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Author: Mr. Andrea Antonello
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, andrea.antonello.it@gmail.com

Mr. Lorenzo Olivieri
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, olivieri.lrnz@gmail.com
Prof. Alessandro Francesconi
University of Padova - DII/CISAS, Italy, alessandro.francesconi@unipd.it

DEVELOPMENT OF A LOW-COST SUN SENSOR FOR NANOSATELLITES

Abstract

Sun Sensors represent a common and reliable technology for attitude determination, employed in many space missions thanks to their limited size and weight with respect to star trackers. Typically, two-axis digital Sun Sensors employ an array of active pixels arranged behind a small aperture; the position of the sunlight spot allows to determine the direction of the Sun. With the advent of smaller vehicles such as CubeSats and Nanosats, there is the need to further reduce the size and weight of such devices: as a trade-off, this usually results in the curtail of the performances.

Nowadays, state of the art CubeSats components have resolutions of about 0.5° with fields of view in the ±45° to ±90° range, with off-the-self prices of several thousands of dollars.

In this work we introduce a novel low-cost miniaturized sun sensor, based on a commercial CMOS camera detector. The sensor consists of a precisely machined pinhole with a 10μm circular aperture, placed at a distance of 7mm from the CMOS. The standoff distance and casing design allows for a maximum resolution of less than 0.05°, outperforming most of the products currently available for nano and pico platforms; furthermore, the nature of the technology allows for reduced size and lightweight characteristics. Moreover, a set of miniaturized solar cells on the top casing of the sensor allows the device to autonomously power its electronics.

The design, development and laboratory tests of the sensor are here introduced, starting with the definition of the physical model, the geometrical layout and its theoretical resolution; a more accurate model was then developed in order to account for the geometrical deviations and deformations of the pinhole-projected light spot, as well as to account for the background noise and disturbances to the electronics. In addition, the model accounts for the diffraction noise introduced by the size of pinhole.

Finally, the laboratory setup is presented along with the test campaigns: the results obtained are compared with the simulations, allowing for the validation of the theoretical model.