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A MODULAR HARDWARE DIAGNOSIS FRAMEWORK FOR SMALL SPACECRAFT

Abstract

The hardware of embedded systems is subjected to natural aging. This especially applies to commercial off-the-shelf hardware being exposed to radiation and large temperature fluctuations in space. Thus, hardware that operates flawlessly after launch of a spacecraft may degrade or fail completely in the course of the mission.

To provide the functionality required by its mission, a small satellite forms a complex embedded system. In such systems a failing component may trigger chain reactions or side effects that make it very difficult to diagnose the root cause of a problem. Here, the ability to actively diagnose the origin of a malfunction by testing individual hardware components proves advantageous.

In this paper we present a concept that allows for actively diagnosing the condition of electronic hardware components within complex embedded systems. To this end, an extensible diagnosis software framework was developed, allowing the execution of tests on individual hardware components and returning comprehensive test results. Taking into account the large number of components, multiple tests are being encapsulated in test sequences which are then executed automatized. The test results are presented in structured graphical representations facilitating their fast evaluation.

However, the ability to test hardware components within larger systems is not only of interest for the spacecraft in orbit. In fact, the diagnosis suite can be used throughout a spacecraft's entire development cycle. Once hardware is manufactured, the suite can be used to confirm the correct functioning of each component in incoming inspections. During environmental test campaigns such as total ionizing dose or thermal testing it can be utilized to continuously monitor the status of the hardware. Furthermore, it can verify test setups and support the integration process. The framework also accounts for safety, as it allows for disabling specific tests for defined use cases, i.e. safety critical tests are excluded from the flight software.

The first mission to implement the diagnosis framework is TechnoSat, a 20kg satellite for in-orbit demonstration that is based on the modular TUBiX20 platform of Technische Universität Berlin. TechnoSat was launched in July 2017 and successfully performs experiments with its seven payloads since then.

Next to an overview of the framework and on how different types of hardware may be tested an outlook is given on how the presented approach can be extended to enable fully automated self-diagnosis of a satellite in orbit.