EPSC Abstracts
Vol. 10, EPSC2015-465, 2015
European Planetary Science Congress 2015
© Author(s) 2015

Space qualification of an automotive microcontroller for the DREAMS-P/H pressure and humidity instrument on board the ExoMars 2016 Schiaparelli lander

T. Nikkanen (1,2), W. Schmidt (1), A.-M. Harri (1), M. Genzer (1), M. Hieta (1,2), H. Haukka (1) and O. Kemppinen (1,2)
(1) Radar and Space Technology research group, Finnish Meteorological Institute, Helsinki, Finland,(2) Aalto University, Finland (timo.nikkanen@fmi.fi)

Abstract

1. Introduction

Finnish Meteorological Institute (FMI) has developed a novel kind of pressure and humidity instrument for the Schiaparelli Mars lander, which is a part of the ExoMars 2016 mission of the European Space Agency (ESA) [1]. The DREAMS-P pressure instrument and DREAMS-H humidity instrument are part of the DREAMS science package on board the lander. DREAMS-P (seen in Fig. 1 and DREAMS-H were evolved from earlier planetary pressure and humidity instrument designs by FMI with a completely redesigned control and data unit. Instead of using the conventional approach of utilizing a space grade processor component, a commercial off the shelf microcontroller was selected for handling the pressure and humidity measurements. The new controller is based on the Freescale MC9S12XEP100 16-bit automotive microcontroller. Coordinated by FMI, a batch of these microcontroller units (MCUs) went through a custom qualification process in order to accept the component for spaceflight on board a Mars lander.

2. Space qualification test process

Thermal, mechanical and material outgassing tests were performed for the component qualification. The thermal tests of the MCUs were conducted at FMI premises, while the component evaluation constructional analysis was performed at HI-REL Laboratories, USA and the material tests at Instituto Nacional de Técnica Aeroespacial (INTA), Spain. Mechanical qualification vibration and shock tests were performed at instrument level in VTT Expert Services, Finland.

Thermal cycling and cold soak tests for the microcontroller took place at the FMI space laboratory in Helsinki, Finland. All of the samples were cycled between -65 °C and +70 °C in an environmental chamber. One batch of samples were cycled 50 times, while another was cycled 100 times. The microcontrollers were also subjected to extended cold periods in -86 °C.

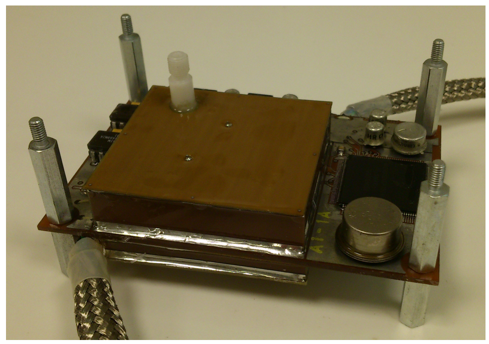

Figure 1: DREAMS-P pressure instrument Flight Model with the integrated instrument controller.

For component evaluation constructional analysis, HI-REL inspected 60 samples of the MC9S12XEP100 MCUs with X-ray and Scanning Acoustic Microscopy (SAM) techniques. Three of the samples were further examined via a Destructive Physical Analysis (DPA) against a set of military standards, including MIL-STD-1580B.

Actual mechanical qualification tests were performed at instrument level with the MCU integrated to the DREAMS-P circuit board. The qualification and flight models of DREAMS-P were vibrated and shock tested at VTT Expert Services in Espoo, Finland. These tests mimicked the type of actual loads encountered during the ExoMars 2016 mission.

Samples of the MCU plastic chip carrier material were tested at INTA to determine the outgassing properties of the material.

3. Space qualification test results

At FMI, the thermal cycling and cold soak tests were followed by a functional test of the MCUs. Each one of the samples was successfully tested to function in the socket of a software development evaluation board.

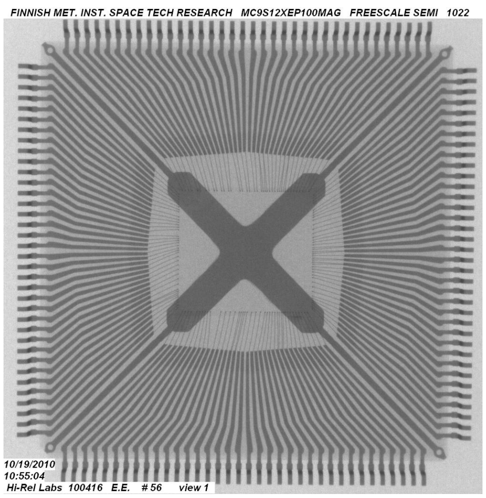

Figure 2: Example of a MC9S12XEP100 X-ray image.

The HI-REL X-ray (example seen in Fig. 2) or SAM inspections revealed no unacceptable mechanical defects in the components. However, some non-critical delamination and voids were detected on few samples with SAM. [2] Likewise, the DPA was passed without unacceptable defects [3].

Mechanical shock and vibration tests were successfully carried out at VTT Expert Services. The DREAMS-P qualification model was shown to function normally after being subjected to qualification test levels and the DREAMS-P flight model after being subjected to flight acceptance test levels.

The outgassing tests by INTA measured the Recovered Mass Loss (RML) of the material as 0.073 % and the Collected Volatile Condensable Materials (CVCM) ratio as 0.000 % [4]. These values are clearly under the ESA outgassing limits of < 1 % for RML and < 0.1 % for CVCM [5].

4. Conclusions

A capable microcontroller with low resource requirements was successfully qualified for spaceflight use. Following the component and instrument level qualification, the MCU is currently being subjected to additional environmental tests on a higher integration level as part of the DREAMS instrument package and the Schiaparelli spacecraft. Finally, as part of the ExoMars 2016 mission, the MC9S12XEP100 microcontroller will be subjected to the rigors of launch, transplanetary cruise, entry, descent and landing as well as the actual Mars surface operations.

The choice to use a commercial component for a planetary lander instrument controller in DREAMS-P/H represents the growing trend in spacecraft engineering of using capable commercial electronic components instead of components designed for space use. Compared to traditional designs, this trend offers more flexible development of efficient autonomous instrument control and data units, while maintaining a high level of reliability, when proper qualification and design guidelines are followed.

References

[1] F. Esposito, et al.: DREAMS for the ExoMars 2016 mission: a suite of sensors for the characterization of Martian environment. European Planetary Science Congress 2013. EPSC Abstracts, Vol. 8, EPSC2013-815.

[2] HI-REL Laboratories. Report Number: US- 100416x. Washington, USA. Technical report, December 2010. DREAMS-P/H team internal document.

[3] HI-REL Laboratories. Destructive Physical Analysis 100416.Washington, USA. Technical report, December 2010. DREAMS-P/H team internal document.

[4] Instituto Nacional de Técnica Aeroespacial. ESE-RPT-4316-055-INTA-13. Outgassing Test: DMAV-1314, Spain. October 2013. DREAMS-P/H team internal document.

[5] ECSS-Q-ST-70-02C. European Cooperation for Space Standardization. Noordwijk, the Netherlands, second edition, 2008.