# HALT test of FEASTMP modules

This document summarizes the results of the Highly Accelerated Life Test (HALT) performed on first production-grade samples of the FEASTMP modules. The test was performed at the premises of MB Electronique, a specialized French firm owning and selling specific equipment for HALT and HASS tests, and providing test services. The chamber used for the measurements was a Qualmark Typhoon 3.0, capable of a temperature range of -100 to +200°C, temperature gradients of up to 70-100°C/min and 6-axis vibration of up to 70gRMS.

## The HALT test

The aim of the HALT test is to help product designers create a more robust and reliable product, thus improving field reliability and reducing warranty costs. When successfully applied, HALT testing rapidly exposes product weaknesses and gives the designer the opportunity to improve the product. As such, this test is most useful at a time when the product is almost ready to go to market, but modifications to the design and production process can still be applied.

In the case of the FEASTMP module, this happened in Spring 2014 when all components of the module were procured and a first batch of modules was assembled. This first batch used all and only production-grade components and procedures. Samples from this first batch were hence very representative of the quality of the production-grade module, while in case of problems there was still the possibility to introduce changes.

The HALT test is composed of a sequence of stress tests to which the product is exposed:

- Thermal Step Stress to identify failure modes that are due to temperature extremes
- Rapid Thermal Transitions Stress to identify failure modes that result from rapid thermal changes
- Vibration Step Stress to find vibration related failures, and to mechanically fatigue the DUT so that its weakest portions will fail quickly
- Combined Stress: all of the stresses used previously in the HALT test are combined and applied simultaneously. The goal is to identify any failures that require this combination of stresses to appear.

The HALT test is run on a single module, which is replaced in case of failure. This event can be frequent, since the aim of the test is to push the DUT to its failure point – within the capabilities of the test chamber.

## Details of the HALT setup

The test was run in June 2014 in a Qualmark Typhoon 3.0 chamber, a dedicated equipment for HASS and HALT tests. A test receiving board (or motherboard) was attached to the test platform of the chamber as shown in Fig.1. A FEASTMP module attaches to the motherboard as in the projected application, via the ruggedized connector and a pair of screws. Input and output signals are provided to the motherboard via dedicated cables from outside the chamber. Depending on the test (thermal or vibrational) appropriate sensors (temperature probes or accelerometers) are positioned on the DUT to monitor the conditions during the test in real time. At the same time, an oscilloscope monitors the output signals (Vout, PowerGood) to check the DUT functionality during the stress.

In both the Thermal Step, Rapid Thermal Transitions and Combined Stresses the temperature is increased well above the Over-Temperature Protection (OTP) threshold of the FEAST2 circuit, which is set to about 103°C. It is hence not possible to verify the correct functionality of the DUT above this temperature, since the module automatically turns off. To check that the higher temperature has not damaged the module, the temperature was brought back to 80°C after each stress step, at which point a healthy module resumes operation.

All stress tests were performed on modules operating at 10V input voltage in the absence of a load, and periodically checked for functionality at different input voltages. The Under-Voltage Lock Out protection feature was also periodically checked as well as the functionality of the enable command.

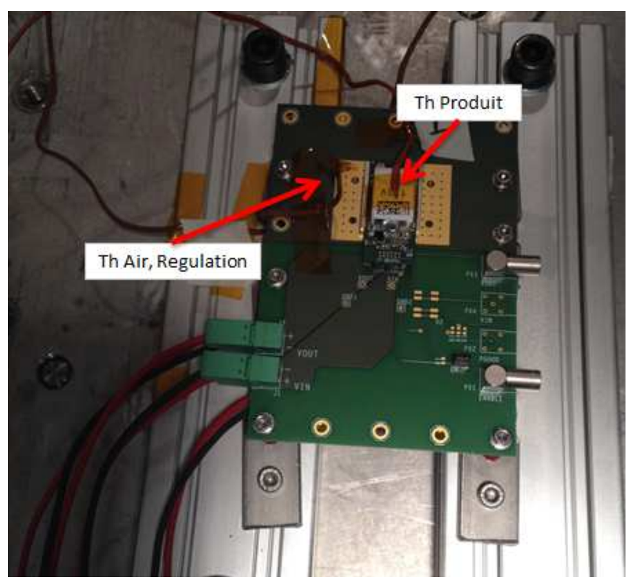


*Figure 1: The motherboard is attached to the test platform inside the chamber, and a FEASTMP module is connected to the motherboard (where the thermal probe "Th Produit" is positioned).*

## HALT test results

*Thermal Step Stress*

This stress was separated in two parts, both starting at 20°C. First the temperature was decreased in steps of 20°C down to -100°C, then it was increased in steps of 10°C up to +200°C. The dwell time at each step was at least 12 minutes. As said above, for steps at 110°C and more the functionality check was performed lowering the temperature at 80°C because of the OTP feature.
During this stress, no sign of failure was observed on the FEASTMP module. The failure limits for thermal step stress are hence beyond the limits reachable with the Typhoon 3.0 chamber.

*Rapid Thermal Transitions Stress*

Temperature was changed at the speed of 60°C/minute in the range -100 to +190°C. Upon reaching the two extremes, the temperature was stabilized for at least 16 minutes. 5 full cycles were performed, and also in this case no sign of failure was observed.

*Vibration Step Stress*

Vibration is applied randomly along 6 axes (3 translational and 3 rotational) at a fixed temperature of 20°C. The energy present in such random vibration signal is typically measured in gRMS, the Root Mean Square of the vibration spectrum in the 10-5000 Hz range and normalized to the gravity acceleration g. The step amplitude during the Stress was set to 5 gRMS, with dwell times of at least 20 minutes. The energy of 40 gRMS was reached at the end of the test.
FEASTMP modules worked undisturbed up to the 25 gRMS step (included). At 30 gRMS the output voltage and the PowerGood signals showed rare oscillations during the stress, which disappeared when decreasing the vibration to 5 gRMS (no permanent failure induced). These disturbances become more frequent when increasing the vibration to 35 gRMS, and even more frequent and larger in amplitude at 40 gRMS. At this level, the module was not working anymore at the end of the stress, showing that a failure level had been reached. Two other modules were tested at 35 gRMS, one without the shield, and reproduced the same result (oscillations during stress, correct functionality at the end of it). The functional limit appeared hence to be at the energy of 25 gRMS.

*Combined Stress*

This stress uses the same temperature profile as the Rapid Thermal Transitions, but after each temperature cycle the vibration energy is increased by 5 gRMS.
A first module passed the test at 5 gRMS, but failed when high temperature and 10 gRMS vibration were applied at the same time. The failure was permanent and due to the displacement of some soldered components (connector, inductor, shield). The solder softens at 190°C and the strong vibration applied for several minutes displaces these components. The maximum temperature of the test was hence lowered to 160°C, still keeping the other extreme at -100°C and using the same temperature gradient. In these conditions, the module could work well up to 20 gRMS. During the temperature cycle at a vibration of 25 gRMS, the module had a couple of restarts, while at 30 gRMS the oscillations observed already in the Vibration Step Stress were observed again. In all these cases, the module was functional at the end of the stress.

*Conclusion*

The HALT test confirmed the very good quality of the FEASTMP modules. Only vibration stress to very large levels (30 gRMS) can disturb the functionality and eventually provoke permanent failure of the modules, especially when vibration is coupled to high temperatures (above 160°C). These limits are very far from the conditions in the projected application. The modules are hence, in their present form, ready to go into production without the need for any modification.

## Revision history

| Revision | Date | Description |
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| 1.0 | October 2014 | First release of the document. |
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