



## Spaceborne Processor Array

NASA's Jet Propulsion Laboratory, Pasadena, California

A Spaceborne Processor Array in Multifunctional Structure (SPAMS) can lower the total mass of the electronic and structural overhead of spacecraft, resulting in reduced launch costs, while increasing the science return through dynamic onboard computing. SPAMS integrates the multifunctional structure (MFS) and the Gilgamesh Memory, Intelligence, and Network Device (MIND) multi-core in-memory computer architecture into a single-system super-architecture. This transforms every inch of a spacecraft into a sharable, interconnected, smart computing element to increase computing performance while simultaneously reducing mass.

The MIND in-memory architecture provides a foundation for high-performance, low-power, and fault-tolerant com-

puting. The MIND chip has an internal structure that includes memory, processing, and communication functionality. The Gilgamesh is a scalable system comprising multiple MIND chips interconnected to operate as a single, tightly coupled, parallel computer. The array of MIND components shares a global, virtual name space for program variables and tasks that are allocated at run time to the distributed physical memory and processing resources. Individual processor-memory nodes can be activated or powered down at run time to provide active power management and to configure around faults.

A SPAMS system is comprised of a distributed Gilgamesh array built into MFS, interfaces into instrument and communication subsystems, a mass storage in-

terface, and a radiation-hardened flight computer.

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## Instrumentation System Diagnoses a Thermocouple

This system can detect an open or short circuit or a debond.

John F. Kennedy Space Center, Florida

An improved self-validating thermocouple (SVT) instrumentation system not only acquires readings from a thermocouple but is also capable of detecting deterioration and a variety of discrete faults in the thermocouple and its lead wires. Prime examples of detectable discrete faults and deterioration include open- and short-circuit conditions and debonding of the thermocouple junction from the object, the temperature of which one seeks to measure. Debonding is the most common cause of errors in thermocouple measurements, but most prior SVT instrumentation systems have not been capable of detecting debonding.

The improved SVT instrumentation system includes power circuitry, a cold-junction compensator, signal-conditioning circuitry, pulse-width-modulation (PWM) thermocouple-excitation circuitry, an analog-to-digital converter (ADC), a digital data processor, and a universal serial bus (USB) interface. The system can operate in any of the follow-

ing three modes:

- *Temperature Measurement*

In this mode, the ADC samples the output voltages of the thermocouple and the cold-junction compensator. Because the output voltage of the thermocouple is very small (typically of the order of microvolts or millivolts), it is necessary to utilize the gain of the ADC. The processor uses the cold-junction-compensator reading to obtain a compensated thermocouple output voltage,  $V_{out}$ , then calculates the temperature at the thermocouple tip by use of the equa-

$$T_{tip} = \sum_{k=0}^n A_k V_{out}^k$$

tion of the form

where the  $A_k$ s are calibration parameters,  $V_{out}$  is the compensated thermocouple output voltage, and  $k$  and  $n$  are integers.

- *Thermocouple Validation*

For the purpose of determining whether there is a short or open circuit,

the two thermocouple leads are subjected to a common-mode DC excitation or, via capacitors, to a differential-mode PWM excitation. From the response to the DC excitation, the processor can determine whether or not there is a short circuit. From response to the PWM excitation, the processor can determine whether there is an open circuit.

- *Bonding/Debonding Detection*

The processor commands the application of a PWM excitation, via a capacitor, to the thermocouple for a certain amount of time to heat the thermocouple. (Inductors in the thermocouple leads prevent the PWM excitation from reaching the thermocouple cold junction.) The characteristic time or rate of increase in temperature during the excitation is analyzed by the processor as an indication of the integrity of the thermocouple. The characteristic time or rate of decay of the temperature after the excitation is analyzed by the processor as an indication of the thermal resistance (and, hence, of bonding or debonding)