, most of which are inexpensive COTS components originally developed for earth applications. Their data is used in self-developed attitude and orbit determination and control laws, that yield the current state and the desired actuation. The CubeSat's actuation is entirely based on magnetorquers (MGTs), which provide two-axis control. The MGTs are self-built at exceptionally low cost. This in-house development allows for adaption to the satellite instead of vice versa – as would be the case with commercial ones. For verification and validation all systems undergo in-depth testing including functional, thermal-vacuum, shaker and electromagnetic interference tests.

The self-developed ADCS algorithms are examined using ESA's "Generic AOCS/GNC Techniques Design Framework for Failure Detection, Isolation and Recovery" (GAFE). Additionally, the satellite's dynamic behaviour and the performance of its ADCS during the early re-entry phase are analysed using a self-developed aerodynamic model that is based on drag coefficients from numerical simulations.

The conducted tests of the developed ADCS validate the system's integrity, taking the SOURCE CubeSat one step closer to its launch and the realisation of its scientific mission. The developed system can serve as an inspiration for future low-cost ADCS.