Pressure Sensors for Mars Meteorology : Instrumentation and Packaging for a 100,000 g Impact on Mars.

Category : Physical Sensors

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NASA, through the New Millennium Program (NMP), has initiated a series of space missions intended to stimulate the infusion of new technologies into the Space Program. Among the missions selected as platforms for this infusion is a novel spacecraft for Mars. This paper will report on selection, packaging, and calibration of off-the-shelf micromachined pressure sensors for measurements on Mars.

The Deep Space-2 Microprobe will be released during the orbital insertion of Pathfinder 2, and will enter the Mars atmosphere, where it will be slowed to a velocity of 200 m/s. Upon impact with the surface, a "Penetrator" will seperate from the remainder of the spacecraft, and travel approximately 1m into the surface, as illustrated in Fig. 1. The remaining "Aftbody" will come to rest on the surface. The penetrator is intended to survive this deployment, and will utilize onboard instrumentation to search for moisture in the surrounding soil and measure other thermo-mechanical properties. The Aftbody will include a communications system suitable for transmission to an orbiting spacecraft, a wiring harness to the penetrator, some solar cells, and a small suite of meteorological instrumentation. Sensors for atmospheric pressure and temperature will be included in this suite. During impact, the aftbody is expected to experience deceleration of order 100,000 g with a very wide spectral distribution.

Absolute measurement of atmospheric pressure is made difficult by the following environmental factors on Mars : The pressure is about 1% of earth atmospheric pressure, and changes by as much as a factor of 3 from day to night. The atmospheric temperature can be expected to change from nearly 300K in full daylight to less then 200K at night. The total power available on the spacecraft is severely limited, so temperature regulation is not possible. Perhaps most importantly, the sensor must not suffer offset or sensitivity errors due to the violent nature of the deployment. The intended packaging scheme for this application is illustrated in Fig. 2. Of equal importance is the fact that the instrumentation must be delivered for integration on the spacecraft no later than 7/97.

Space-rated pressure sensors are not available for such a mission. We have decided to pursue the following approach : We have noted that the performance of commercial micromachined pressure sensors are not appropriate for this mission. However, we intend to select and individually calibrate a set of Novasensor pressure sensors. The temperature coefficients of such devices are large, but should be very stable, and we expect that careful calibration will allow us to eliminate errors well enough to measure atmospheric pressure on Mars to an accuracy of 0.1% over the 2-week lifetime of the mission. The use of such pressure sensors will demonstrate 2 important issues. (1) Micromachined silicon pressure sensors can be packaged to survive violent deployment, and are therefore suitable for almost any space applications. (2) Off-the-shelf MEMS devices are not generally intended for such high-performance applications, but careful instrumentation design and precise calibration can enable their use.

This paper will describe the measurement of atmospheric pressure on Mars. A description of the design and testing of the instrument package will be presented. Calibration data for Lucas Novasensor pressure sensors will be presented. This data will illustrate the potential high performance of off-the-shelf piezoresistive pressure sensors which are individually-calibrated and carefully-instrumented.

Because this project started in the last month, calibration data was not available for inclusion in this abstract. We will begin accumulating calibration data in the very near future, and plan to present such data along with design details. As a result, this abstract is probably inappropriate for selection as an oral presentation. Nevertheless, we believe it will lead to a very interesting poster presentation and proceedings paper, and hope the selection committee agrees.

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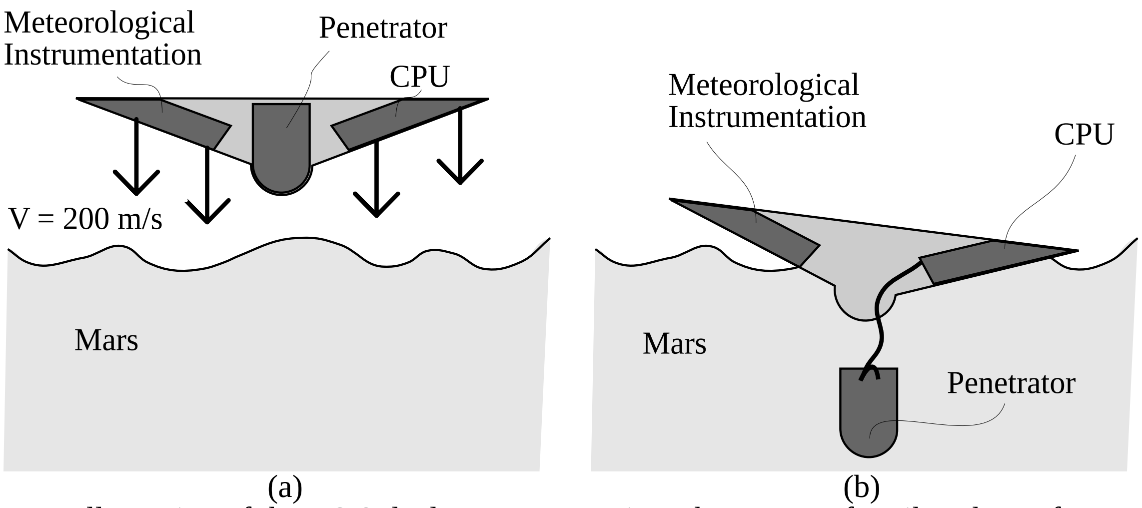

Figure 1 Illustration of the DS-2 deployment scenario. The spacecraft strikes the surface at 200 m/s, and separates into a penetrator and an aftbody. Pressure sensors will be mounted on the aftbody, where they are subject to deceleration of 100,000g, and environmental temperature variations.

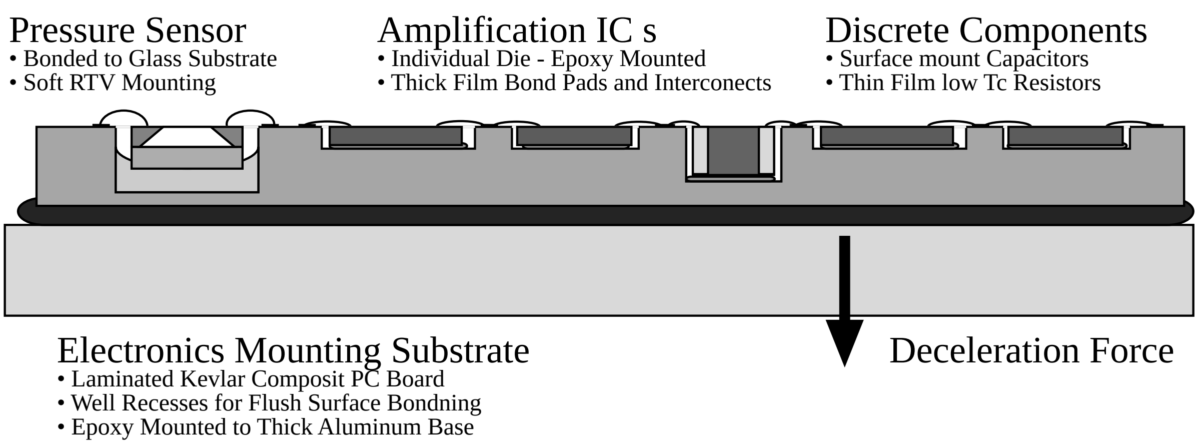

Figure 2 Illustration of the sensor and electronics instrumentation packaging scheme. The sensor will be mounted in a silicone-filled recess in a composite PC board, with discrete circuit components.

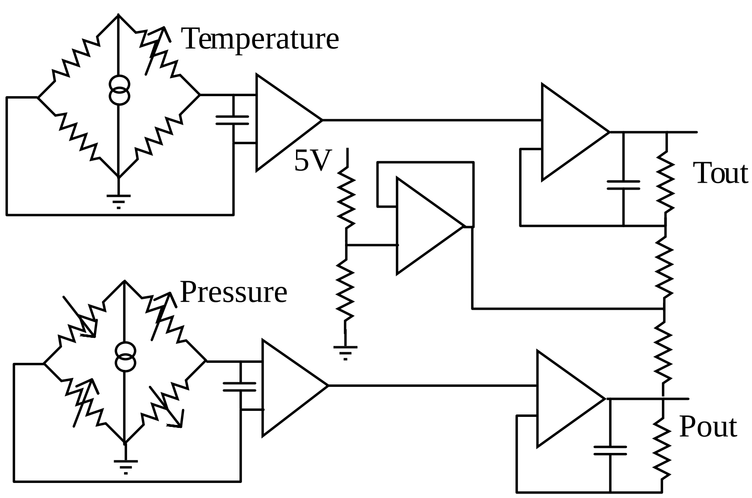

Figure 3 Schematic for pressure and temperature measurement circuit. An on-board temperature sensor will be measured along with pressure for post-acquisition removal of temperature coefficients.