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SUPERNOVA™
6U Nanosatellite-class Spacecraft
Hardware Revision: Block IV

Configurable Supersymmetric Nanosatellite

Applications
- LEO Spacecraft

Features
- 6U size, up to 14kg total mass
- Tested to NASA GEVS (14grms) levels
- Compatible with PSC Canisterized Satellite Dispenser (CSD)
- Structure:
  - 197Hz first mode stiffness @ 12kg
  - 6 internal 100x100x100mm unit cells
  - 22 80x80mm Space Access Ports (SAPs)
  - Accommodates CSD separation connector
  - 0.8-8mm of attachable shielding
- Solar array:
  - 64W PMDSAS array
  - Resettable ultra-high-reliability pin puller actively deploys all four panels
  - 4 panels deploy into single XY plane
  - All 18 X&Y SAPs uncovered by solar array
- Bus:
  - 2U / 2kg / <8W SWAP
  - 4 switchable power feeds to payload(s)
  - 4-port 10/100 Ethernet switch for payload(s)
  - Bus firmware runs under Debian® Linux® on 1GHz ARM® processor
  - +12Vdc, battery, +5Vdc & +3.3Vdc power
  - Multi-BCR EPS & >60Wh high-power battery
  - GPS receiver with on-board orbit propagator
  - ADACS w/star camera
  - GSE w/panel release, battery charging, Ethernet and USB interfaces
  - CSD-compatible RBF and sep switches
- Supersymmetric unit cell arrangement places each unit cell origin at center of co-located SAP
- Comms:
  - Compatible with multiple third-party radios
  - Supports UHF, S-band, X-band, etc.
  - Efficiently heatsinked to structure
  - Typically occupies 0.5U-1U of a unit cell and one SAP for antenna(s)

ORDERING INFORMATION

Pumpkin P/N 715-01362

- Payload accommodation:
  - Up to 3.5U and 8kg available, in multiple configurations
  - Ethernet (preferred) and serial interfaces to bus
  - Harnessed to bus for power and interface
  - Unfettered access to nearly all co-located SAPs
- Linux-class bus & payload software development environment (C, python, etc.) with bus-to-payload and space-to-ground interfaces via TCP/IP and UDP/IP sockets

CHANGELOG

Rev.	Date	Author	Comments
A	20160707	AEK	Initial release of hardware Block IV.

A NOTE ON CONFIGURATIONS

The design of the SUPERNOVA™ family of spacecraft permits a wide range of different configurations that remain compatible with the PSC CSD specification. This datasheet covers the following configurations:

- 6U size, bus in unit cells A1 & A2, 64W solar array deployed from +Z face, GPS antenna in +ZA1 SAP, star camera looks out +XA2 SAP

DESCRIPTION

SUPERNOVA is a fully integrated 6U-size spacecraft that conforms to the PSC CSD specification for 6U nanosatellites. Of the six identical 1000cc unit cells inside the structure, two (i.e., 2U) are occupied by the bus (C&DH, EPS, BATT, GPS, ADACS, payload interface, etc.) and four (i.e., 4U) are available for the user-selected comms system and for user payload(s). A deployable solar array converts solar energy to power for the bus and payload(s), and to charge the on-board batteries. An ADACS with miniature reaction wheels, a star camera and other sensors provides accurate attitude determination and control. A space-grade GPS receiver provides position and velocity information. The spacecraft's bus is controlled by flight-proven firmware running under Linux® on a high-performance processor. The interface between the payload(s) and the bus is via Ethernet through standardized, open protocols.

The deployable solar array is held via a mechanical linkage that locks the panels in the stowed position. A single, resettable pin puller releases the panels when energized. Utilizing the stored mechanical energy in the hinge springs, the solar panels then swing through 90 degrees to their deployed position. Power from the strings of solar cells is routed into the structure via flex circuits. All of the hardware associated with the solar array (hinges, flex circuits, release mechanism, pin puller interface) is located on the +Z plate; when deployed, the X and Y faces of the spacecraft are completely uncovered, for use as radiators, access to the space environment, etc.

SUPERNOVA's design is predicated on accommodating six identical 100x100x100mm unit cells arranged on a regular grid inside the structure. The external volume left over from the PSC CSD payload specification is occupied by the solar array, RBF and separation switches, the CSD separation connector and (typically) antennas and sensors. By providing a full 100mm of internal room in each of three axes of a unit cube, it is possible to mount nearly any component originally designed for a CDS-conforming CubeSat inside SUPERNOVA. There is a small interstitial space between unit cells that can be used for harness routing, etc.

SUPERNOVA's supersymmetric design locates standardized openings (the Space Access Ports (SAPs)) on the six plates that form the structure such that they are centered relative to the origins of the corresponding / neighboring unit cells. Unit cells can be implemented as stacks of modules within a frame, or as solid blocks, or in other ways; all unit cells measure up to a maximum of 100x100x100mm. A symmetric bolt square pattern is provided on the +Y and –Y plates for mounting and thermally coupling the contents of a unit cell to the structure. This permits 24 different orientations for the contents of each unit cell, relative to the SUPERNOVA structure. Additionally, a standardized bolt square pattern is associated with external covers for each SAP; depending on which face the SAP is located on, these covers may be flush or inset into the structure.

The SUPERNOVA bus connects C&DH, EPS, BATT, GPS, ADACS, and comms together through a variety of local interfaces. The bus firmware manages all of these subsystems, providing telemetry, tracking and control to the ground station (via the space-to-ground ICD) and the payload(s) (via the bus-to-payload ICD). All interfaces are via TCP/IP or UDP/IP sockets. The preferred method for interfacing user payload(s) is via Ethernet, and an Ethernet switch is provided. Switched payload power and payload Ethernet connectivity is via dedicated harnesses between the payload(s) and the bus.

A Ground Support Equipment (GSE) port is provided. It enables external battery charging, permits a manual release of the solar panel deployment system, and provides Ethernet and USB connections to the C&DH processor (and hence, to the payload(s)).

Remove-Before-Flight (RBF) pins are provided to isolate the battery and activate the separation switches.

BUS COMPONENTS

The standard configuration for a Block IV SUPERNOVA bus consists of the following items, located in unit cells A1 and A2:

Payload Interface Module (PIM)

The Pumpkin SupMCU-based PIM provides power switching on four independent power ports. Each power port can be configured to deliver +12Vdc, VBATT or +5Vdc. Because the PIM draws its power from the EPS, these ports are limited to a maximum of ca. 4A each. The PIM also provides various test points and indicators, as well as a 4-port 10/100 Ethernet switch (when fitted). Control and telemetry of the PIM is provided via SCPI over I2C. The PIM connects to the bus via the CSK 104-pin bus connector.

Bus Interface Module (BIM)

The Pumpkin SupMCU-based BIM provides multiple serial interfaces to bus-specific components that are not connected to the CSK 104-pin bus connector. Some of these serial interfaces can also be used to connect to serially-connected payloads. The BIM controls the pin puller. The BIM also provides routing for certain bus-specific signals. Control and telemetry of the BIM is provided via SCPI over I2C. The BIM connects to the bus via the CSK 104-pin bus connector.

Motherboard Module 2 (MBM2) + BeagleBone Black (BBB)

The Pumpkin MBM 2 hosts a Rev C BBB as the bus C&DH processor. The MBM 2 manages power-on, WDT gating, level shifting and interfacing to the bus signals. The MBM 2 also hosts a RTC and the secondary SD Card. The GSE's Ethernet and USB connections to the system are through the BBB. The BBB communicates with all of the SupMCU-based modules over SCPI, and with other subsystems (e.g. ADACS, GPS) over dedicated I2C and serial links. The comms interface is typically over Ethernet or Ethernet-over-USB. Control and telemetry of the spacecraft as a whole is provided via UDP/IP sockets to/from the BBB. The MBM 2 connects the BBB to the bus via the CSK 104-pin bus connector.

Electrical Power System (EPS)

The EPS has eight 12W Battery Charge Regulators (BCRs) and four output bus voltages (+12Vdc @ 1.5A, VBATT @ 4.2A, +5Vdc @ 4.2A & +3.3Vdc @ 4.2A). Six of the 12W BCRs are connected to six independent strings of solar cells on the deployable array. One BCR is for ground charging, and the remaining one is a spare. Control and telemetry of the EPS is provided via I2C. The EPS connects to the bus via the CSK 104-pin bus connector.

Battery Module (BM 2)

The Pumpkin SupMCU-based BM 2 provides energy storage in the form of eight 18650 Li-Ion batteries arranged in a 2S4P configuration. BM 2 electronics provide battery safeties (OV, UV, OC, OT), a battery heater, and a "gas gauge". The BM2 can be charged and discharged via its connection to the CSK 104-pin bus. Additionally, it has a separate, independent, high-current discharge connector for payloads that require higher power via currents in excess of 4.2A. Control and telemetry of the BM 2 is provided via SCPI over I2C. The BM 2 connects to the bus via a dedicated harness.

Global Positioning System Receiver (GPSRM 1)

The Pumpkin SupMCU-based GPSRM 1 provides position and velocity information via a space-grade GPS receiver. The GPSRM 1 also provides a PPS signal for the bus. Control and telemetry of the GPSRM 1 is provided via SCPI over I2C, and the NovAtel® OEM615 receiver connects directly to the BBB via a serial interface. The GPSRM 1 connects to the bus via the CSK 104-pin bus connector.

Attitude Determination and Control System (ADACS)

The ADACS utilizes three miniature reaction wheels, a pyramidal sun sensor, a star camera, and other internal sensors to provide accurate attitude determination and control of the spacecraft. Control and telemetry of the ADACS is provided via a serial interface to the BBB. The ADACS connects to the bus via a dedicated harness.

COMMUNICATIONS

Several different radios are available for SUPERNOVA. They all share these common traits:

- Separate from the 2U bus,
- The radio itself (along with its heatsink) can be mounted in a unit cell of the customer's choosing,
- The radio is connected to the bus via Ethernet or Ethernet-over-USB,
- Power and interface connections to the bus are via harnesses, and
- Antenna(s) is(are) typically located on the –ZA3 face.

Because of the need for considerable heatsinking for a typical high-speed radio, the radio's heatsink is typically attached to the –Y or +Y plate of the structure, and the radio and its components are "built up" on top of the heatsink. If a radio does not occupy a complete 1U unit cell, the remaining volume can be used for other components (e.g., user payload components).

Since the radio can be placed in any available unit cell, its is typically placed in unit cell B1 if an L-shaped volume (unit cells A3, B2, B3) is desired for the payload, or its is placed in unit cell A3 if a "straight" volume (B1, B2 & B3) is desired for the payload.

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