Towards the Industrialization of the SunTracker

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The CSEM SunTracker has been fully redesigned to meet industrial specifications, among them the resistance to shocks and a wide operational temperature range, including a fabrication process for the optical front-end and an easily implementable calibration procedure. Additionally, its intrinsic performances were enhanced with an increased field of view, a lower power consumption and a sub-millidegree accuracy. The technology has been transferred to the industrial partner, who will now integrate CSEM SunTracker devices in various geo-localization products.

Based on the CSEM spaceCoder technology, a SunTracker prototype [1] was realized in 2013, providing the azimuth and elevation angles of the Sun with high accuracy (+/- 25.10^{-3}) under a 120° field of view (FOV) with a power consumption of 800 mW. This prototype has been redesigned with industrial constraints such as the resistance to external shocks, the operability under a wide temperature range, a lower power consumption and a viable manufacturing process including calibration aspects.

A major point of this redesign was the optical front-end, which consists of an imager, an optical attenuation filter and the spaceCoder shadow mask. The Aptina imager was replaced by another version compatible with the required temperature range (-40°C to +50°C) and which has a better package: the smaller sensor-to-glass air gap increases the FOV up to 150°, and allows the use of a new shadow mask that provides a higher precision. This shadow mask was etched directly on the attenuation filter (NG1 substrate) with anti-reflective chromium.

The assembly process of the front-end was key, as it had to be both easy to manufacture with a high repeatability to simplify the calibration procedure, and shock-resistant to avoid a recalibration after an unexpected shock. The solution for this assembly was a gluing of the etched filter on the imager. As UV curing was not possible due to the OD4 attenuation filter, the assembly was realized with a high-precision mechanical setup by gluing the mask-filter reticle centered on the imager, and heat curing it. The repeatability of this process was perfectly satisfactory, as the assembly variations (offset and rotation) were small enough to be compensated by the calibration. Equipped with a reliable temperature sensor for metrological corrections, the optical front-end was mounted on a separate board with a flex connector to decrease the mass on glass, and thus increase the system sturdiness (Figure 1).

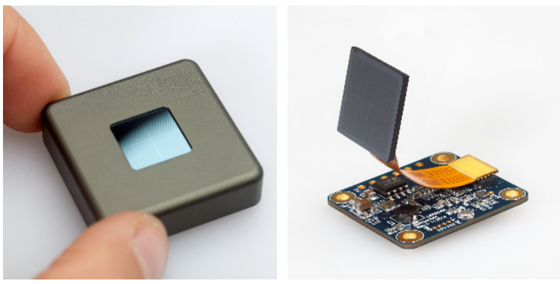

Figure 1: SunTracker prototype (left), front-end flex-board on its processing board (right).

The processing board was redesigned with two modes of operation and related supply voltages: RS232 under 3 V for programming, measurements and calibration, RS422 under up to 24 V for industrial operational use. The image acquisition scheme has been re-implemented (acquisitions on request with a low-power standby mode in-between). The Sun angles measurement is performed by a cortex M4 ARM processor, including the front-end calibration and the temperature correction. Built from off-the-shelf components, the complete system in its aluminum package is compact (33x33x10 mm); it delivers accurate Sun angles in real time (30 ms after user request) and consumes 80 mW.

A new calibration process has been implemented that compensates most of the front-end variations, such as the hardware variations (thicknesses of imager air gap, glass parts and glue), the assembly imperfections (planarity, offset and rotation) and the internal reflections (NG1-Air, chromium and silicon). This resulted in a significant enhancement of the performances, achieving a sub-millidegree accuracy for the angle detection under a 120° FOV, and still +/- 3.10^{-3}° under the extreme 150° FOV. Based on a few measurements points, this calibration is compatible with an industrial production line. A compensation of the temperature effect has also been implemented; it allows to maintain an accuracy of +/- 30.10^{-3}° from -40°C to +50°C (Figure 2).

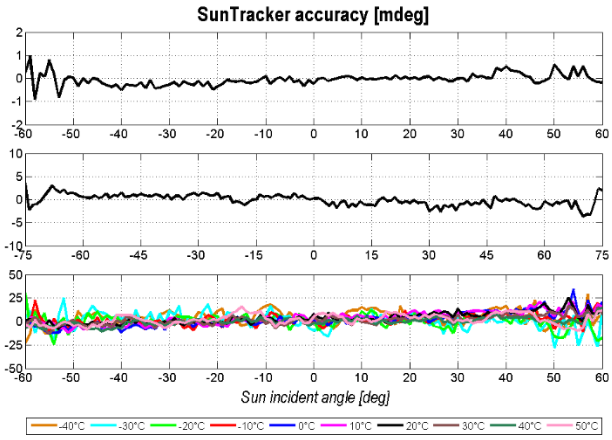

Figure 2: SunTracker accuracy [mdeg] under stable temperature (top and middle) and under large temperature variations (bottom).

Reshaped for industrialization, the CSEM SunTracker reaches very high performances in real time. It can be used in combination with other instruments (telescope, goniometer, theodolite etc.) or by itself. This achievement was made possible only with the support of the CTI office. The SunTracker know-how, based on the CSEM spaceCoder technology, has been fully transferred to the industrial partner, who will integrate SunTracker devices in various geo-localization products.

[1] E. Grenet, *et al.*, "Embedded sun tracker with extreme precision", CSEM Scientific and Technical Report, (2013) 100