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A COMPACT THERMO-OPTICAL SUN AND EARTH SENSOR FOR SMALL SATELLITES

Abstract

This paper proposes a Thermo-Optical-Sun-Sensor (TOSS) for small satellites, which combines a single radiant intensity measurement with two temperature sensors and can be used for coarse pointing in sun and eclipse. Since commonly available sensors utilise complex photometry, TOSS can serve as a replacement or technological redundancy to state-of-the-art commercial products.

The underlying technology has already been established on a bigger scale in the Coarse Earth Sun Sensor (CESS) developed by SpaceTech as a safe mode sensor for ESA, JPL and DLR missions and was protected by an European Patent from 1997. These designs used the temperature from two surfaces with different thermo-optical properties to differentiate between the three sources of thermo-optical-radiation: sunlight, earth's albedo and earth's infrared. In combination with the measured radiant intensity, e.g. from a solar cell, this system can calculate the satellite's orientation towards sun and earth - even in the eclipse.

We will report on the ongoing effort to miniaturise this technology against the background of an emerging interest in small satellites and affordable COTS technologies. The proposed miniaturised TOSS reduces the design to the essential components and integrates these in the form of commercial off-the-shelf (COTS) integrated circuits (ICs) in a small form factor. A photodiode measures the radiant intensity , while the corresponding surface temperature is determined using digital 1-Wire thermometers. We coated the thermometers, which come in Micro Small Outline Packages (μSOP), with the two different thermo-optical surfaces. This system is conceivably simple and can proof to work on a breadboard.

To achieve a better accuracy, we based the internal calculations of the TOSS on a thermal model of the system. Even though the structure of the thermal model is not complex, accurate thermal parameters are always hard to determine. Therefore, we developed a prototype of the sensor to fly as a payload on MOVE-ON, a high-altitude pseudo satellite mission. We will discuss the gathered data and analyse the fit to the parameters of the thermal model. According to TRL definitions, the MOVE-ON mission does qualify the sensor as working in near-space environment.

Based on the results, a further optimised sensor prototype will be presented for discussion, evaluation and modification by small satellite integrators. Possible applications range from direct utilisation as a stand-alone module to multi-sensor configurations. The seamless integration into custom side panels or an existing satellite architecture is also possible.