Dual Imaging Readout Electronics for long-term Remote Sensing Measurements from CubeSats in Low-Earth-Orbits

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Introduction

Motivation
- Scientific long-term measurements with remote sensing require the online applications with high-resolution, high-speed imaging.
- Complex remote sensing payloads require reliable commercial off-the-shelf (COTS) electronics.
- High speed and high spatial resolution for long-term and specific data processing for image sensors.

Impact
- Figure 1: In-Orbit Verification - AtmoSHINE remote sensing instrument.
- Sensors become increasingly important for the modeling of the climate system and lead to a great interest for cost-effective reliable payload electronics.

Electronics Design

Key features
- Radiation tolerant CubeSat sized electronics for several 2D scientific CMOS sensors.
- High speed detector data acquisition, onboard data processing and storage, provide housekeeping data and interface to satellite bus.
- Based on a System-on-Module (SoM) with embedded processor, programmable logic and memory.
- Modular concept with ProXemity Electronics and FrontEnd Electronics boards.
- Designed for mission lifetime > 3 years.
- Data pre-processing (pixel binning) and data reduction for daytime and nighttime measurements.

Hardware Implementation

Electronics Assembly

System-on-Module Architecture (TEO720-03-2IF)

- Processing system (PS): XC7Z020.
- Dual-core ARM Cortex-A9 MPCore™, 867MHz.
- Programmable logic (PL): Artix-7 FPGA, 89k logic cells, 4.9 MB BRAM, 220 DSP slices.
- Up to 1 GByte DDR3 SDRAM memory.
- 32 MByte Quad SPI Flash NAND memory.

Limb Sounding Detector (GSENS 400BS)

- Image Area: 2048 x 2548 pixels.
- Spectral range: 380 – 850nm (QE=0.5).
- Pixel size: 11.0µm x 11.0µm.
- Readout noise 1.6 e- (rms).
- Dark current: < 0.2 e- /pixels @ -50°C.

Albedo Cloud Detector (HWK 1915A)

- Image Area: 1920 x 1080 pixels.
- Spectral range: 420 – 800nm (QE=0.3).
- Pixel size: 5.04µm x 5.04µm.
- Readout noise 1e- (rms).
- Dark current: 0.25 e- /pixels @ 30°C.

System-on-Module Architecture

- Dual-core ARM Cortex-A9 MPCore™, 867MHz.
- Programmable logic (PL): Artix-7 FPGA, 89k logic cells, 4.9 MB BRAM, 220 DSP slices.
- Up to 1 GByte DDR3 SDRAM memory.
- 32 MByte Quad SPI Flash NAND memory.

Instrument Design

AtmoCube A1: 6U Dual Imager Concept

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operability</td>
<td>-20°C to +105°C</td>
</tr>
<tr>
<td>Power</td>
<td>3W (max)</td>
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<tr>
<td>Mass</td>
<td>3 kg (max)</td>
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<tr>
<td>Size</td>
<td>176 x 176 x 370 mm</td>
</tr>
<tr>
<td>Speed</td>
<td>0.1 Hz to 10Hz</td>
</tr>
<tr>
<td>Temperature</td>
<td>-20°C to +60°C</td>
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<tr>
<td>Humidity</td>
<td>90% (max)</td>
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<td>Water Content</td>
<td>0.1% (max)</td>
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<td>Vibration</td>
<td>2g (max)</td>
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<tr>
<td>Shock</td>
<td>20g (max)</td>
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</tbody>
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Summary
- Dual imaging electronics based on a SoM architecture requires less development resources, improving reliability.
- Useful for a wide variety of remote sensing instruments in future LEO missions with capability of at least 3 years of mission lifetime.
- Negligible error rates over mission time using triplicated logic and reconfiguration of the SoM in combination with SEL protection.
- Analysis of the long-term behavior regarding SEU and SELF interaction after the end of AtmoSHINE instrument mission is planned.

References