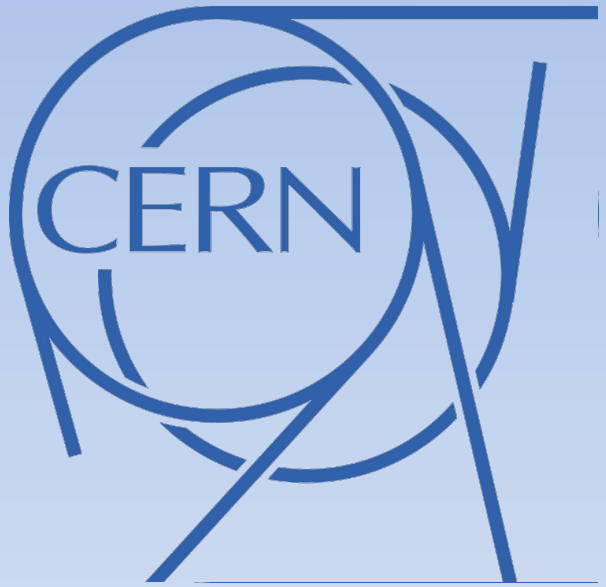

A Reliability Test System for Production Grade DC-DC Modules

TWEPP 2013 - Power Working Group

September 2013

I. Troyano, F. Faccio, S. Michelis, G. Blanchot

PH - ESE

Outline

- Motivating Scenario
- Overview of HALT
- The HALT Process Description
  - Cold and Hot Step Stress
  - Rapid Thermal Transitions
  - Vibration Step Stress
  - Combined Stresses
- Test Setup Description
  - Hardware involved
  - Monitoring software
- Test Results @ CERN
  - Cold Step Stress
  - Hot Step Stress
  - Rapid Thermal Transitions
- Conclusions

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Motivating Scenario

- The prototyping phase of the DC-DC converter module should be finished to face a production of 10,000 parts next year
- It is really important to find the prototype weaknesses before entering in production
- The investment of time and resources should be done efficiently to maximize the design reliability
- The main goal is to provide a reliable device that fulfills the experiments needs, being able to work for a long periods of time without problems or malfunctioning
- Taking all this points into account, it was decided to use the ***HALT test*** process to accomplish all the points mentioned above

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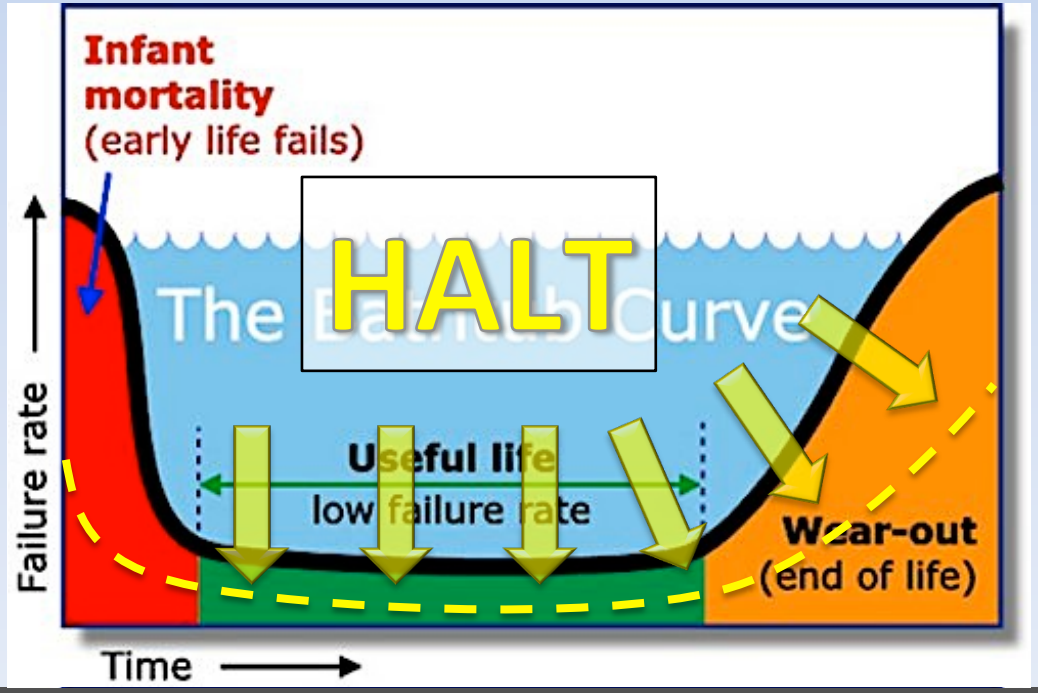
What is the HALT process?

HALT = Highly Accelerated Life Test

- Test specifically done during the prototyping phase to increase device reliability
- The basic stresses applied are: Temperature, vibration and a combination of both
- The stresses applied do not reproduce the field conditions. They are used to precipitate the flaws on the device.
- Shorter in time
  - A full HALT test could be carried on in just one week time
- Widely used in the industry since 1990 (aeronautics, automotive, consumer electronics, etc…)
- A specific chamber is needed for running HALT tests properly. However, it is possible to do some parts of the test using a conventional climatic chamber

- The Bathtub Curve
  - The HALT test will have a big impact basically in the useful life of the device and also, the time to reach the wearout mode is extended.
  - In other words, the device goes into production as a mature design



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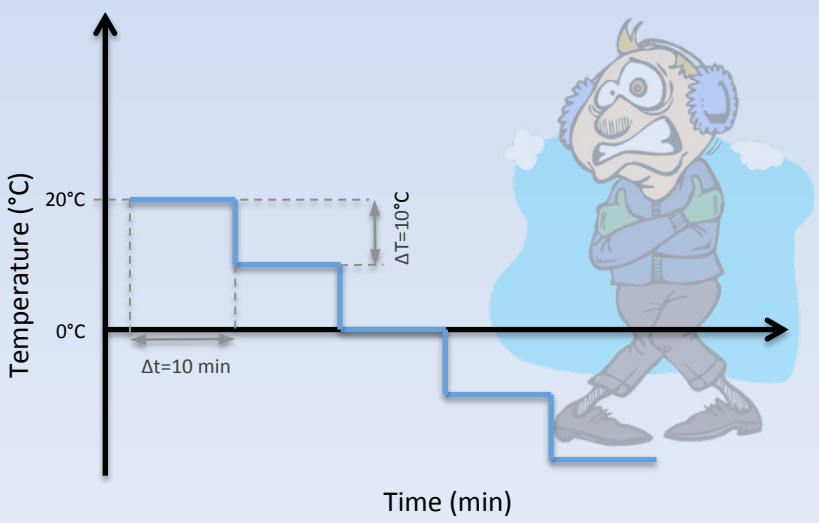
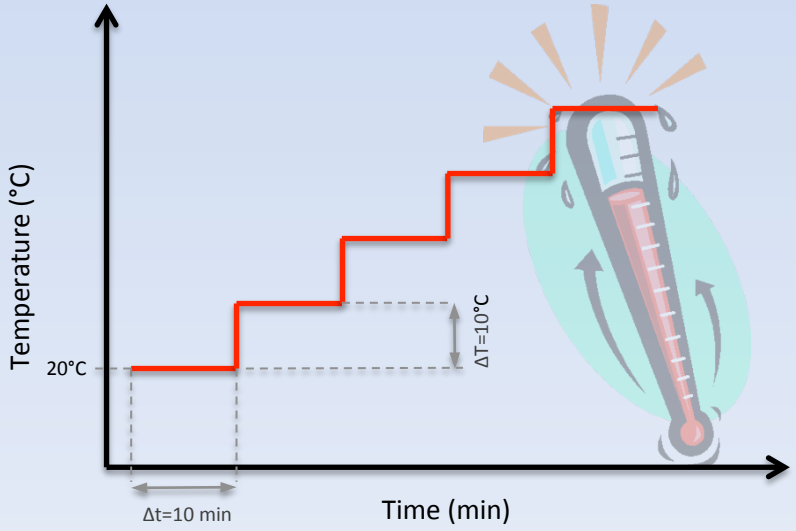
The HALT Process Description

Cold and Hot Step Stress

- This part of the test uncovers flaws related to temperature dependency effects of the device and its components
- The test is meant to start at 20°C going down/up in steps of 10°C with a DWELL time of around 10 minutes.
- The test is stopped when:
  - **The device stops working**: In that case, the device should be restored to ambient temperature and corrective action taken. Once the problem is identified and solved, the test should continue where it was stopped.
  - The chamber limits are reached

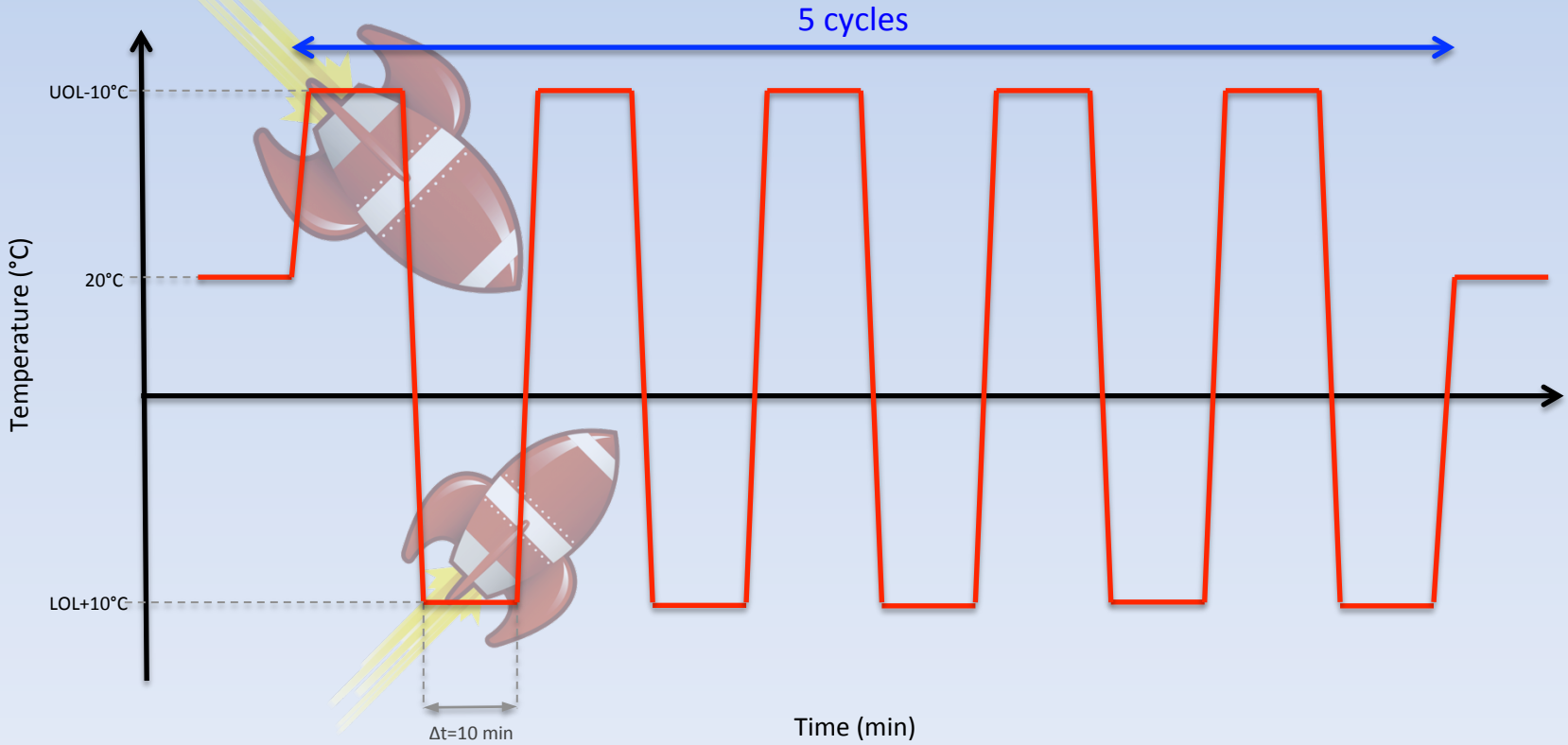




The HALT Process Description

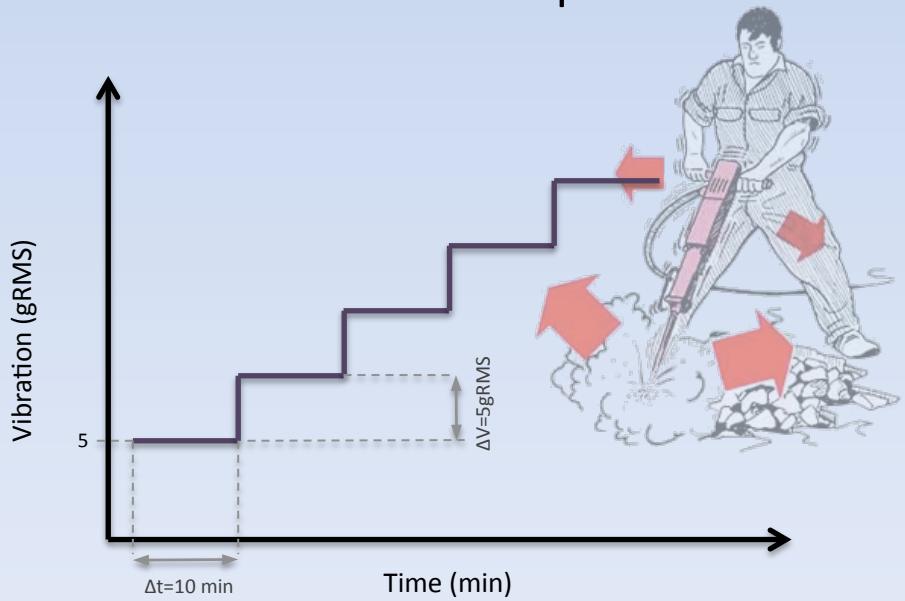
Rapid Thermal Transitions

- The fast change in temperature will rise up mechanical problems due to the sudden expansion and contraction of the device
- At least five thermal cycles are performed unless a destructive failure is encountered prior to completion. The **thermal transitions** are performed at the **maximum attainable rate of change**.



Vibration Step Stress

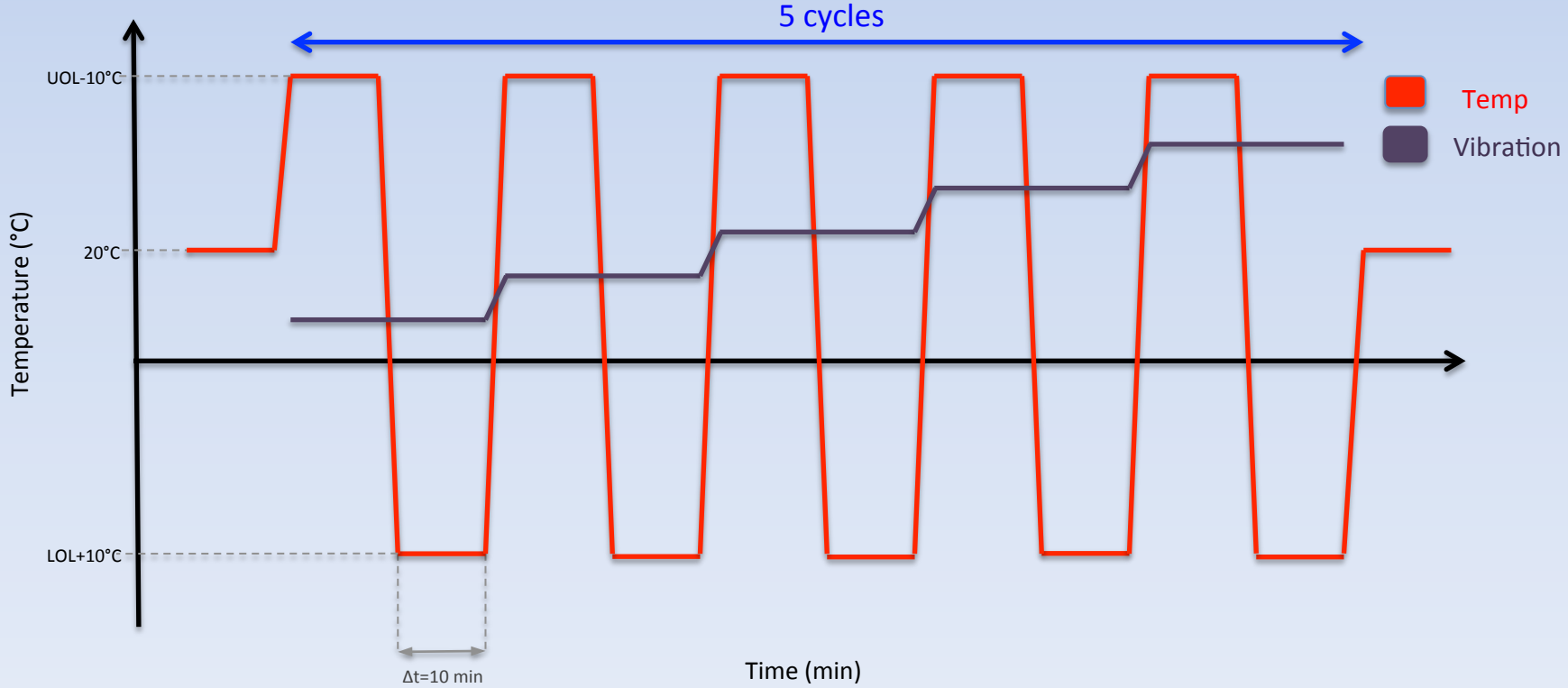
- The main goal of this part of the test is to find vibration related failures due to a mechanical fatigue of the device
  - The vibration levels on the device are monitored through accelerometers placed on major assemblies and subassemblies. This helps to evaluate the overall transmission of vibration into this areas.
  - Ideally, a six-degree-of-freedom vibration should be applied to uncover as much failures modes as possible



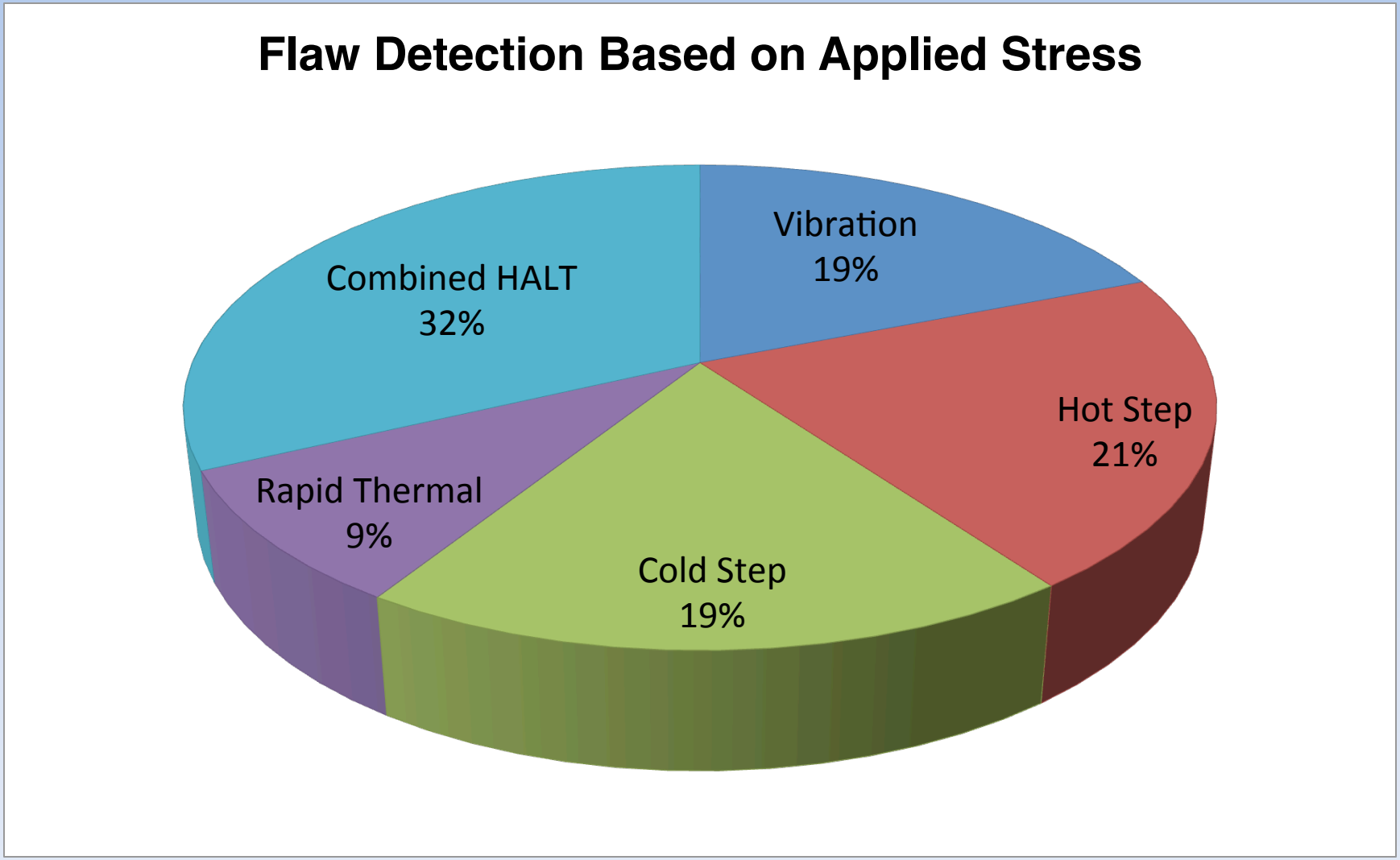
The HALT Process Description

Combined Stresses

- A combined stress of temperature plus vibration is applied with the aim of drive out any failure modes that require the combination of both
- Basically is a composition of the Rapid Thermal Transitions and the Vibration Step Stress



Combined Stresses



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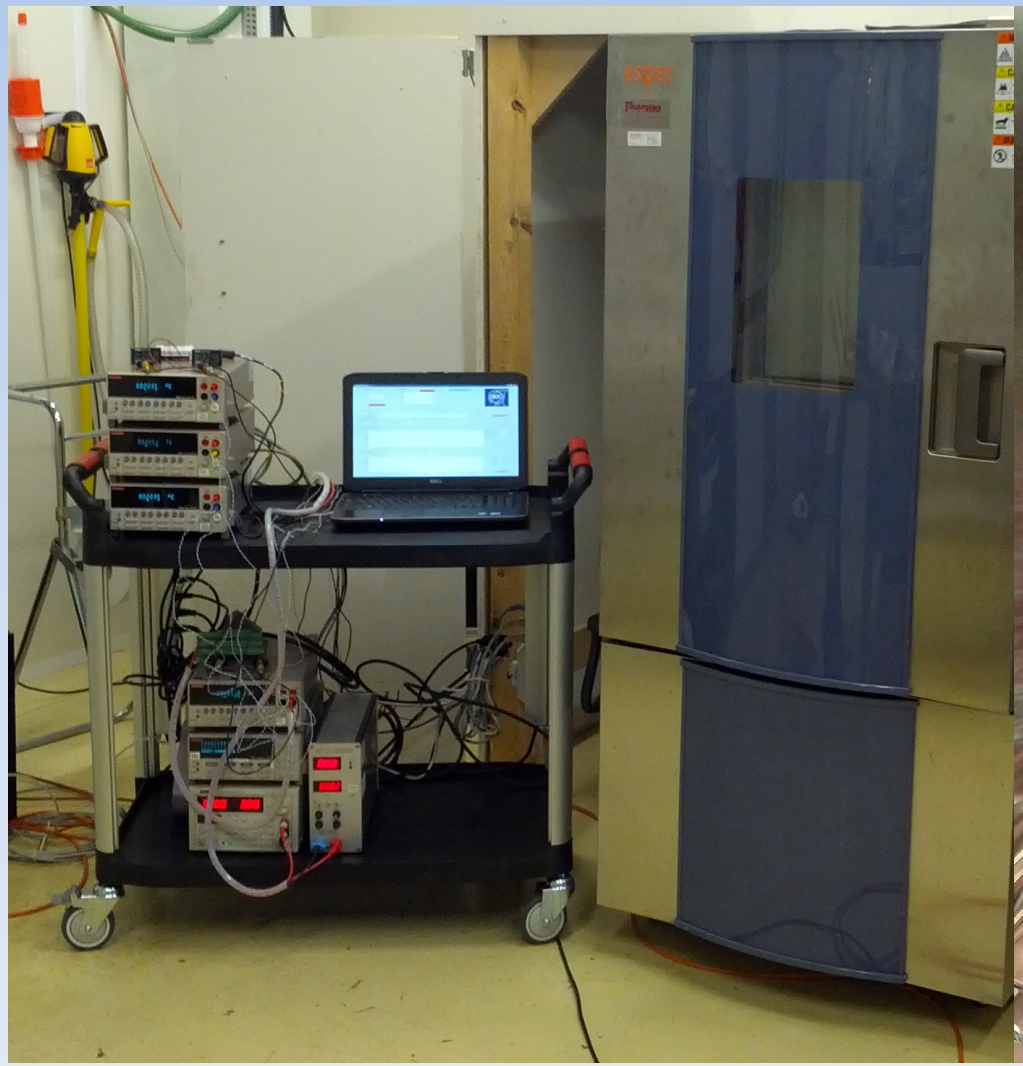
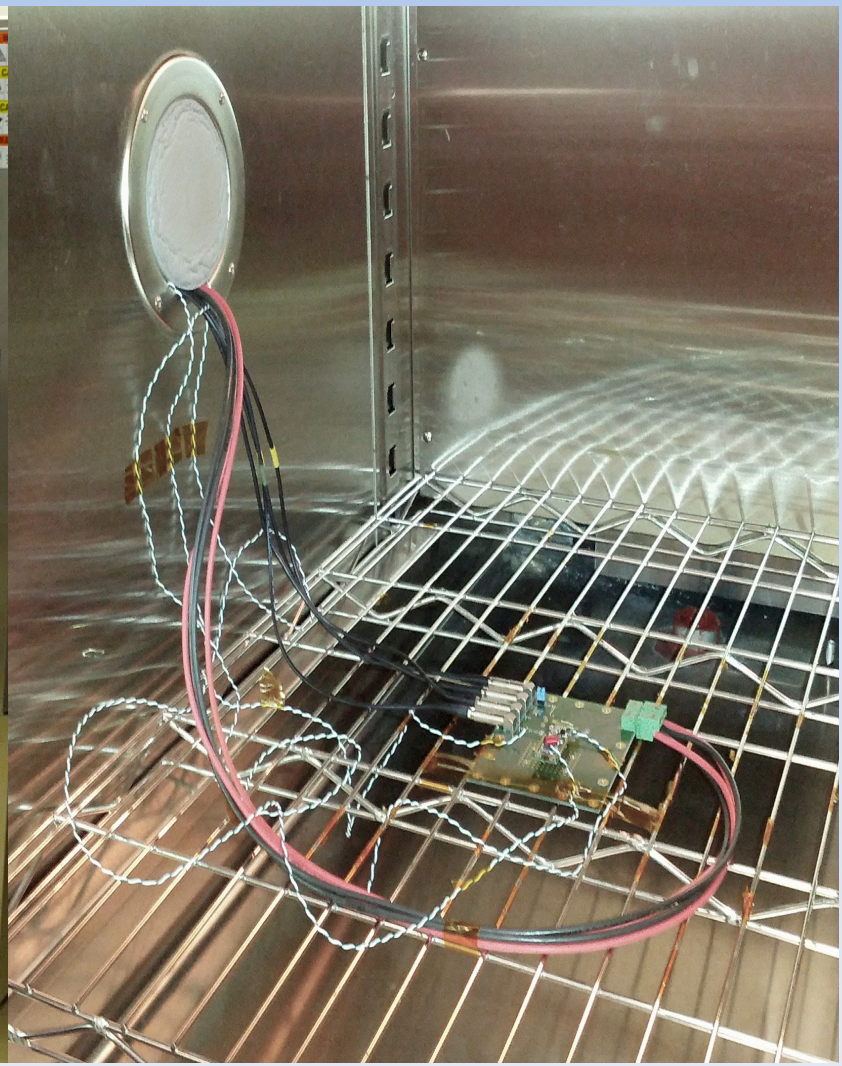
Test Setup Description

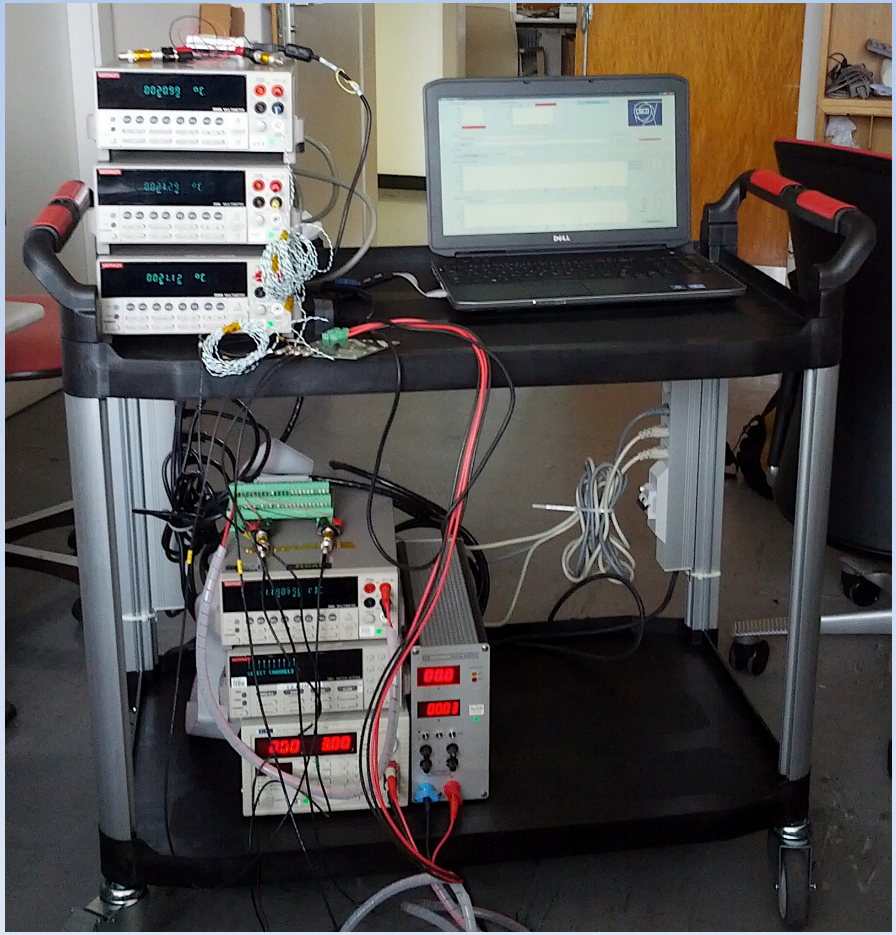
Hardware involved

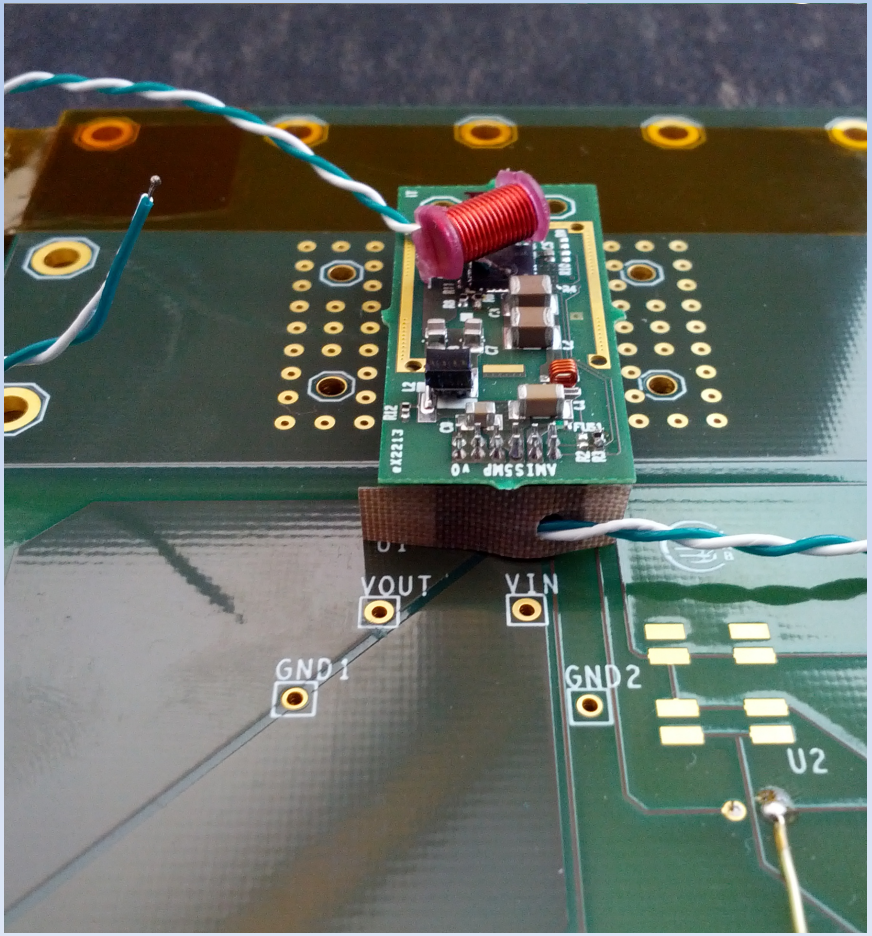




Test Setup Description

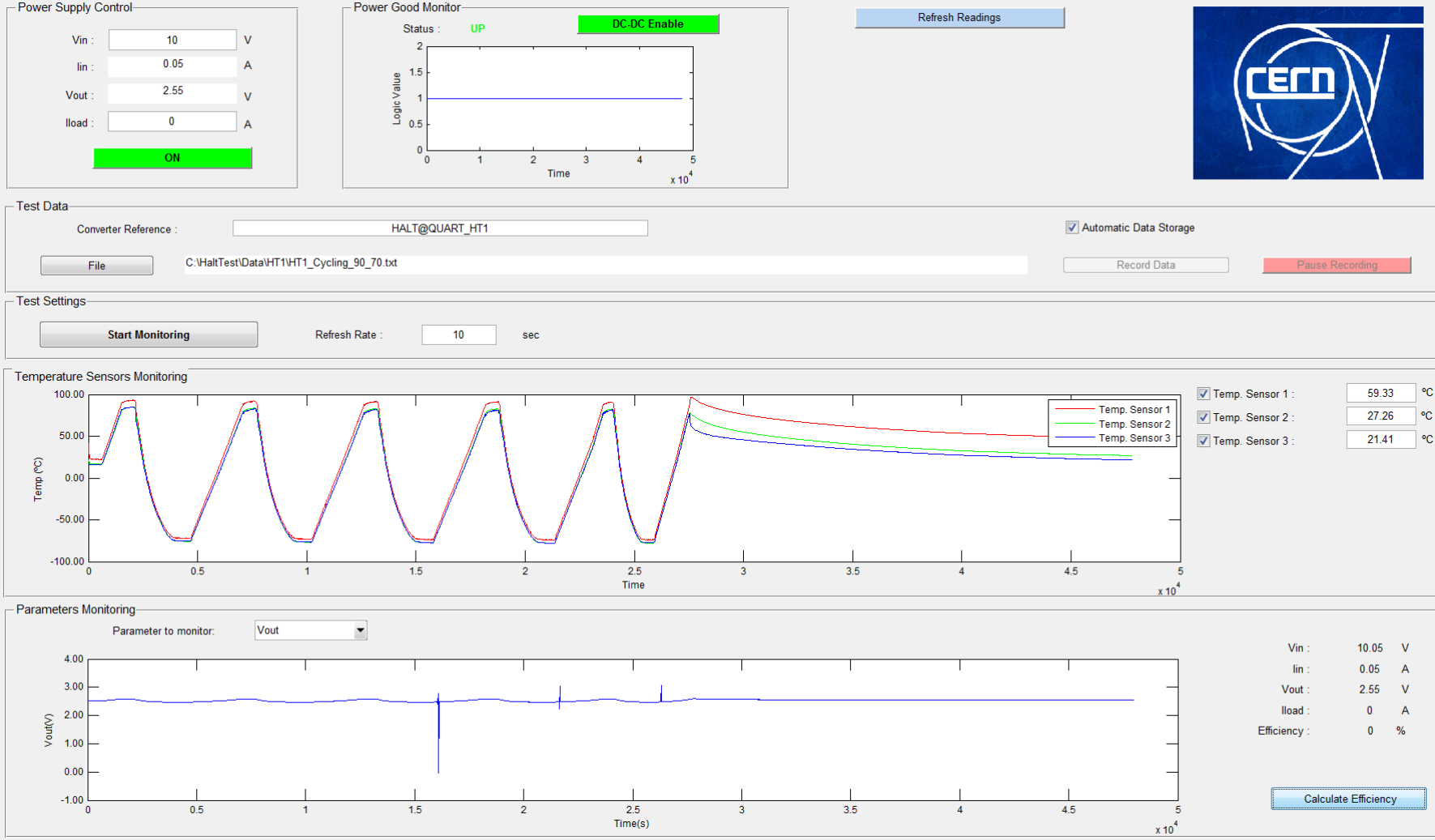
Hardware involved





Test Setup Description

Monitoring software



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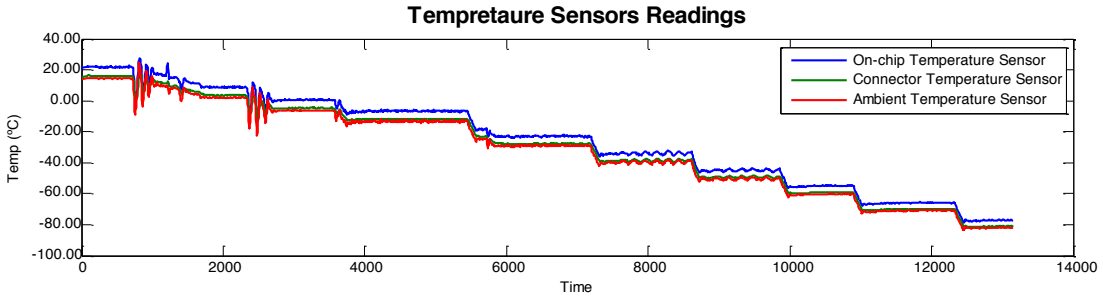
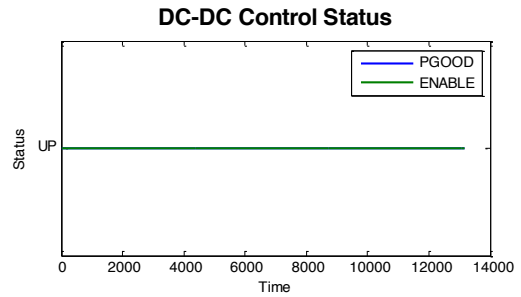
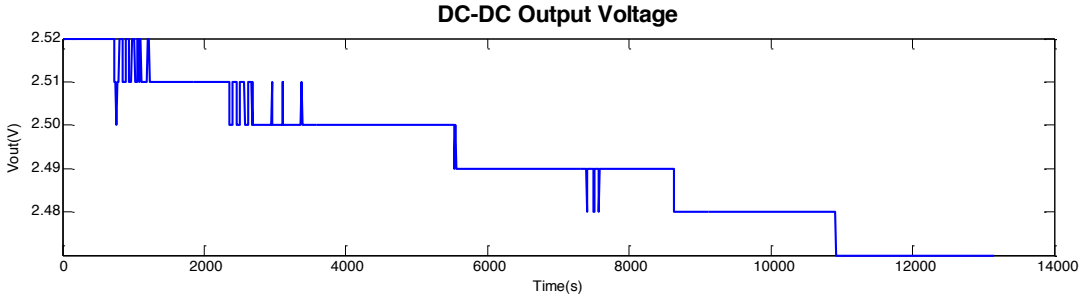
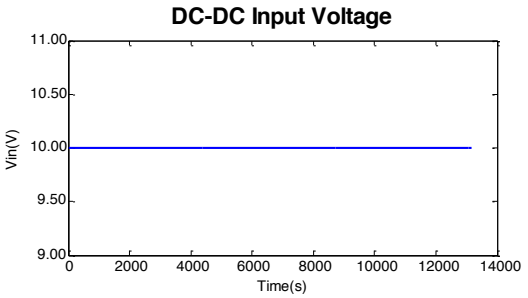
Test Results @ CERN

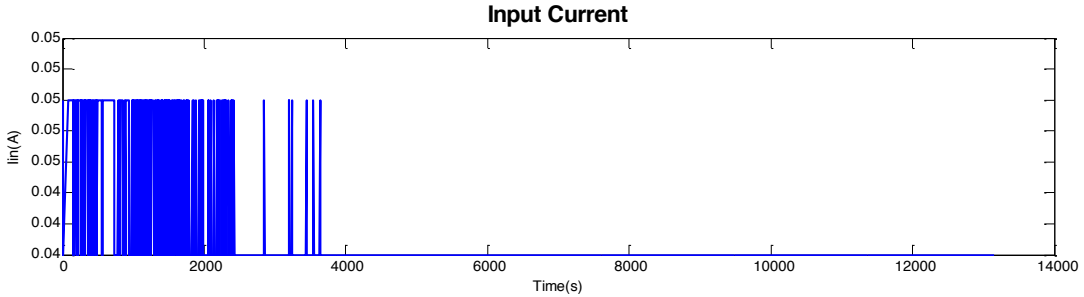
Cold Step Stress

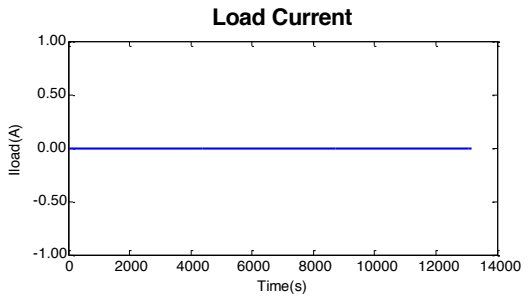








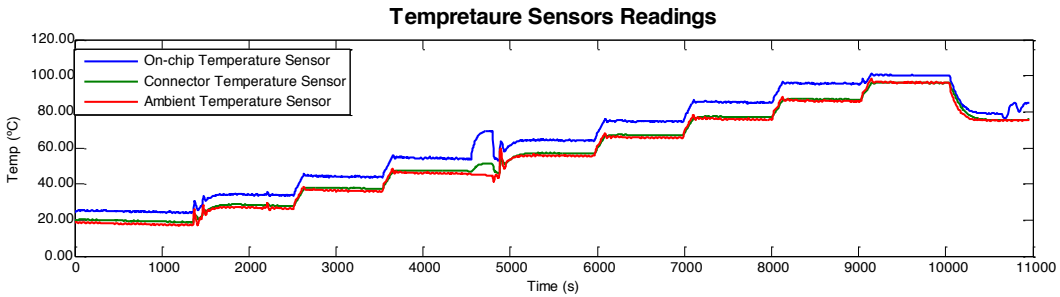


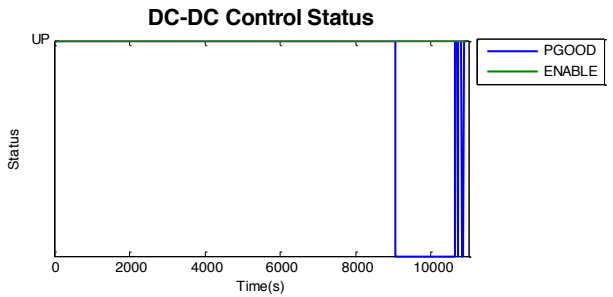


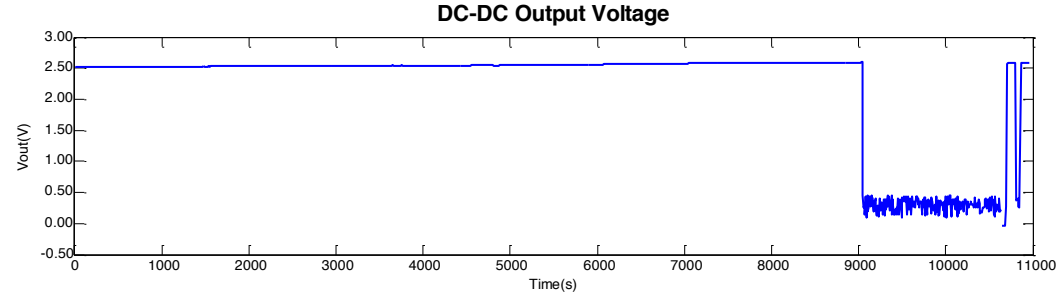
- Negative Step Stress test conclusions
  - The test was done between +20°C and -70°C and any flaw was uncovered within this range
  - Going lower than -70°C not possible due to climatic chamber limitations
  - By definition, the temperature step stress procedure should continue until the device is destroyed and the cause known

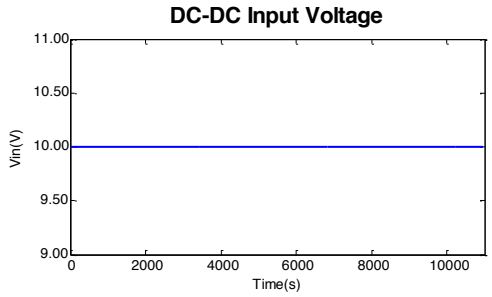
Test Results @ CERN

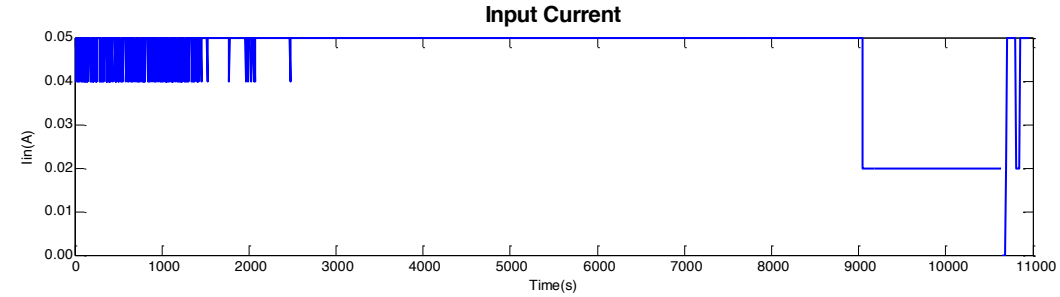
Hot Step Stress

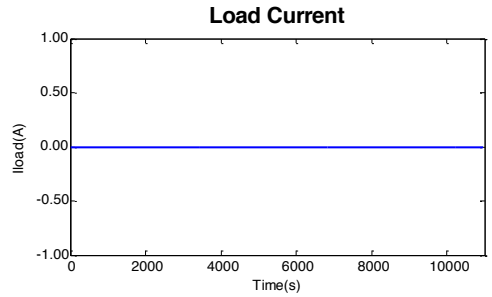






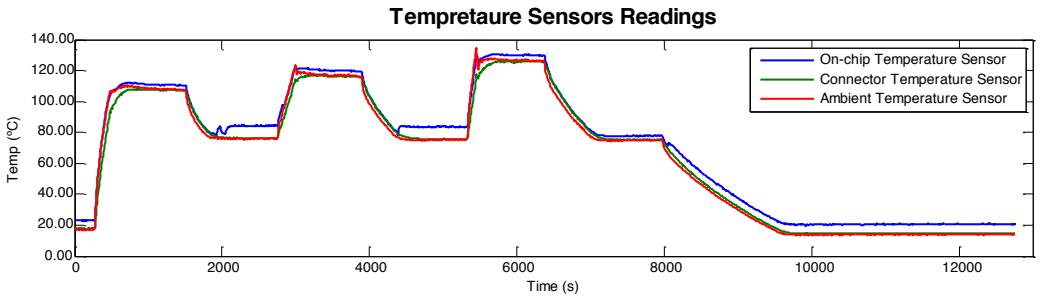


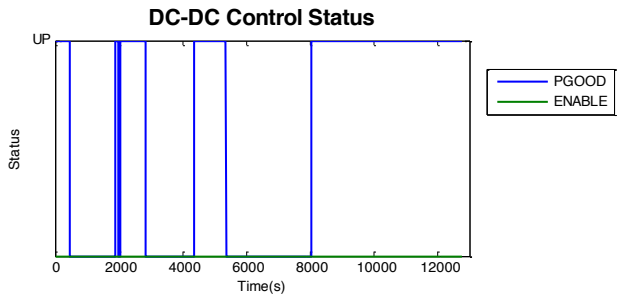


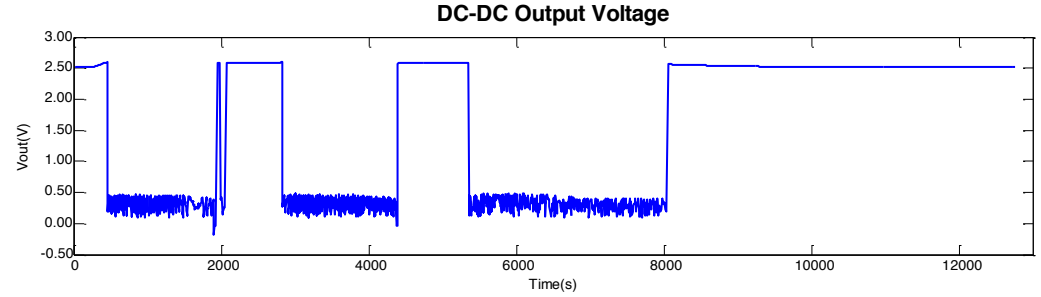


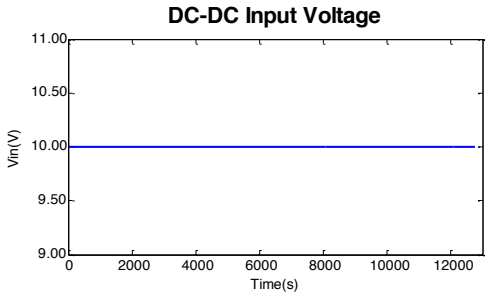
Test Results @ CERN

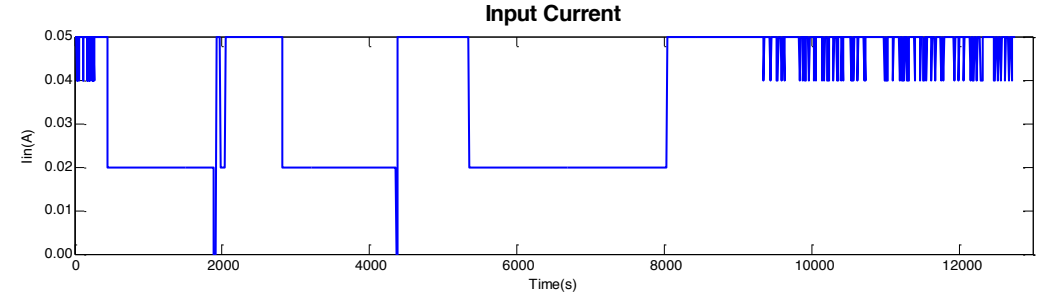
Hot Step Stress

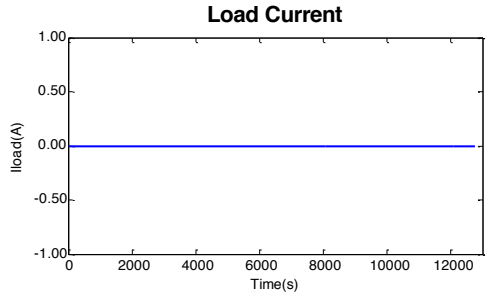






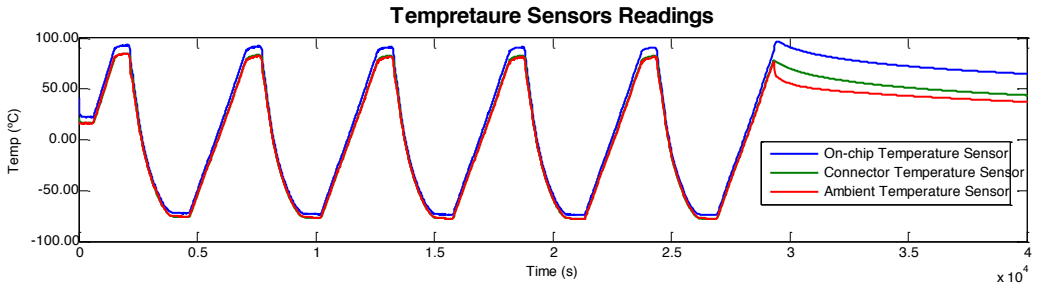


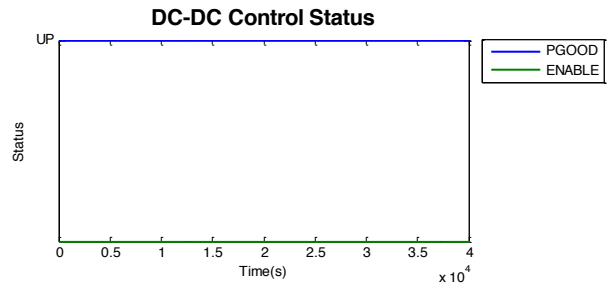


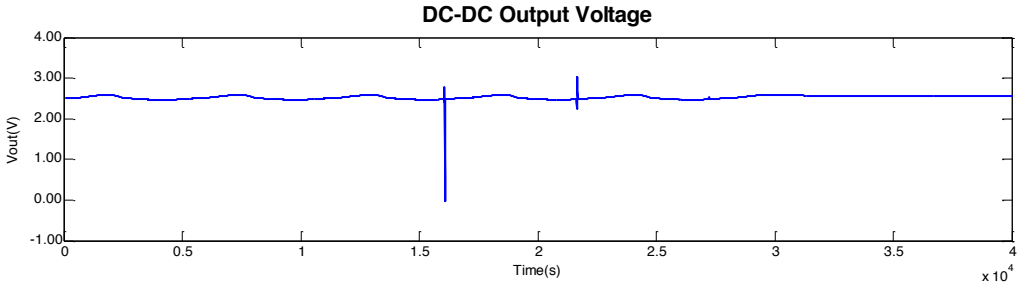


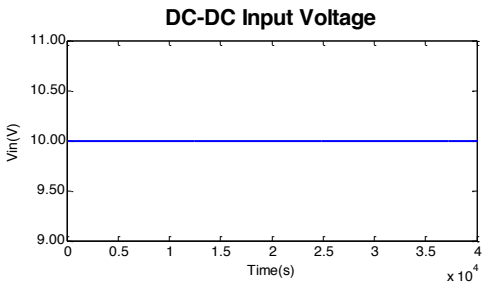
- Hot Step Stress test conclusions
  - The test was done between +20°C and +150°C and any flaw was uncovered within this range
  - It would be interesting to push the temperature up until finding the flaws and study them
  - It exists a known temperature limitation above +150°C in the cabling and connectors. Further actions will be taken to be able to arrive at even higher temperatures

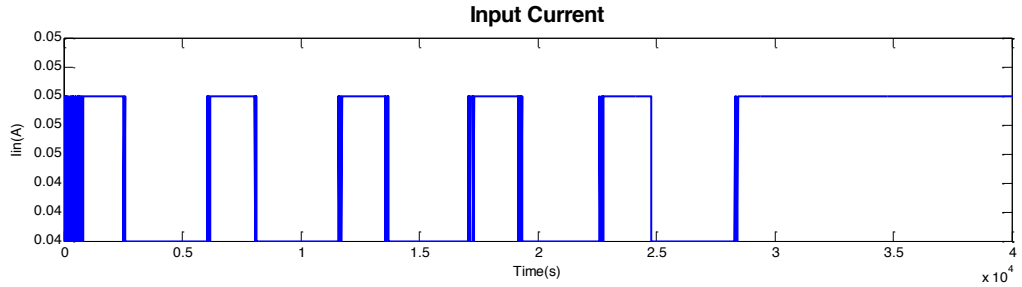
Rapid Thermal Transitions (-70°C to 90°C)

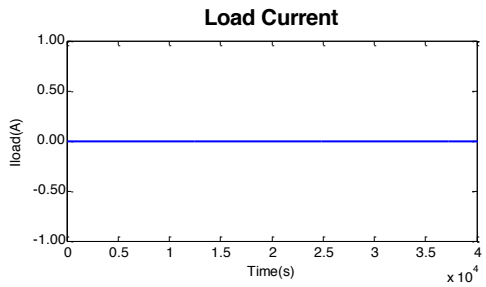




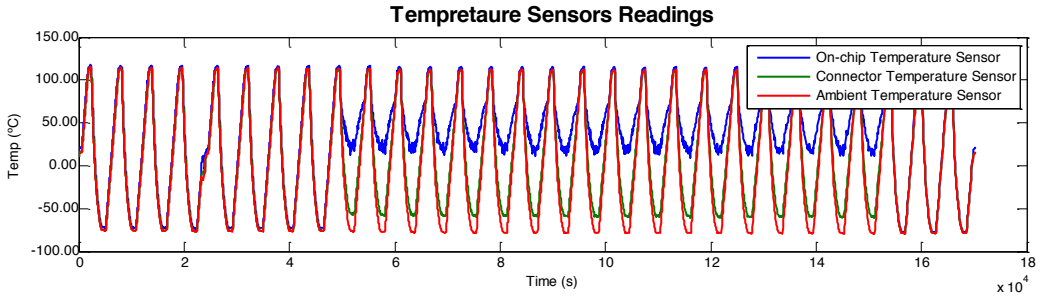


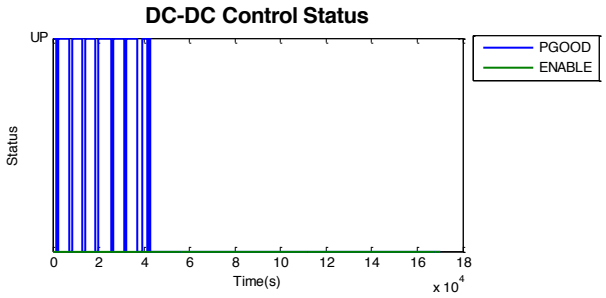


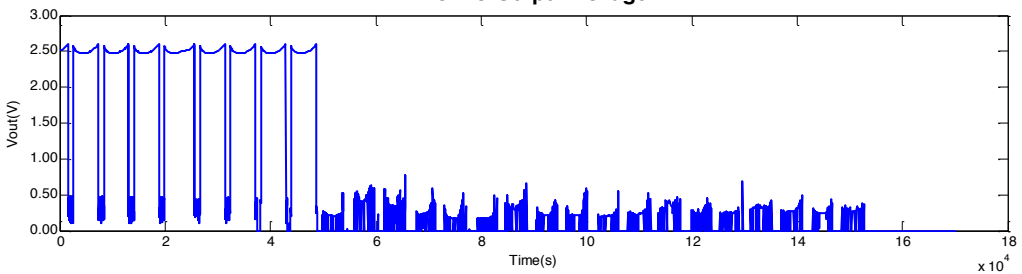


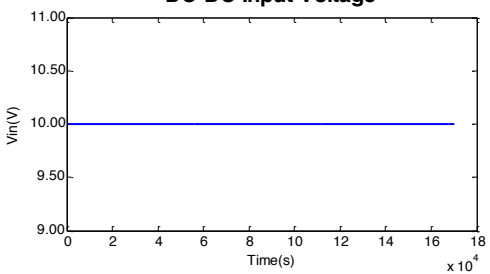


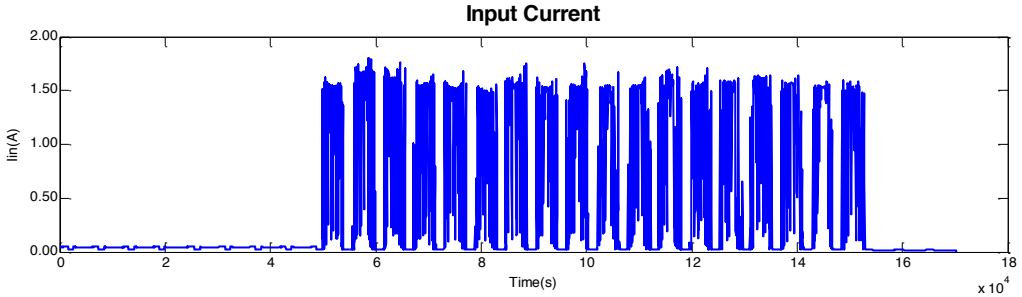
Rapid Thermal Transitions (-70°C to 120°C)

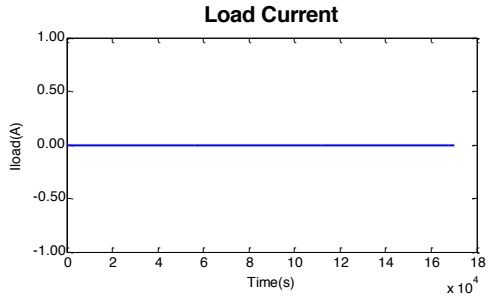












- Rapid Thermal Transitions test conclusions
  - Thermal transitions between -70°C to 90°C did not uncover any failure mode
  - However, the module stop working while applying a wider temperature sweep (-70°C to 120°C) after 10 thermal cycles
  - The device under test will be studied and the root cause found soon. In the meantime

Conclusions

- The HALT test procedure is understood and we are now ready to go more into detail
- A HALT test setup was developed and a partial test carried on at CERN with relative good results
- We have found some limitations during the test linked to the climatic chamber and the test setup itself
- After analyzing the results obtained, further tests could be done externally using a specific HALT test chamber and the specialists support

Thanks for your time and attention!!

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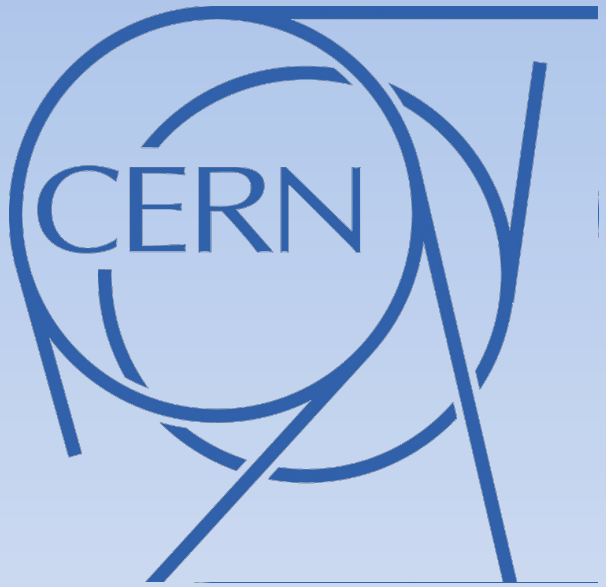

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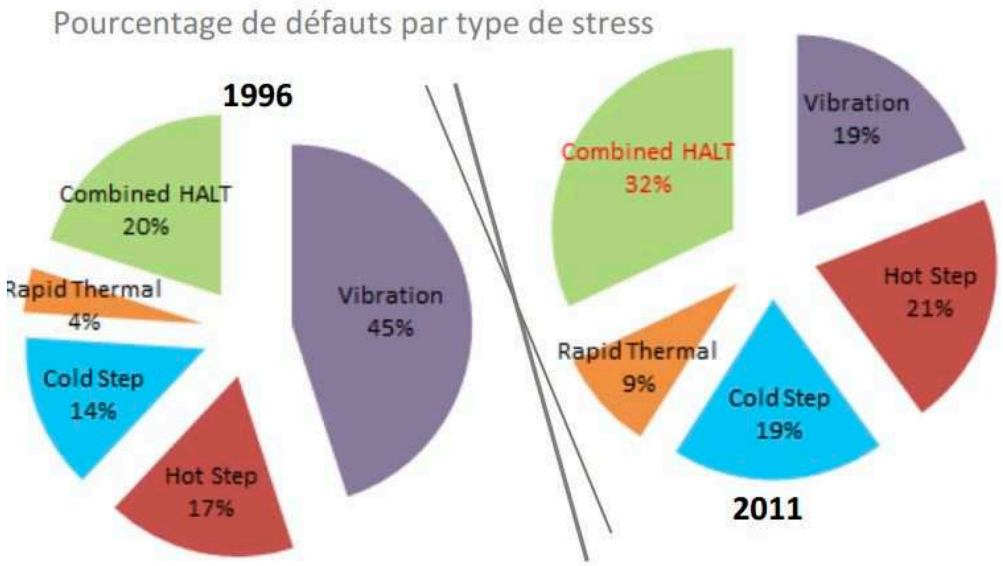
Datas de 5000 campagnes de test



32% de défauts non détectés *sans l'utilisation de la méthodologie HALT par rapport aux moyens de test conventionnels.*