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Author: Mr. Christian Korn
Institute of Space Systems, University of Stuttgart, Germany

Prof.Dr. Georg Herdrich
Institute of Space Systems, Germany
Mr. Felix Schäfer
Institute of Space Systems, University of Stuttgart, Germany
Mr. Manfred Ehresmann
Institute of Space Systems, University of Stuttgart, Germany

DESIGN AND MANUFACTURE OF A TORQUE MEASURING TEST-BED FOR EXPERIMENTAL ATTITUDE CONTROL ACTUATORS

Abstract

The design and manufacture of a low-cost test-bed for the investigation of torque generation devices is presented. This work is part of the FerrAC (Ferrofluid Attitude Control) project at the Institute Space Systems of the University of Stuttgart. FerrAC aims for developing a new type of actuator, which will be able to provide a satellite attitude control system without any mechanical moving parts by means of ferrofluid manipulation. The actuator validation requires a test-bed capable of reliably and quantifiably measuring generated torques. The simulation of some implications of the microgravity environment of space is a crucial challenge for such a development. Since these actuators are engineered for space operation, gravity and atmospheric interaction is a source of error on Earth due to friction affecting validations on Earth. Therefore, the aspect of the microgravity environment, which enables the frictionless operation of actuators in space, must be simulated for test-beds on earth. To compensate this effect, an air-bearing was developed, designed and tested, which due to its properties allows an almost friction-free bearing. The test-bed is based on a planar air-bearing with a porous-type restrictor, which enables the mounting of generic torque generators for validation. For the torque derivation, a high-precision incremental magnetic encoder was selected, which can determine a highly accurate angular position of the platform. Based on these measurements a microcontroller calculates the torque and angular momentum of the system. For validation and referencing of various test scenarios, a control-torque mechanism is integrated, which uses a conventional reaction wheel as an actuator and is able to apply a defined torque to the system. The experiments and subsequent system validation tests demonstrate that the development of the test-bed was a success as it enables the precise validation of torque-generating actuators. The almost frictionless system, as well as the torque measurement, were verified with sufficient accuracy. The test-bed possesses a load capacity of at least $W = 10$ kg at an operating pressure in the range of $p_o = 1.25$ 1.5 bar. The top of the test-bed offers a surface with a diameter of $D_{Pl} = 400$ mm for the mounting of actuators. In addition, torque measurements with an accuracy of $T_{meas} = 0.00093$ Nm are possible. Thus, this research demonstrates the feasibility of developing and manufacturing an air-bearing test-bed, which typically involves complex and costly work, in a university setting with limited resources, both in terms of time and budget.