Final HPcu Design and Build
Preliminary Design of HPcu
Industry Partner for Deep Space 1
Deep Space 1 Mission

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Acknowledgments:

Conclusions
Flight Data & Analyses
Operations
Testing & Stability
Design & Fabrication of High Voltage Power Converter
High Voltage Bus Requirements

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SPCMASTRO

OVERVIEW
paramount in accomplishing the mission goals. Distance from the sun, the need to operate near the peak power point is.

As the available power from the solar array power decreases as the square of the

Significance of the Requirements

Provide Current and Voltage Telemetry from Solar Array and Batteries
Load Each of 8 Solar Cell Modules to Measure I-V Profiles of Array Segments
Provide Battery Charge Control

33+/1/-1V @ 18.2 A Maximum for Spacecraft Power
HV Switching for PPU & PPU Heaters (2500W, 100W & 70W, Respectively)

Other HPCU Design Requirements

To support S/C loads occasionally during IPS thrusting.

High Voltage Bus Requirements

For the spacecraft to reach the asteroid,
OPERATION

Keep the PPU from getting too cold during low power and off.

PPU Heaters

Designed to provide over 2300 W of output power.

Converst high voltage to seven volatages to drive an Ion thruster.

Power Processing Unit (PPU) - part of the Ion Propulsion Subsystem (IPS)

and trickle charging.

V-T (voltage-temperature) curves to account for cell age, cell short,

Includes a charge control unit to charge the battery based on one of 16

A to the engineering loads and science instruments.

Converst high voltage to low voltage (~32 Vdc) while providing up to 18

High Voltage Power Converter Unit (HPCU) - Original Requirements

Estimated output power is 2500 W at 1 a.u. from Sun.

Output voltage range is from 80 V to 120 Vdc.

Solar Array

THE HIGH VOLTAGE BUS INTERFACES

JPL
Based on the projected estimates of the PPU voltage, the array voltage regulation set-point is selected near the PPU.

- The voltage range is 78 to 132 Vdc in 64 x 0.85 volt steps.
- Voltage set-points in the HPCU.
- The flight operations team or on-board sequence can command any one of 64 array points selected by an uplink command.

Additional control loop was added in the HPCU that allows regulation to an array voltage set-point.

The focus shifted to modifying the HPCU design.

Abandoned. Since the PPU design was frozen, the decision of a PPU approach was abandoned.

The PPU being a 2500 W load is a better choice for implementing a PPU.

- The goal was to maximize power to the PPU not the spacecraft loads.
- Incorporating a PPU in the HPCU has very limited advantage since it is a small load (~450 W).

Initially, the use of a peak power tracker (PPU) was considered.

Including PPU/thruster demands more power than the solar array could supply.

With the original HPCU design, the array voltage would collapse if the spacecraft loads

**THE HP CU DESIGN CHANGE**
side of the PPU (without collapsing the array voltage).

On-board flight tests indicate that the HPCU can operate at a set-point voltage on either

ground is near the power source.

A single-point ground approach is used on the spacecraft for power return lines; the star

grounding configuration.

As expected, the magnitude of the noise on the high voltage is dependent on the

collapsing the array voltage. 

noise on the high voltage bus, the HPCU performed in a stable manner.

The test results showed that although the PPU with a thruster load generated some

with a HPCU breadboard and a PPU breadboard.

Using a solar array simulator as a power source, compatibility tests were performed

HIGH VOLTAGE BUS STABILITY TESTING
autonomously.

Software algorithm on-board sends a command to IPS to throttle back one step if the battery discharges too deep (projected to reach 65% SOC in about 30 minutes), then a

from the array minus the expected spacecraft power consumption.

The IPS is commanded to a throttle level that corresponds to the maximum projected power.

The set-point selection is updated every week during spacecraft tracking.

The spacecraft operates near the PPP of the array.

To provide maximum power to the IPS during the thrusting phase, the spacecraft has to

Spacecraft on-orbit operations.
1. Upon sun acquisition, HPcu operates in battery current limit mode.

2. During nominal cruise, HPcu operates in V-T battery charge limit mode.

3. While thrusing, HPcu operates in solar array voltage control mode; the voltage

set-point is near the Pp.
Results from a PP search test performed in flight.

Battery Current vs SA Voltage

Flight Data & Analysis (cont.)
future missions that have one or more ion propulsion subsystems.

The next step for this technology is to investigate the use of onboard autonomy to

determine the optimum S/V voltage regulation set-point (i.e., near the P3P); this is for
changing the operating power level of the ion engine.

- Stable operation even to the left of the peak power point is achievable so long as you do not
- The solar array voltage set-points have to be updated every week to maintain operation near P3P.
- This approach relies on a fairly well-defined solar array model to determine the projected P3P.

The design of the high voltage power converter unit on DSI allows both the spacecraft

SUMMARY