SPACESTAR

Space

SATELLITE PLATFORM AVIONICS COMPUTER EMBEDDING STAR TRACKER ALGORITHMS AND RESOURCES

SPACESTAR is a novel star tracker architecture, originally developed for a high volume constellation program which, through an integrated configuration to Attitude Control System computers, enables significant size, weight, power and cost benefits. The results of these efficiencies provide the ability to utilize high performance star tracking systems on small satellites that were previously unable to accommodate the size, weight, and power of legacy architectures.

State-of-the-art star sensors are constituted by an optical system, a detector and a computer that executes image processing and attitude measurement algorithms. The computer may be separated from the housing which hosts the optics and the detector, but is always fully devoted to executing the star sensor SW.

The availability of increasingly powerful computers in state-of-the-art spacecraft's defines an innovative architecture of star sensors, in which the main spacecraft Platform Computer (PFC) hosts, further to the attitude control SW, also the stars' tracking SW (to compute the attitude quaternion in the J2000 Inertial Reference Frame).

The SPACESTAR star sensor HW is thus limited to Optical Heads, each hosting the optics, the detector and the small portion of digital electronics needed to operate the detector and perform communication with the PFC.

The SPACESTAR Star Tracker SW is optimised to use the improved computational capability of onboard computers and is designed to match the tight CPU time allocation (sharing resources with all the other satellite Attitude Control System activities), without penalising robustness and reliability of the system. It also introduces additional features for simultaneous management of up to three SPACESTAR Optical Heads per satellite.

Optical Head HW on Ground Qualification and SPACESTAR SW integration in spacecraft Attitude Control Computer SW already achieved within a high volume constellation program (Iridium NEXT).

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MAIN FEATURES

The SPACESTAR Optical Head is built around the optics and focal plane (the two core parts of a star sensor) already developed for the company's space qualified AA-STR star tracker.

The optical system is assembled in a titanium structure, to match thermal expansion coefficients, allowing good optics performance stability over a wide temperature range. The optical barrel also supports the focal plane assembly, completing the electro-optical module, following a well consolidated design criteria already adopted in all of the company's STR designs. A steady and rigid detection module is thus obtained, with a very high stability of the sensor performance over a large temperature range.

The detection module (optics plus focal plane) is included in an OH structure that also support the OH electronics, and through a dedicated thermally isolating spacer, the baffle. The full OH electronics is integrated in only two PCBs, one directly connected to the focal plane assembly, including some bias and filter circuitry for the APS detector, and the other with the digital electronics, including the HAS2 APS and based on a radiation hardened FPGA. Further to the blocks already implemented in the main ASIC of the AA-STR product (i.e. APS timing control and APS signal pre-processing) the SPACESTAR Optical Head FPGA contains the logic necessary to implement the Spacewire I/F.

The FPGA reads the areas of interest of the APS (windows) to find targets above the thresholds and to produce Run Length Encoding (RLE) segments, upon an adaptive background calculation and pixels threshold. Only segments (columnwise clusters of pixels) and a reduced set of data relevant to detected pixels are thus transmitted from the SPACESTAR Optical Head to the ACS computer via the SpaceWire interface. This allows for traffic reduction on the SpaceWire I/F and CPU load.

TECHNICAL CHARACTERISTICS

Detector	HAS2 APS
Field of view	20 x 20° full cone
Dynamic range	1.5 to 5.5 Mi
Number of tracked stars	Up to 15
Tracking rate	Depending on SW settings
Acquisition time (from lost in space)	Depending on SW settings
SEU tolerance	Depending on SW settings
Update rate	4 to 10Hz Depending on SW settings

ACCURACY (3SIGMA, EOL, FULL TEMPERATURE RANGE)	
Bias (Gaussian distribution)	7.7 arcsec (pitch/yaw) 10.6 (roll)
Low Frequency Error (FOV error)	<12 arcsec (pitch & yaw)
NEA (random error)	7.5 arcsec depending on number of optical heads and SW settings

DATA INTERFACES	
Data Interface (each OH versus ACS computer)	SpaceWire (two redundant channels - 50 Mbit/sec)
Interface for EGSE (electrical stimulation)	Custom

MECHANICAL INTERFACES	
Size	Total Envelope: 164mm x 164mm
Height	284mm (26 deg SEA baffle)
Mass	1.6kg with 26° SEA baffle GEO orbit radiation shielding

ELECTRICAL INTERFACES	
Power supply	OH input voltage 5VDC (allowed range 4.5 to 5.5V)
Thermo-electric-cooler driving	Each OH TEC shall be commanded with a DC voltage in the range from 0 to 3.3V (exact level defined each cycle by SPACESTAR SW)
Power consumption	<1.5W for each OH (excluding TEC)
TEC Power consumption	< 6W @ +60°C

ENVIRONMENTAL CONDITIONS	
Operational temperature	-30°C to +60°C
Storage temperature	-35°C to +65°C
Pressure	Ambient or space vacuum
Vibrations levels	Qualification level: 20.1G RMS All axis
Shock	1200G
Lifespan	18 years in GEO orbit
Reliability (per each optical head)	120 fits with Level 1 parts 170 fits with Level 2 parts

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