Guidebook for

New Accelerated Reliability Improvement Methodology with Case Studies

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香港生產力促進局

1.Acknowledgements

This SME Development Fund project "To Enhance the Competitiveness of Hong Kong's Electronics Industry by Improving Product Reliability in a Short Product Development Cycle" was organized by Hong Kong Electronics & Technologies Association Limited (HKETA) with collaboration of the Hong Kong Critical Components Manufacturers Association (HKCCMA) and implemented by the Hong Kong Productivity Council (HKPC).

Among the latest accelerated reliability improvement methodologies, Highly Accelerated Life Test (HALT) method was selected in this project, thanks to its technological readiness and short result turnaround time. The introduction of HALT method had enabled HKPC to support local industries to enhance their products' reliability during the product research and development phases.

The project team would like to express their appreciation to all the supports and help provided by concerned individuals and organizations, especially the in-kind sponsorship and technical support from the Qualmark Corporation which have contributed to the successful completion of this Project.

Acknowledgements (Cont'd)

In terms of administration of the Project, especially on the selection of companies for case study, the Project Steering Committee is of great merits and the following members' selfless contributions are greatly appreciated.

- Mr Victor NG, Chairman of HKETA
- Ir Dr Aaron TONG, Deputy Chairman of HKETA & Managing Director of TQM Consultants Co. Ltd.
- Mr Lawrence LI, Chairman of the HKETA Technology Sub-committee & Managing Director of Concord Technology Ltd.
- Dr Lawrence CHEUNG, General Manager of the Automotive & Electronics Division of HKPC
- Professor H.C. MAN, Dean of Engineering and Chair Professor of Department of Industrial and System Engineering of The Hong Kong Polytechnic University
- Professor Michael TSE, Chair Professor of Department of Electronic and Information Engineering of The Hong Kong Polytechnic University
- Ir Dr C.K. LI, Former Associate Professor of The Hong Kong Polytechnic University
- Dr Henry LAU, Former Head of Department of Industrial and Manufacturing System Engineering of The University of Hong Kong

Acknowledgements (Cont'd)

Lastly, the following case study participants who have actively involved in this Project, provided engineering support and test samples in the initial and improvement HALT test were highly appreciated.

First Round Application	*Second Round Application*
• Actfair Limited	• GP Batteries International Limited
• Joilmark Holdings Limited	• Creaxon Limited
• Altai Technologies Limited	• AdvanPro Limited
• Vantage Engineering Limited	• Concord Technology Limited
• Qualiman Industrial Company Limited	• Sierra Wireless Hong Kong Limited
• Edwin McAuley Electronics Limited	• Opulent Electronics Company Limited

Table 1 - Participation Companies

Without the support, valuable guidance and timely advice, the team of consultants working on this project may not be able to achieve the targets.

Program Implementation Team

Automotive & Electronics Division

Hong Kong Productivity Council

2. Contents

3. Executive Summary

The implementation of the Project is a great opportunity to promote the High Accelerated Life Test (HALT) technology to the local electronics industries. This Project helps the local industries to adopt new accelerated reliability technology through training, dissemination seminars and case studies.

Two free training sessions (one in Dongguan) and three free dissemination seminars (one in Dongguan) were held in the following dates:

First Seminar:	16 August 2013
First Training (Dongguan):	4 March 2014
Second Seminar (Dongguan):	7 August 2014
Second Training:	3 December 2014
Third Seminar:	25 September 2015

The training sessions involved more in-depth theory on High Accelerated Life Test and aimed to guide the participants the method of using the HALT test to improve their products' reliability.

The dissemination sessions, however focused more on the sharing of the project deliverables and introducing HALT technology.

Executive Summary (Cont'd)

A total of twelve case studies were completed in this program. Each case study was divided into two phases, the first round and the second round.

The product of the case studies from different electronic categories namely, portable electronics, home appliances, automotive electronics and healthcare electronics were selected by the Steering Committee.

Each case study consisted of an initial test and a post improvement test. The initial test was a preliminary process to preview the capability of the product and find its failure mode. Then the participant manufacturer will get back their product and conduct an engineering improvement to see whether the reliability of the product has been improved in the post improvement HALT test.

The obligation of the case companies is to provide engineering support on the testing, improvement of the test and to provide sufficient samples for testing.

More on the test result details are illustrated in Chapter 3 - "Project Case Studies" of this guidebook.

Summary of Project Deliverables
• Two free training sessions • Three free dissemination Seminars • Twelve case studies • A web-based guidebook

Table 2 - Summary of Project Deliverables

4. Introduction of New Accelerated Reliability Improvement Methodology

4.1. Overview

An accelerated life test speeds up the failure process to obtain information about the product and thus could be used to improve product's reliability.

There are two major categories of reliability improvement methodology in the industry. Namely, Qualitative Accelerated Life Testing and Quantitative Accelerated Life Testing. While quantitative testing concerns mostly about the product's life time in a numerical sense, such as B10 life, qualitative testing is used to identify failures and failure modes without making any predictions as to the product's life under normal conditions.

Quantitative accelerated testing has been widely adopted by the industry thanks to the wide availability of equipment and modeling software. On the other hand, qualitative accelerated life testing is less known to the general public, disregarding the fact that qualitative testing has its own benefits:

- Short turnaround time
- Precise identification of failure modes
- Provide valuable feedback in designing quantitative tests. It could be served as a pilot run for a quantitative test

Overview (Cont'd)

To promote the awareness of Qualitative Accelerated Life Testing, HALT method, as one major stream of this was selected in this project because of its high acceleration factor.

In HALT analysis, a product is subjected to certain stimuli well beyond its expected operating conditions to determine its operating and destruction limits. The failure modes found from these exaggerated conditions could often reflect precisely the actual failure when it is subjected to normal operating environment.

With the failure modes found, product development engineers could review the selection of components, design of circuit and mechanical structures and make improvements. After a reconfirmation testing process, the engineers could then found solid proof that the product is of reliability performance soundly improved. This results in a reduced number of field returns and realizing long-term savings.

4.2. The Purpose of HALT

As discussed in section 4.1, the purpose of performing HALT is to find out the failure mode of a product so as to improve the overall product reliability.

When comparing HALT method with other existing reliability testing or environment testing methods, HALT provides stress level high enough for product to be “destructed” in a minimum requirement of time (usually the whole process is within several days, when comparing to months in traditional ALT simulations). HALT could address a “FAIL” of the product quickly, while other methods are still waiting for the product’s first failure after weeks of testing. With this “FAIL” indicator found, engineering team could start rolling up their sleeves.

Product engineering team investigates the failure symptoms found from HALT process. They could decide whether a component should be added, replaced, the PCB board should be rerouted, or additional protective parts should be introduced. The HALT process could then be repeated again until desired product reliability is achieved.

Meanwhile, found failure mode does not necessary mean that such symptom must be removed. It is the engineering team choice whether the failure mode found is the best the product could perform in nature. More often, it is an optimization between cost and reliability in consumer electronic products. What HALT method could tell for these cases is, whether these found failure modes are expected. If there is any failure mode that is not previously predicted by the engineering team, it is the time which this HALT method values.

On the other hand, HALT could be used as a quick benchmarking with similar products in the market to serve as a quick proof of product reliability with a product which has its expected life time known. This could provide a quick reference for the lengthy Accelerated Life Test (ALT) investigations.

Last but not least, HALT could be helpful in providing a stress level reference for ALT investigation, if life time investigation is necessary. With suitable stress levels selected ALT investigation could be performed in a more efficient way.

4.3. Three Phases of HALT

4.3.1. Pre-HALT

During this phase, test engineers and designers will prepare to execute the HALT. Test suites (software), fixtures, cables, data collection, as well as resource allocations are items that should be considered. Typically, one or more meetings are scheduled to discuss the progress and to set a start date for HALT. Normally four samples are required.

4.3.2. HALT

During this phase, the HALT is executed per the test plan formulated during the pre-HALT meetings.

4.3.3. Post- HALT

A few days after the distribution of the HALT report, the same group of test engineers and designers should discuss the issues uncovered during the HALT. The group should report the root causes of the failure and corrective actions should be initiated to fix the failure.

4.4. Advantages of HALT

Mature and robust product can be achieved during manufacturing release stage. A mature product can lead to greater customer satisfaction, higher brand reputation and reduce warranty and service costs.

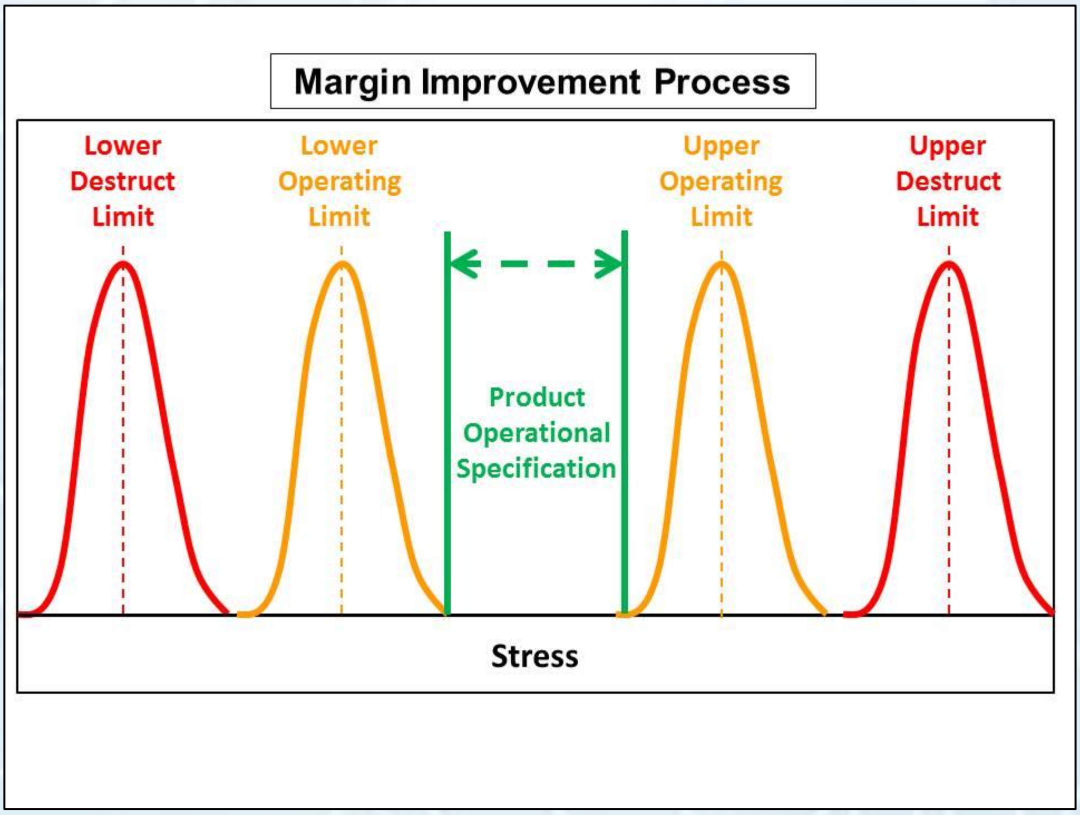


Figure 1 - Margin Improvement Process

HALT aims to expand the product’s operating and destruction limit which leads to wider product operational specification. Widening the product specification can lower the warranty and maintenance costs.

Advantages of HALT (Cont'd)

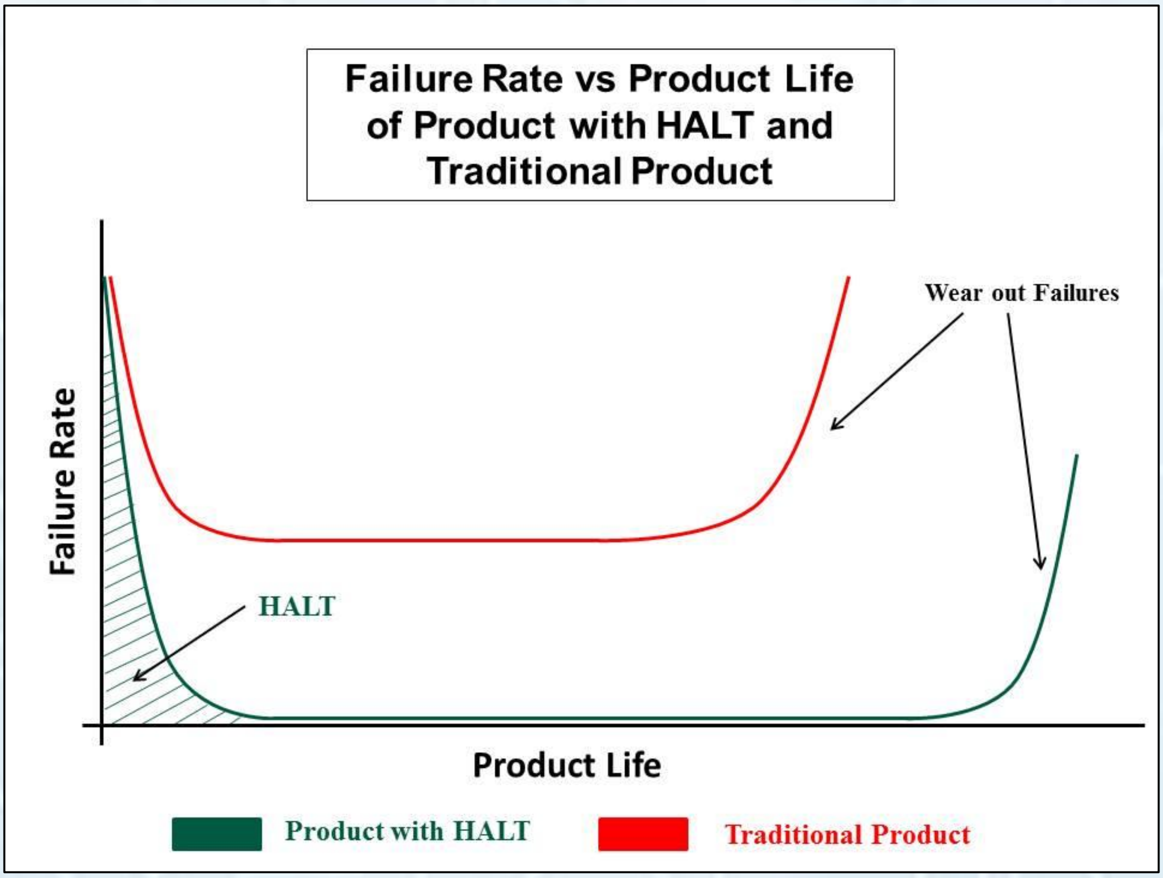


Figure 2 – Failure Rate vs Product Life of Product with HALT and Traditional Product

HALT is able to lower the failure rate during the earliest development stages, for example, design deficiencies, out of control production process, raw material defects and etc.

Higher reliability enables a longer product life compared to traditional product without conducting HALT.

Advantages of HALT (Cont'd)

Another potential benefit is earlier release of the product. Shortened time of uncovering the latent defects enables early introduction of the product to the market and therefore capture early market share.

Shortening of the research and development (R&D) stage can also allow the R&D and process engineer to develop another design of product.

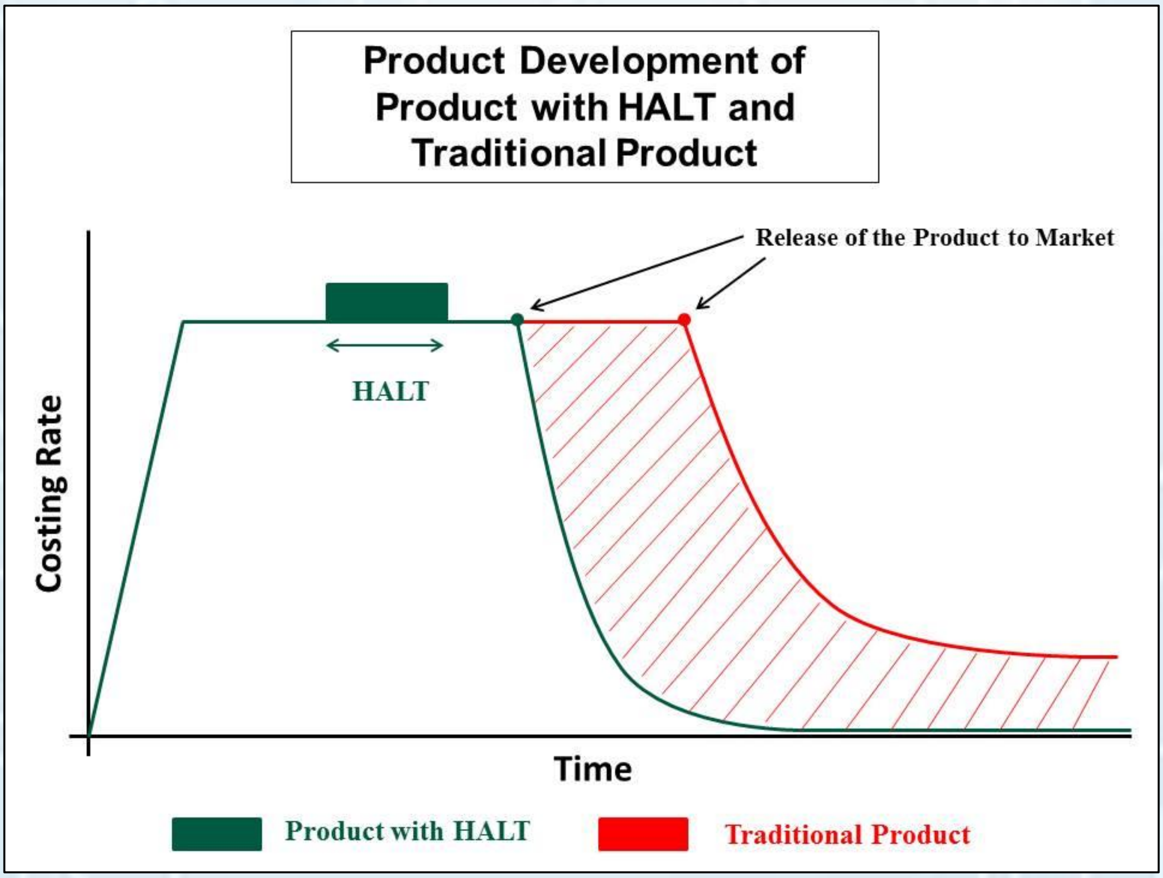


Figure 3 – Product Development of Product with HALT and Traditional Product

5. The HALT Process

5.1. HALT Terminology

5.1.1. Destruct Limit

Defined as the stress level that causes an unrecoverable failure to occur (i.e. when all applied stresses are removed the product no longer functions).

5.1.2. Functional Test

A test to measures the functionality, operation and critical parameters of the unit under test in order to indicate if the product is fails to perform normally or any degradation.

5.1.3. G-rms

The root mean square level of an acceleration signal, normalized to the value of acceleration due to gravity. G-rms is typically used as a measurement of the vibration energy present in a random vibration signal.

5.1.4. Hard Failure

It is a non-recoverable failure mode. A hard failure will not resume to normal when the applied stress is reduced or removed.

HALT Terminology (Cont'd)

5.1.5. Operating Limit

Defined as the last chamber set-point at which the product still fully function.

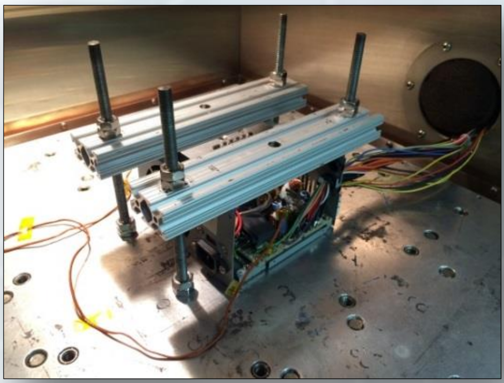
5.1.6. Six Degree of Freedom Random Vibration

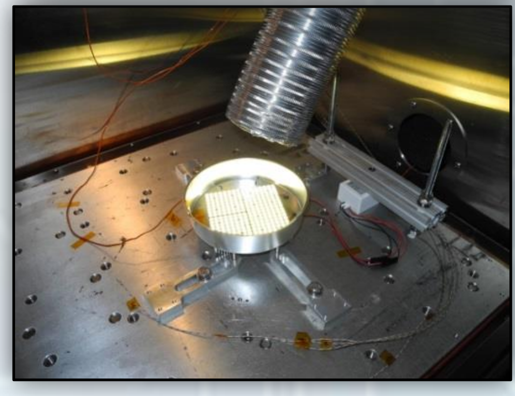
Vibration that has simultaneous acceleration energies in three axes (X,Y and Z) and the three rotations (roll, pitch and yaw) around axes.

5.1.7. Soft Failure

IT is a recoverable failure mode. A soft failure will resume to normal when the applied stress is reduced or removed.

5.2. HALT Test Procedures





The HALT test procedure adopted in the project was referenced to Qualmark HALT Testing Guidelines Document 933-0336 Rev. 04. The product under test was subjected to the HALT (Highly Accelerated Life Test) process to uncover its design, component selection and/or process weaknesses. During the HALT test process, the product under test was subjected to progressively higher stress levels of thermal dwells, rapid thermal transitions, vibration and combined environments stress tests in order to precipitate inherent defects.

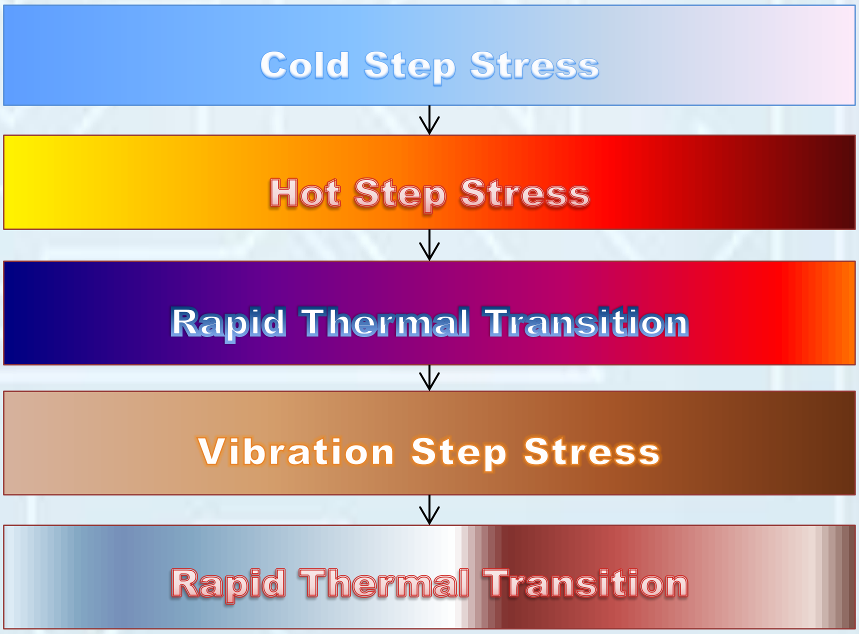


Figure 4 – Key Steps of HALT Methodology

5.2.1. Step 1 and 2 – Cold and Hot Step Stress

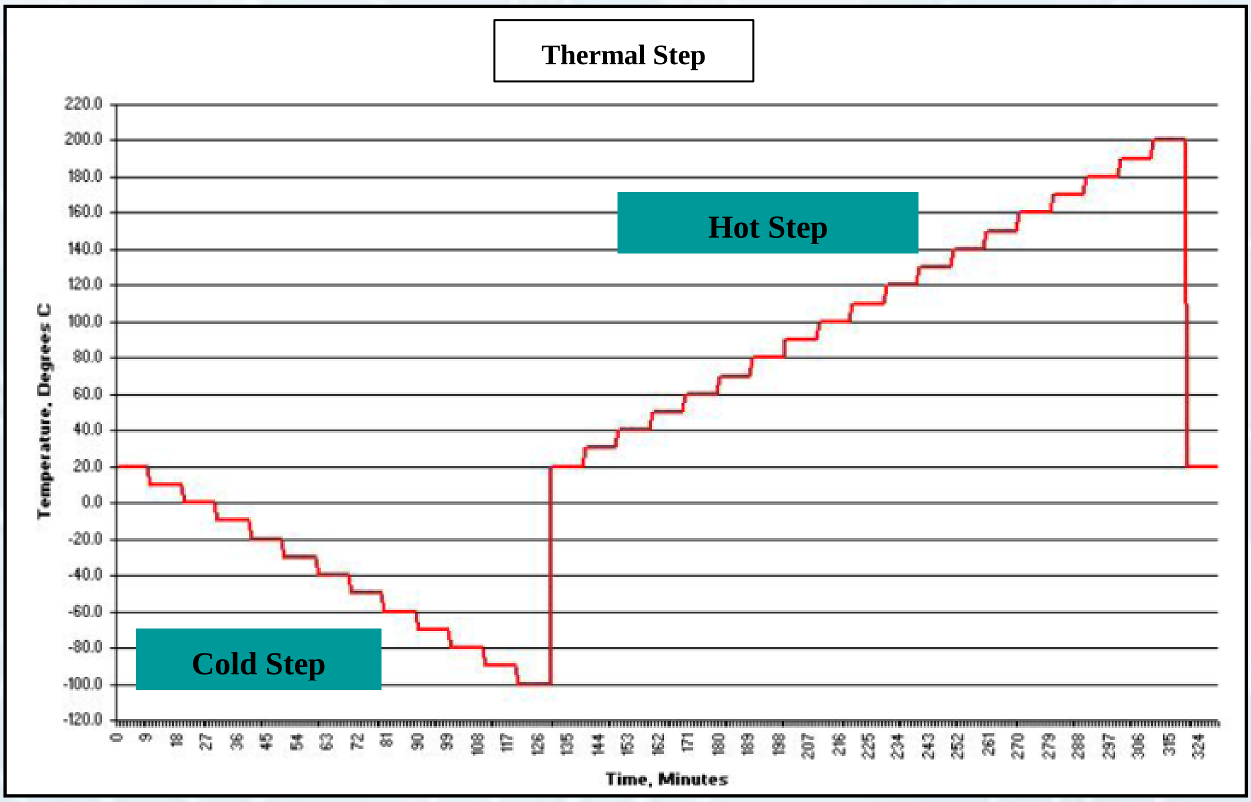


Figure 5 – Temperature Plot for Cold and Hot Step Stress

Main Features

- At least 10 minutes dwell time, 10℃ increment per step
- Full functional test performed at the end of the each dwell
- Target to find out the Operating Limit and Destruct Limit of the product under test.

Cold and Hot Step Stress (Cont'd)

5.2.1.1. Test Procedure

1. The thermal step stress is beginning at ambient around 20℃.
2. The typical thermal step increments are 10℃.
3. During thermal stress testing, thermocouples are attached to the product to monitor the vibration response.
4. The dwell time is minimum of 10 minutes after the stabilization of the product at the set point.
5. A full functional test is performed at the end of the dwell time.
6. After the full functional test at the end of the dwell, the thermal stress is increment and the steps are repeated.
7. The steps are repeated and continued until a failure is reached, and then the stress will be reduced or removed to see whether the product is recovered.
8. If the product can be recovered, then the operating limit is the last stress level that the product still fully functions. If the product cannot recover, then the stress level which the failure occurred is the destruct limit.
9. The test is continued until the destruct limit or the chamber limit is reached.

5.2.2. Step 3–Rapid Thermal Transition

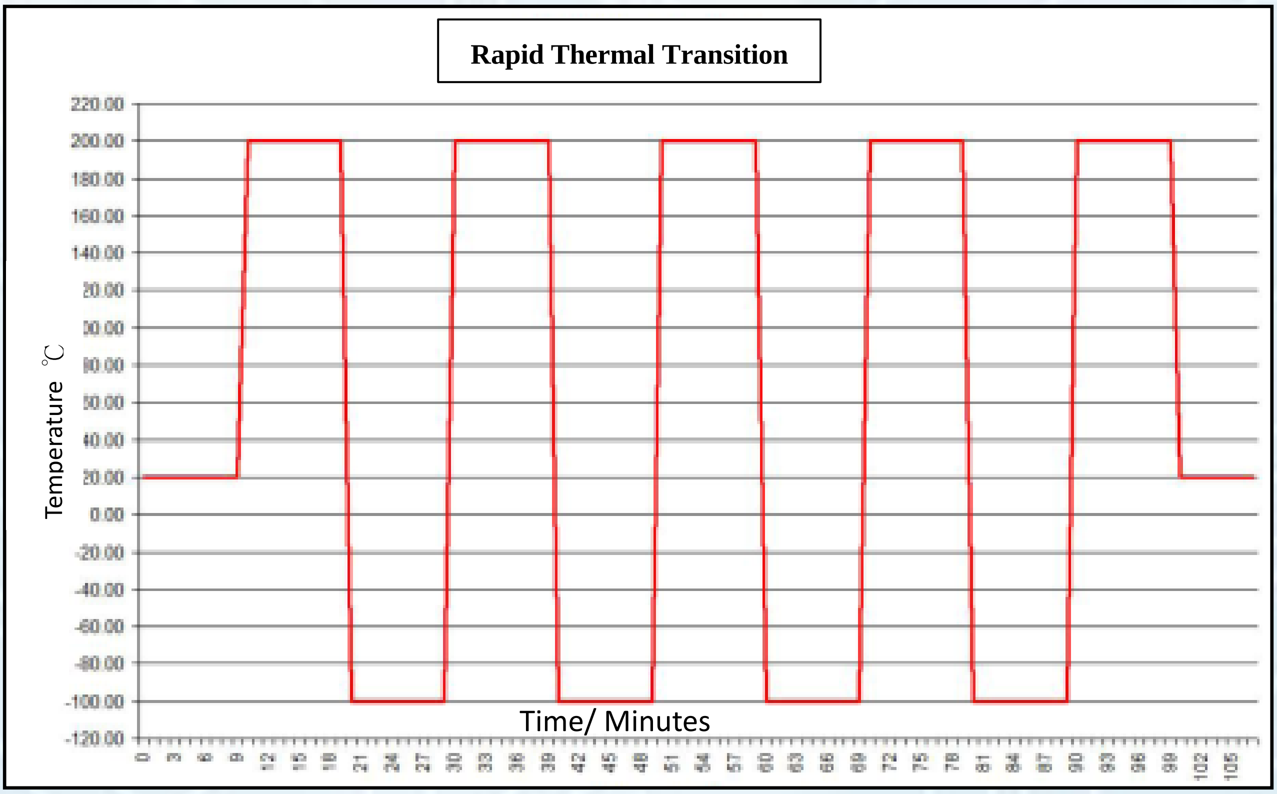


Figure 6 – Temperature Plot for Rapid Thermal Transition

Main Features

- Temperature extremes set at lower thermal operating limit plus 10℃ and upper thermal operating limit minus10℃
- At least 5 minutes dwell time at each temperature extreme
- 15℃ / min transition rate
- Five thermal cycles
- Full functional test performed at the end of the dwell

Rapid Thermal Transition (Cont'd)

5.2.2.1. Test Procedure

1. A minimum of five thermal cycles are performed unless a destructive failure is encounter prior to the cycles are completed.
2. During rapid thermal transition, thermocouples are attached to the product to monitor the vibration response.
3. The thermal transition extreme is within 10℃ of the operating limit obtained in the thermal step stress. For example, if the cold operating limit is -60℃, then the lower extreme of the cycle will be -50℃; if the hot operating limit is +120℃, then the upper extreme of the cycle will be +110℃. The thermal transition range will be -50℃ to +110℃.
4. The minimum dwell time of the extreme temperature is five minutes after the stabilization of the product at the temperature set point.
5. The thermal transition rate is around 70℃/min.
6. A full functional test is performed after the dwell time.

5.2.3. Step 4 –Vibration Step Stress

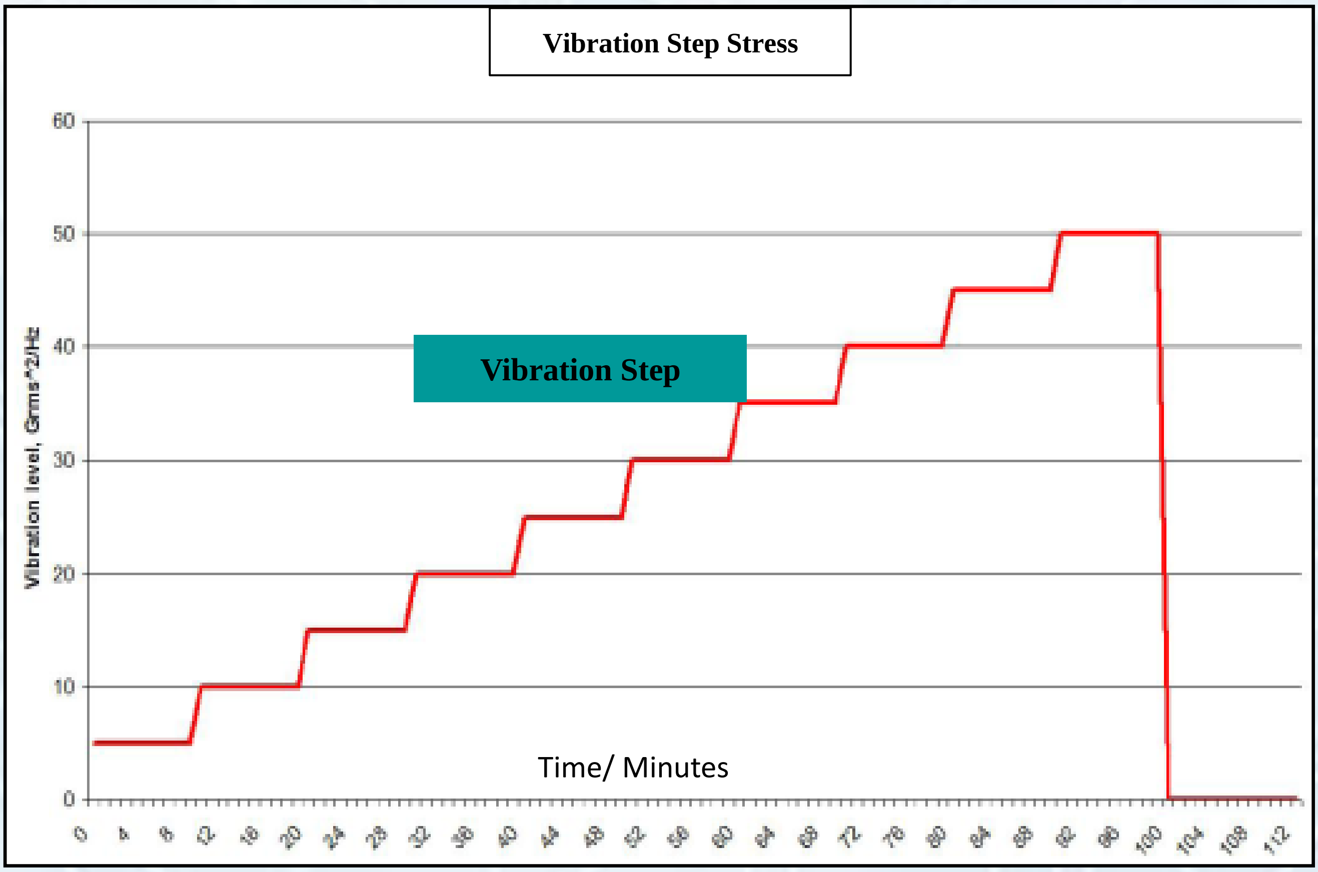


Figure 7 – Vibration Level Plot for Vibration Step Stress

Main Features

- At least 10 minutes dwell time, 5 G-rms step increment per step
- Full functional test perform at the end of the dwell
- Target to find out the Operating Limit and Destruct Limit

Vibration Step Stress (Cont'd)

5.2.3.1. Test Procedure

1. The typical thermal step increments are 5 G-rms, as measured over a 10Hz to 5 kHz bandwidth.
2. During vibration stress testing, accelerometers are attached to the product to monitor the vibration response.
3. The dwell time is at least 10 minutes at each vibration level.
4. A full functional test is performed at the end of the dwell time.
5. After the full functional test at the end of the dwell, the vibration stress is increment and the steps are repeated.
6. The steps are repeated and continued until a failure is reached, and then the stress will be reduced or removed to see whether the product is recovered.
7. If the product can be recovered, then the operating limit is the last stress level that the product still fully functions. If the product cannot recover, then the stress level which the failure occurred is the destruct limit.
8. The test is continued until the destruct limit or the chamber limit is reached.
9. At 30 G-rms and higher, alternating low level of vibration should be introduced. The vibration level is reduced to 5 G-rms and a full functional test is performed, no waiting of the dwell time is required in this level. This step helps to detect the failure that is precipitated at a high G-rms level, but is not detectable at that level.

5.2.4. Step 5 – Combined Environment

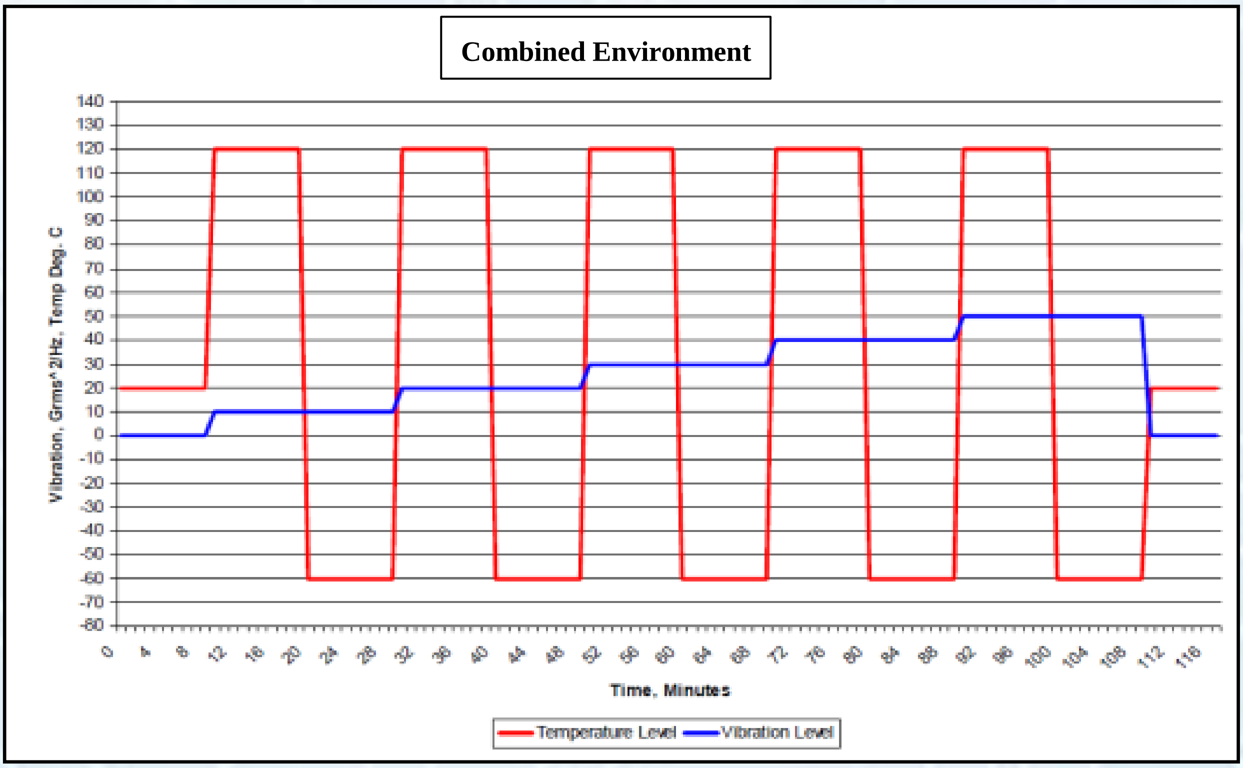


Figure 8 –Temperature and Acceleration Plot for Combined Environment Stress

Main Features

- Simultaneous Thermal Cycling and Vibration
- Same thermal condition as Rapid Thermal Transition
- Vibration increment : vibration destruct limit divided by five
- At least 10 minutes dwell time
- Five combined cycles
- Full functional test performed at the end of the dwell

Combined Environment (Cont'd)

5.2.4.1. Test Procedure

1. A minimum of five thermal cycles are performed unless a destructive failure is encounter prior to the cycles are completed.
2. During combined environment, thermocouples are attached to the product to monitor the vibration response. The accelerometers should be removed as it can be damaged by temperature extreme.
3. The thermal transition extreme is within 10℃ of the operating limit obtained in the thermal step stress. For example, if the cold operating limit is -60℃, then the lower extreme of the cycle will be -50℃; if the hot operating limit is +120℃, then the upper extreme of the cycle will be +110℃. The thermal transition range will be -50℃ to +110℃.
4. The vibration is maintained at the dwell set point until one complete thermal cycle is finished. The starting vibration level of the five combined environment cycles is determined by dividing the vibration destruct limit by five.
5. The minimum dwell time of the extreme temperature is ten minutes after the stabilization of the product at the temperature set point.
6. The thermal transition rate is around 70℃/min.
7. A full functional test is performed after the dwell time.

5.3. Sample Preparation

- Usually at least 5 samples is need and each sample is for one part of the test. If the samples do not reach the destruct limit at the stress test, the sample can be used for the next test.
- High resistance connecting cable is recommended to use for the hot step stress, rapid thermal transition and combined environment to eliminate influence of the accessories to the test result.
- For the connecting cable that is easily loosen, it is recommended to use the method of soldering to fix the cable.
- It is recommended removing the case of the samples if possible to enhance the thermal stress transmission.

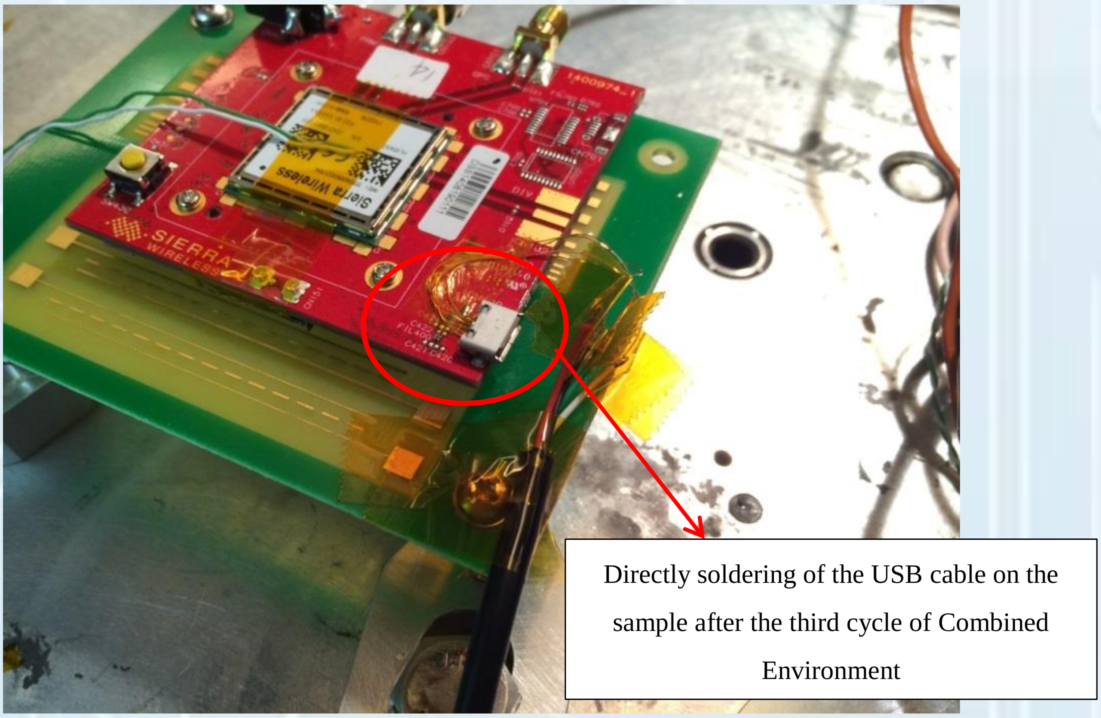


Figure 9 –Example of Sample Preparation

5.4. Functional Test

Functional testing is a critical component of HALT testing. The functional test should be able to perform outside the chamber during test.

The functional testing should be sufficient to determine the overall performance of the product

The longer the functional testing time will leads to a longer overall HALT testing duration. Hence the functional test should be well designed and is sufficient enough to exercise the major functions of the product, but shorten the HALT test duration if possible.

The design of the functional test should be conduct mainly by the product design engineer with the assistance of the HALT test engineer. The functional testing should be performed by the product engineer if possible as they are who knows the failure mode of the product most in the product designing stage.

6. Case Studies

6.1. First Round Application

Case	Sample	Participating Company
1	LED Light Bulb and Transformer	Actfair Limited
2	Control Board and Power Board of Printer	Joilmark Holdings Limited
3	Wi-Fi Base Station	Altai Technologies Limited
4	LED Driver	Vantage Engineering Limited
5	7" Tablet Computer	Qualiman Industrial Company Limited
6	Outdoor Sprinkler Timer	Edwin McAuley Electronics Limited

Table 3 – Participant List of First Round Application

***Remark:** Due to confidentiality considerations from participating companies, the test observations, including operating limit, destructive limit, and failure modes are not disclosed in this Handbook.

6.2. Case 1: LED Light Bulb and Transformer

Product Category: Home Appliances - HALT was performed on LED light bulb and one transformer.

6.2.1. Initial Test (Case 1)

Figure 10 – LED Light Blub

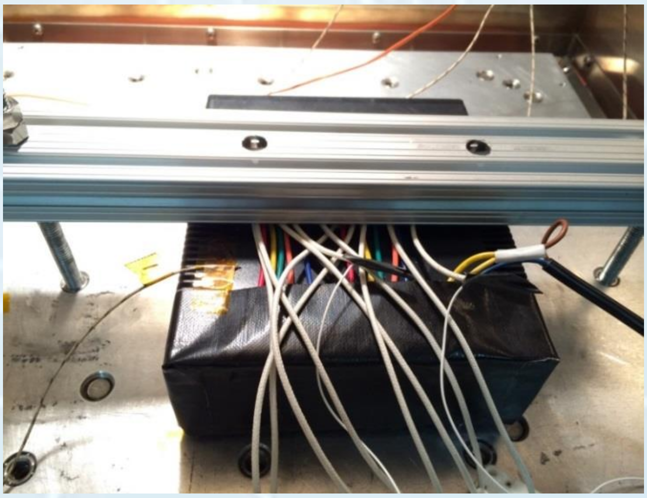


Figure 11 – Transformer of LED Light Blub

6.2.1.1. Test Setup (Case 1)

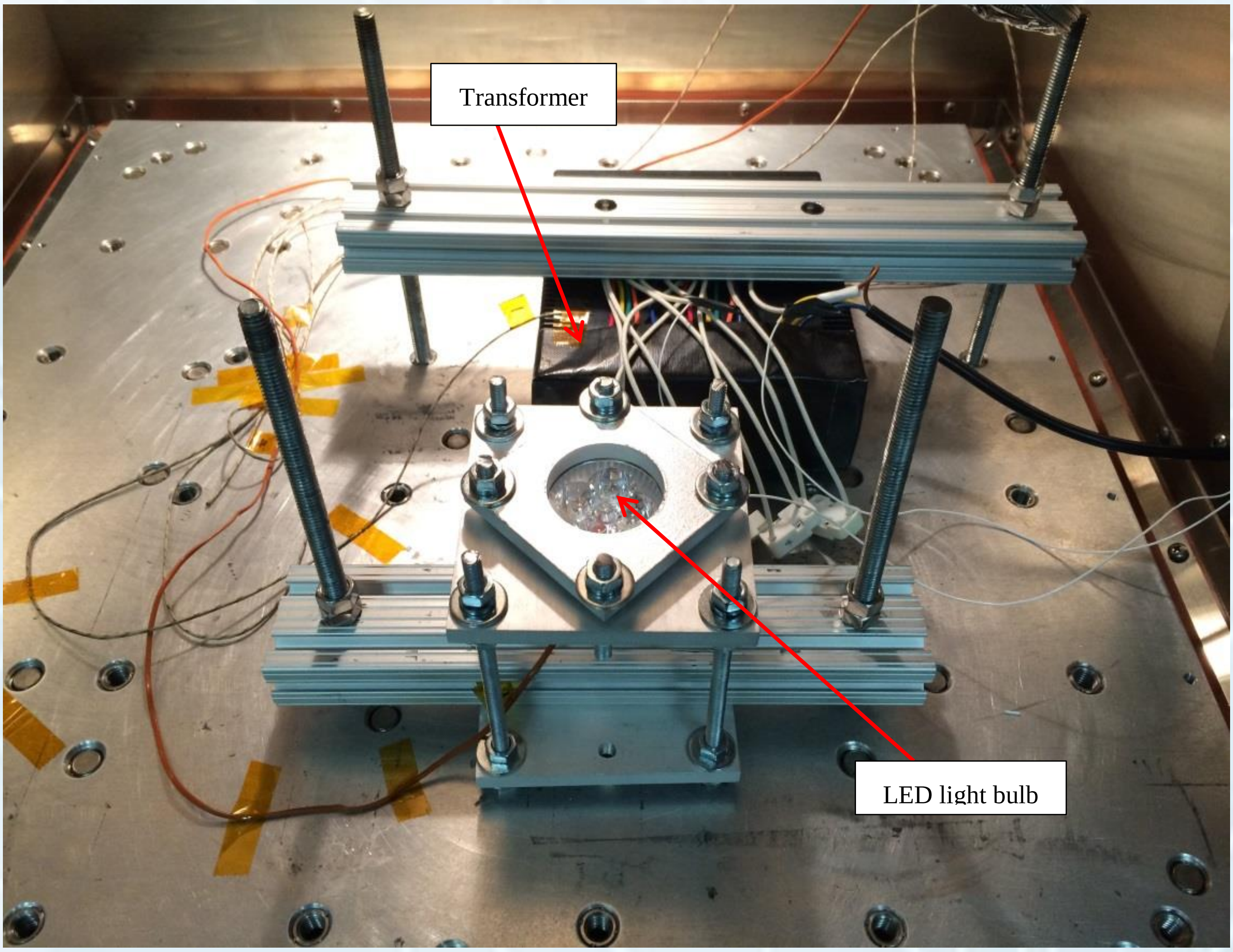


Figure 12 – Test Setup of LED Light Blub

A 220V AC voltage was applied to the transformer and it stepped down the voltage to about 6V and supplied to the LED light bulb directly.

6.2.1.2. Functional Test Items (Case 1)

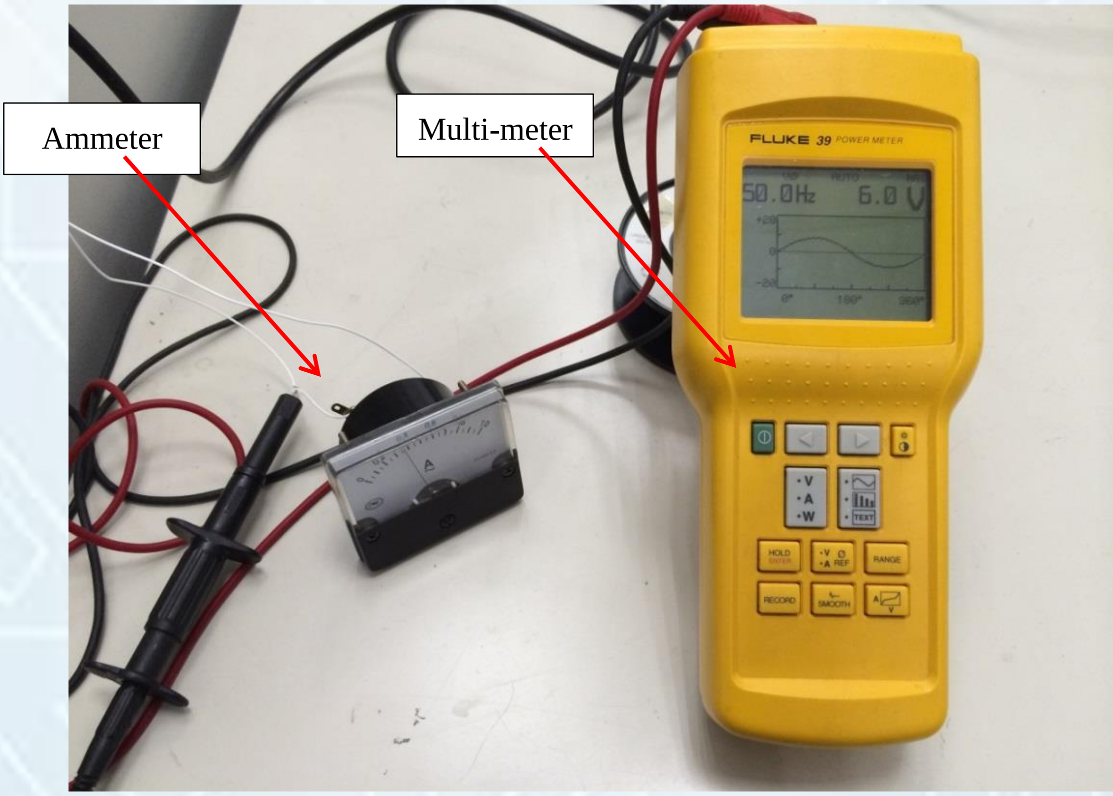


Figure 13 – Functional Test Setup of Case 1

Functional Test Items		Measuring Equipment	Pass/ Fail Criteria
1	Output current of the LED	Ammeter	The pass or fail criteria depending on the lights up or not of the LED light bulb.
2	Output voltage of the LED	Multi-meter	

Table 4 – Functional Test Items of Case 1

6.2.1.3. Test Fixtures - Thermal Test and Vibration Step Stress (Case 1)

Specially crafted aluminum fixture of the LED light bulb for its round shape, to achieve better vibration transmission.

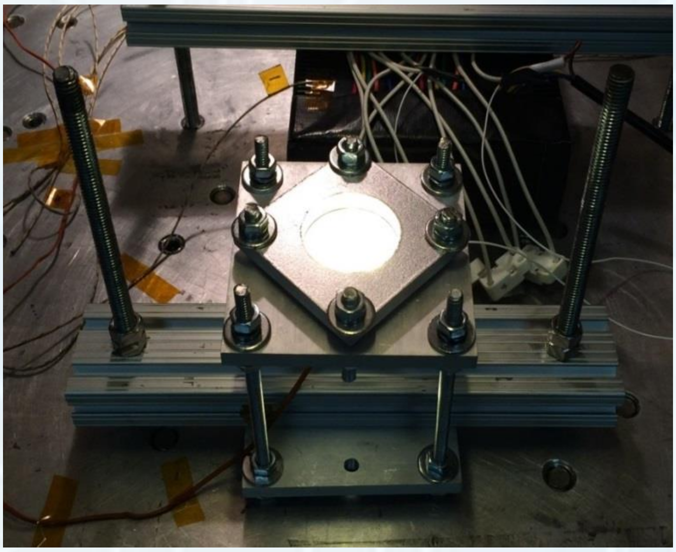


Figure 14 –View 1 of Thermal and Vibration Step Setup for Case 1

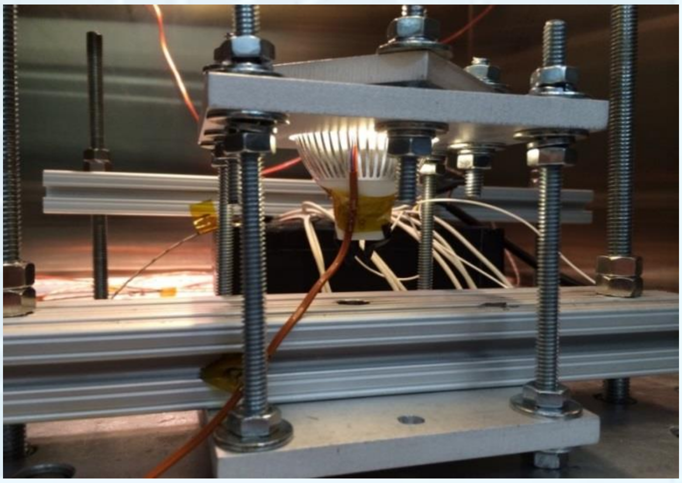


Figure 15 – View 2 of Thermal and Vibration Step Setup for Case 1

6.2.1.4. Test Fixtures - Combined Environment (Case 1)

For the combined environment, the plastic case of the transformer had been removed and directly mount on the table, to prevent loosen of fixture due to the melting of the plastic case.

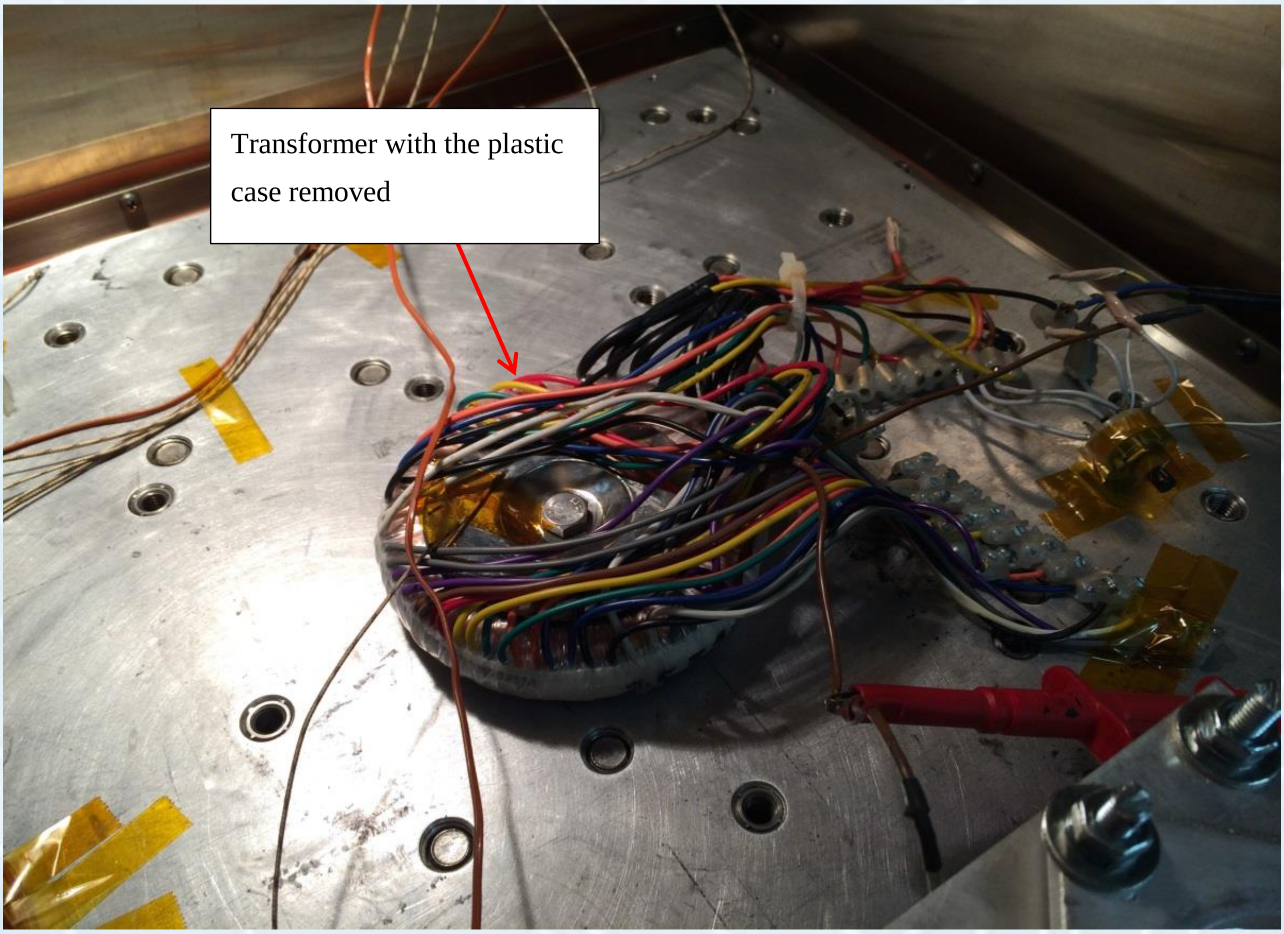
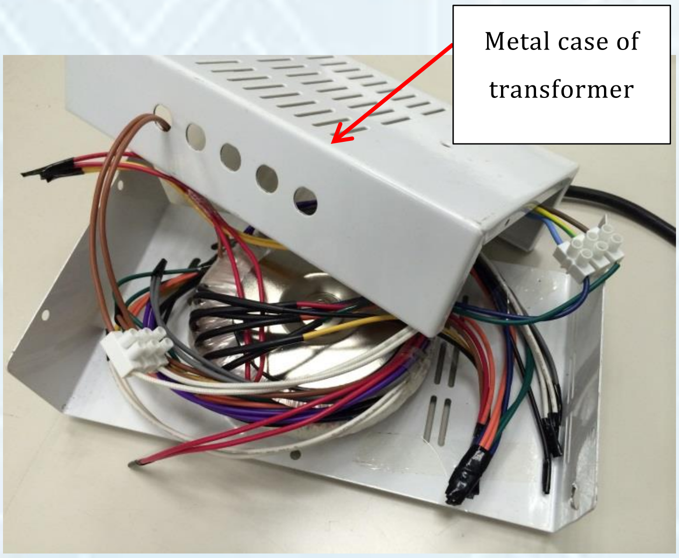


Figure 16 – View of Combined Environment Test Setup for Case 1

6.2.2. Improvement Test (Case 1)

Compare to the initial HALT test, the following changes had been made for this improvement test:

- The case of the transformer changed from plastic to metal.
- The maximum operating temperature of the thermal fuse of the transformer had been changed from 130℃ to 150℃, and the thermal fuse had been changed from non-reversible to reversible.
- The connector of the transformer had been changed from plastic to Bakelite.



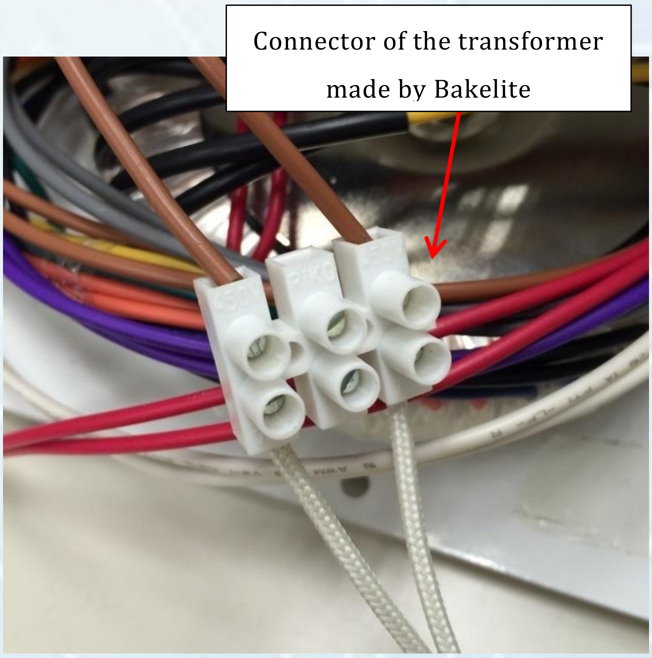


Figure 17 – Improvement from Initial Test (Case 1)

6.2.3. Highlighted Quality Improvement Found from the Improved Test (Case 1)

Highlight on the result of the improvement test compare to the initial HALT test:

- The hot destruct limit had been improved from +160℃ to +170℃.
- The vibration operating limit had been improved from 65 Grms to 75 Grms.
- The vibration destruct limit had been improved from 75 Grms to >75 Grms.
- For the combined environment:
  - In the initial test, the LED light bulb could not light up and could not recover after the first cycle.
  - In the improvement test, LED light bulb could not light up and could not recover after the fourth cycle.

6.3. Case 2: Control Board and Power Board of Printer

Product Category: Information and Communication Technology Devices - HALT was performed on one control board and one power board of a printer. The mechanical parts of the printer were placed outside the chamber during test.

6.3.1. Initial Test (Case 2)

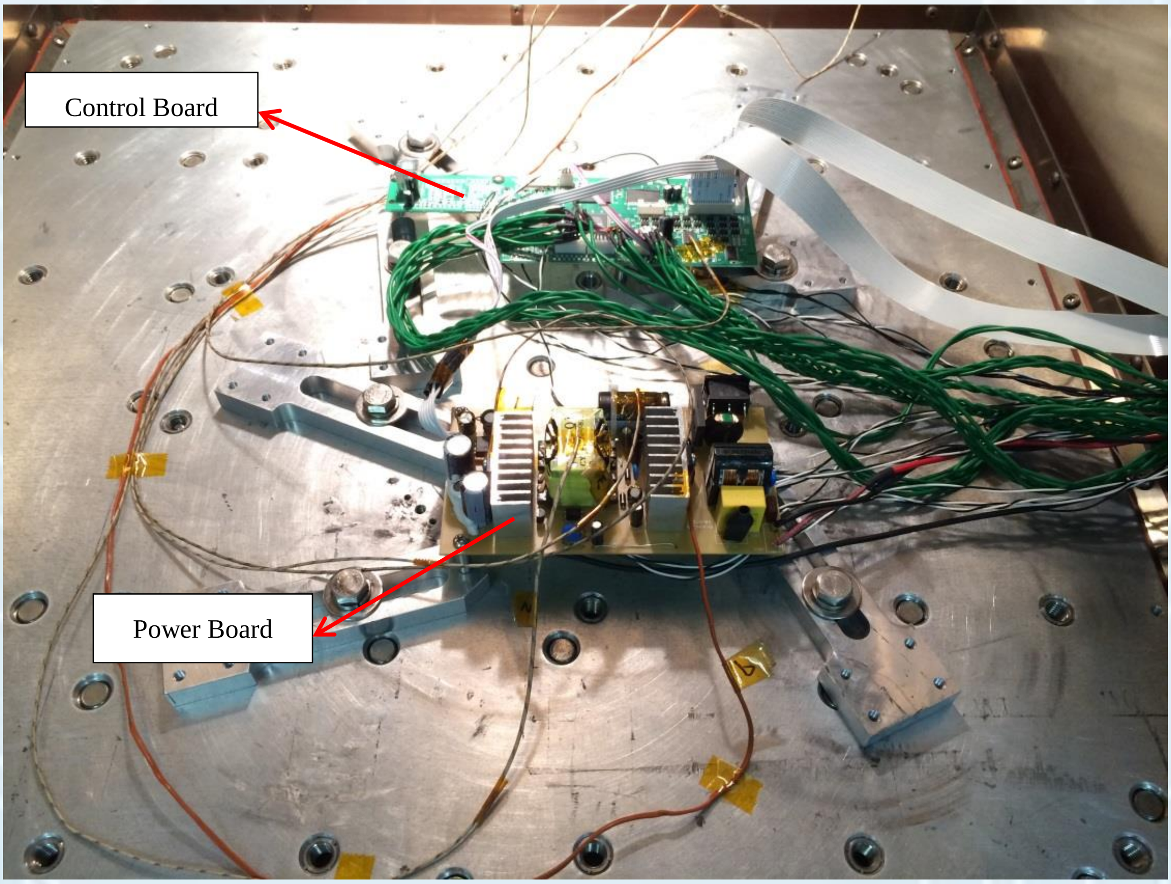


Figure 18 – Printer Control Board and Power Board (Case 2)

6.3.1.1. Test Setup (Case 2)

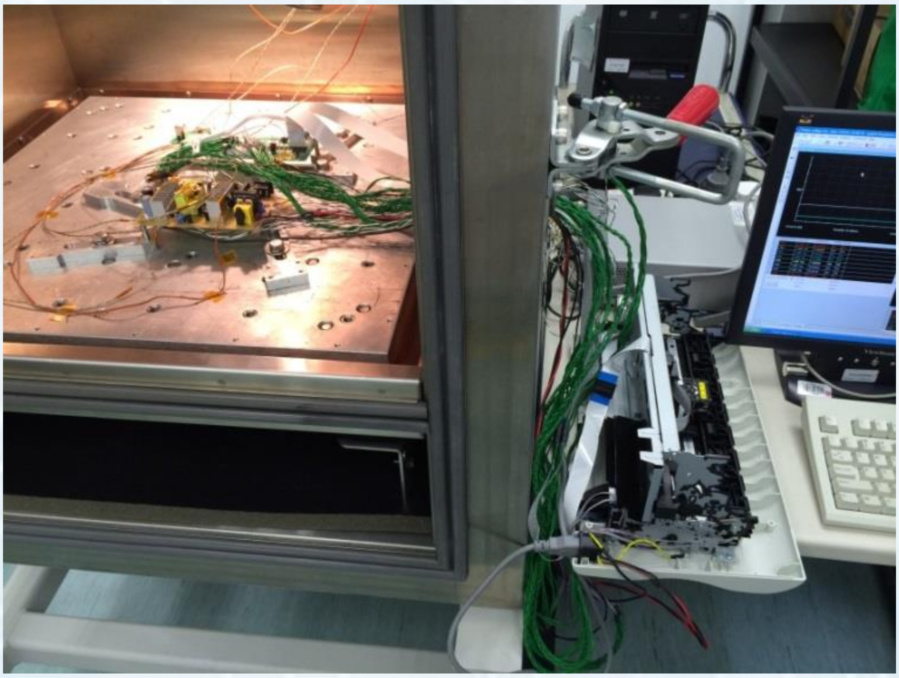


Figure 19 – Test Setup of Printer Control Board and Power Board

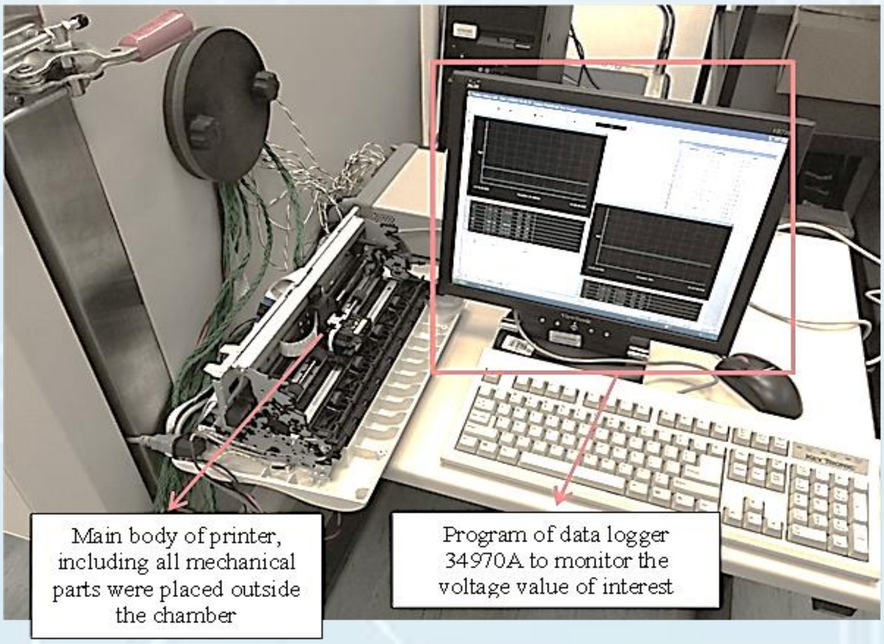
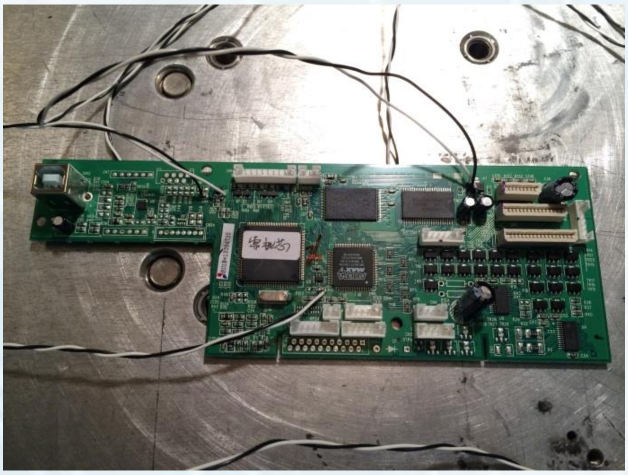


Figure 20 – Function Checking Connections for the Setup of Printer Control Board and Power Board

6.3.1.2. Functional Test Items (Case 2)



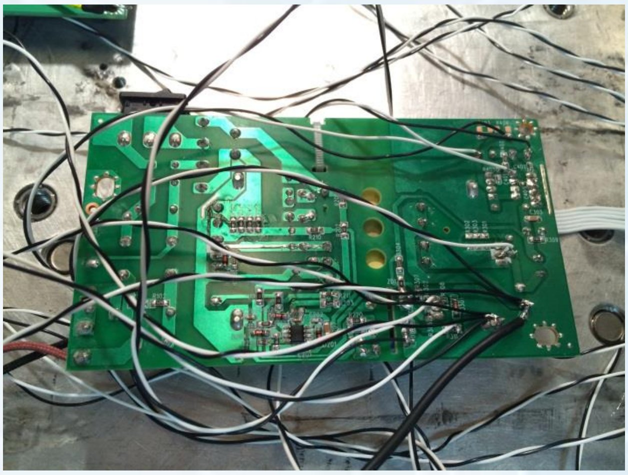


Figure 21 – Temperature Monitoring for the Setup of Printer Control Board and Power Board

Functional Test Items		Pass/ Fail Criteria
1	Motor driving chip fault signal voltage of control board	Correct movement of printer head scanning function
2	Motor driving chip fault signal voltage of control board	
3	System RESET signal voltage value of control board	
4	The voltage value of the voltage conversion chip on control board	
5	The voltage value of the voltage conversion chip on control board	
6-13	Power board	

Table 5 – Functional Test Items of Case 2

6.3.1.3. Test Fixtures - Thermal Test (Case 2)

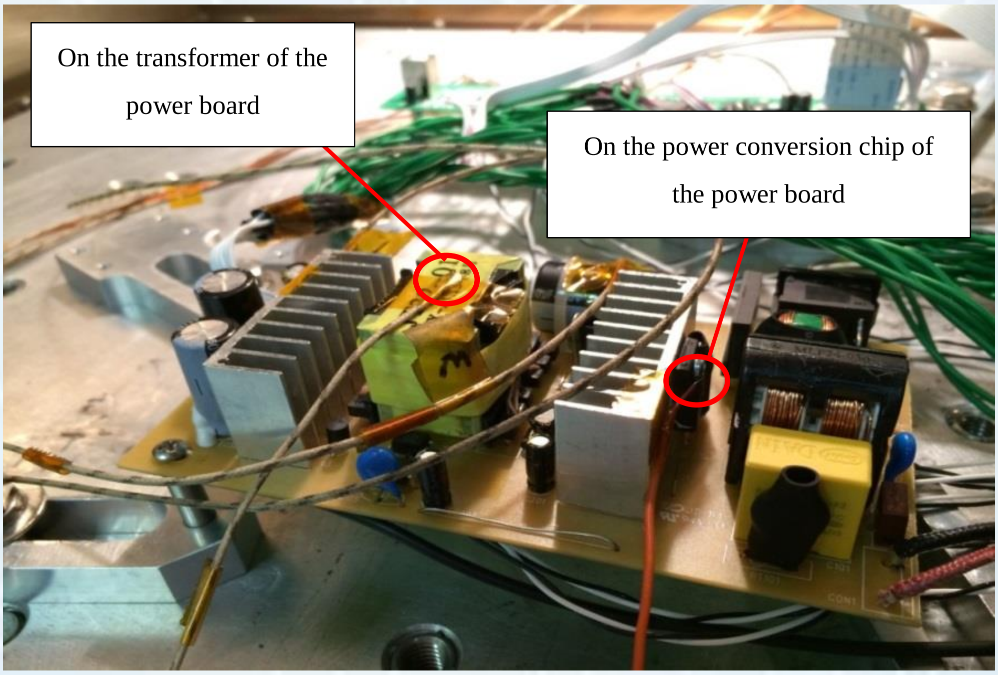


Figure 22 –View 1 of Thermal Step Setup for Case 2

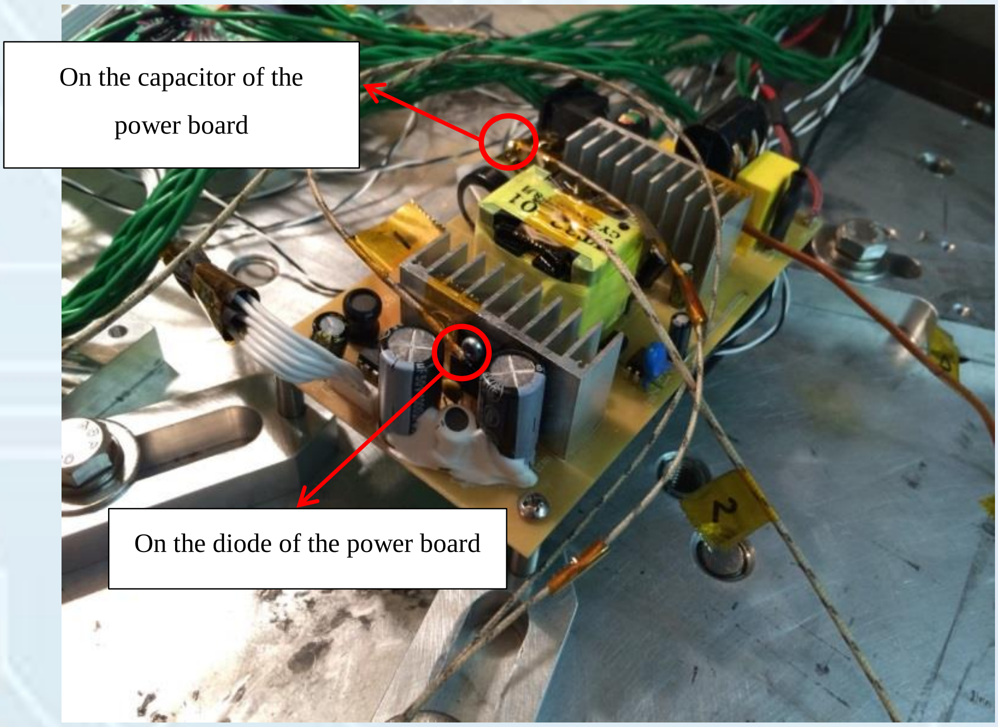


Figure 23 –View 2 of Thermal Step Setup for Case 2

Test Fixture – Thermal Test for Case 2 (Cont'd)

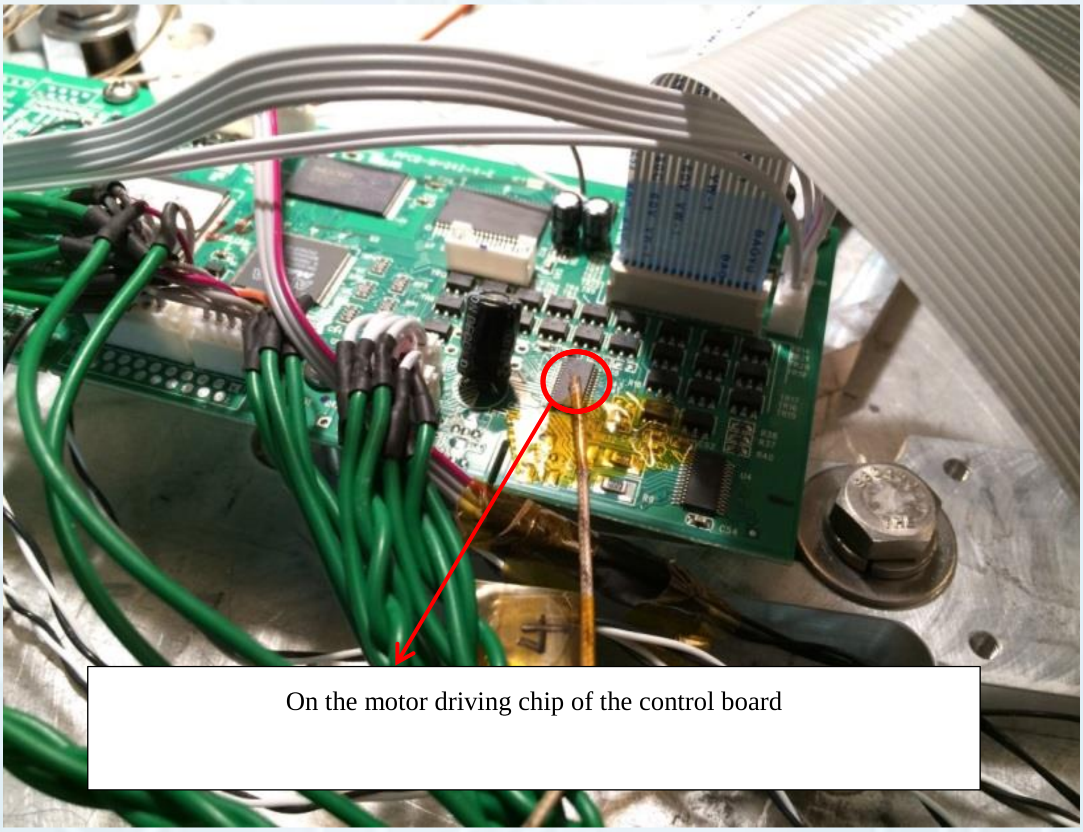


Figure 24 –View 3 of Thermal Step Setup for Case 2

Thermocouples were attached to the power conversion chip of the power board, the diode of the power board, the transformer of the power board, the capacitor of the power board and the motor driving chip of the control board.

6.3.1.4. Test Fixtures – Vibration/ Combined Environment Test (Case 2)

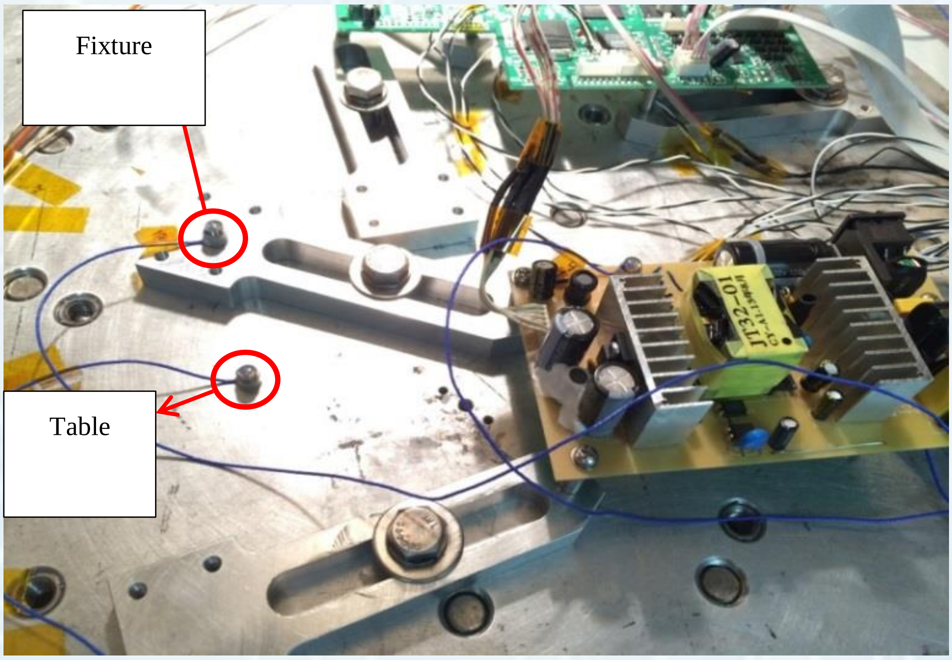


Figure 25 –View 1 of Vibration/ Combined Environment Test Setup for Case 2

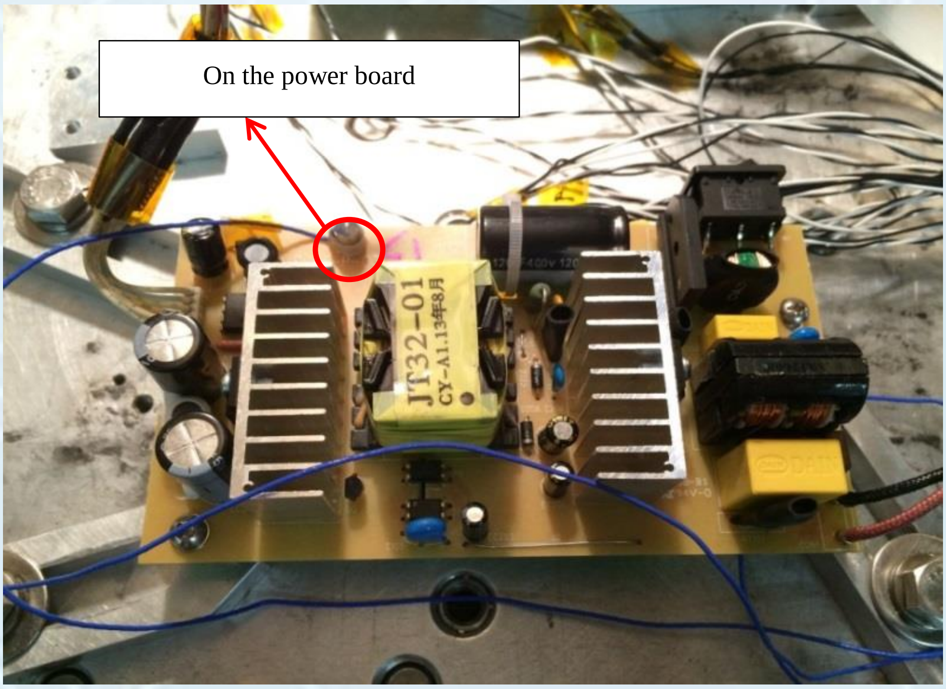


Figure 26 –View 2 of Vibration/ Combined Environment Test Setup for Case 2

Test Fixture – Vibration Test for Case 2 (Cont'd)

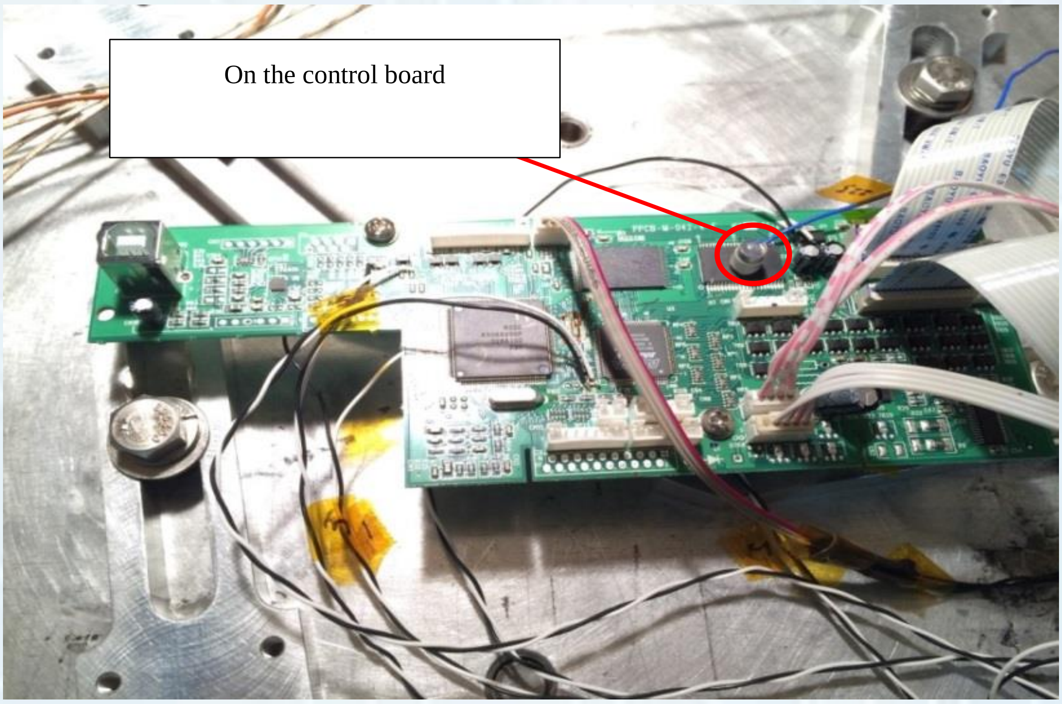


Figure 27 –View 3 Vibration/ Combined Environment Test Setup for Case 2

Accelerometers were placed on the vibration table, the mounting fixture, the power board and the control board during vibration step stress.

6.3.2. Improvement Test (Case 2)

Compare to the initial HALT test, the following changes had been made for this improvement test:

- Epoxy was potted on the junction of the inductor and capacitors of the power board.
- The capacitor of the power board was modified with corner craft process.
- New branding transformer of the power board from alternative supplier.

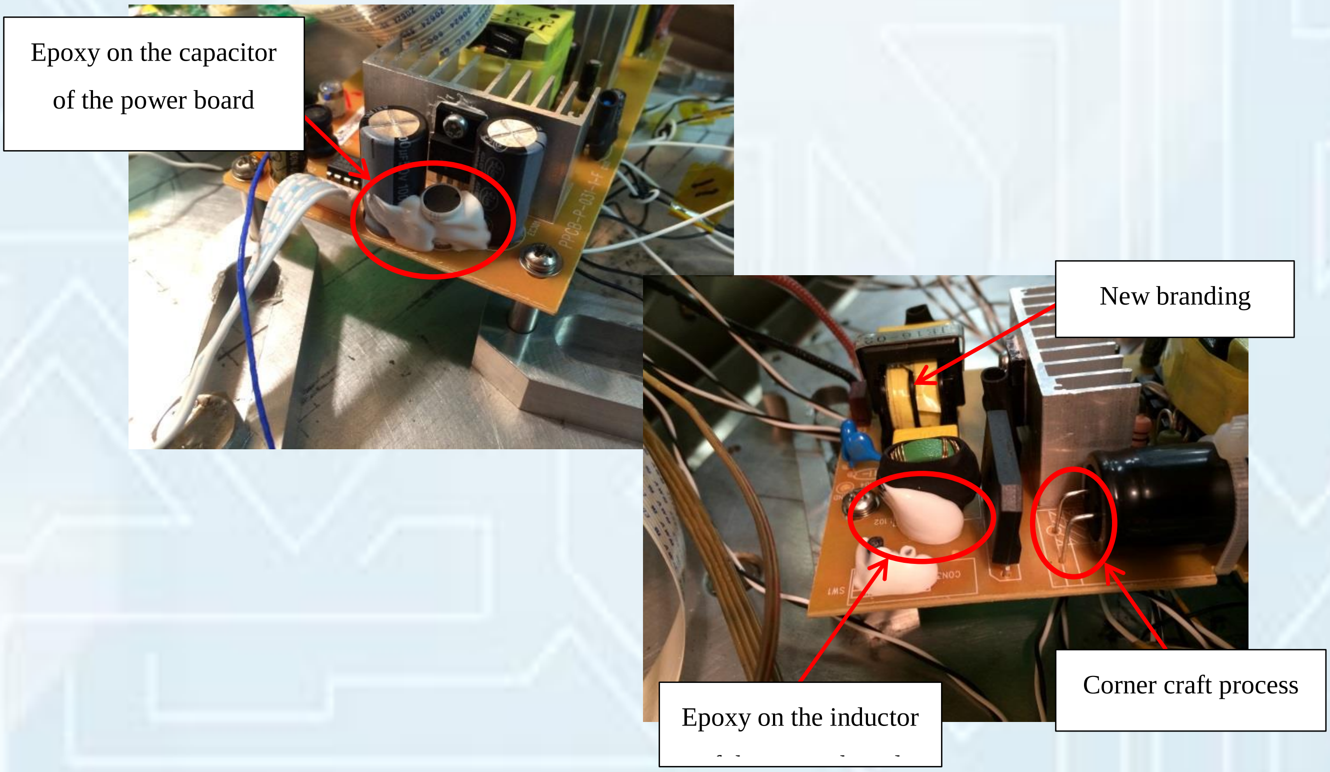


Figure 28 –Improvement from Initial Test (Case 2)

6.3.3. Highlighted Quality Improvement Found from the Improved Test (Case 2)

Highlight on the result of the improvement test compare to the initial HALT test:

- The hot destruct limit had been improved from +180℃ to +200℃.
- The vibration operating limit had been improved from 20 G-rms to 35 G-rms.
- The vibration destruct limit had been improved from 25 G-rms to >40 G-rms.

6.4. Case 3: Wi-Fi Base Station

Product Category: Automotive Electronics - HALT was performed on one Wi-Fi base station which consists of multi of PCBs, e.g. surge protection board, RF board, interface board and power board. This Wi-Fi base station is designed for automotive applications.

6.4.1. Initial Test (Case 3)

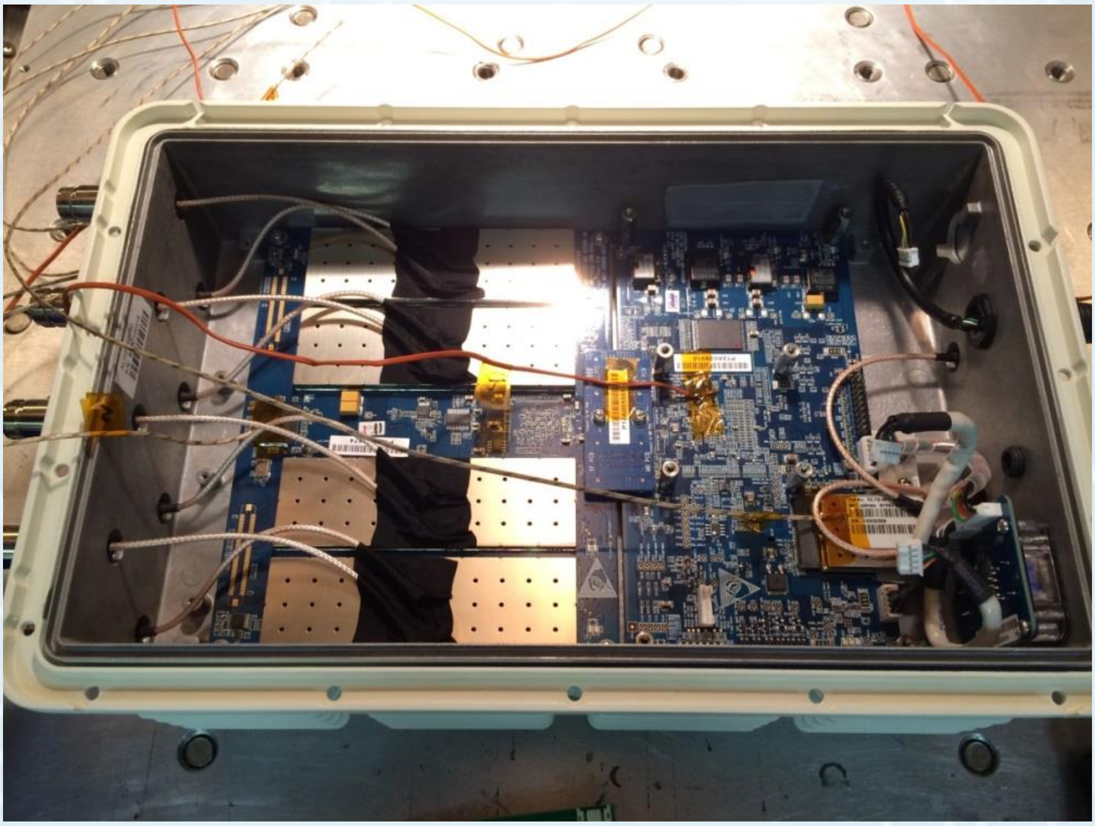


Figure 29 – Outlook of Automotive Wi-Fi Base Station

6.4.1.1. Test Setup and Functional Check (Case 3)

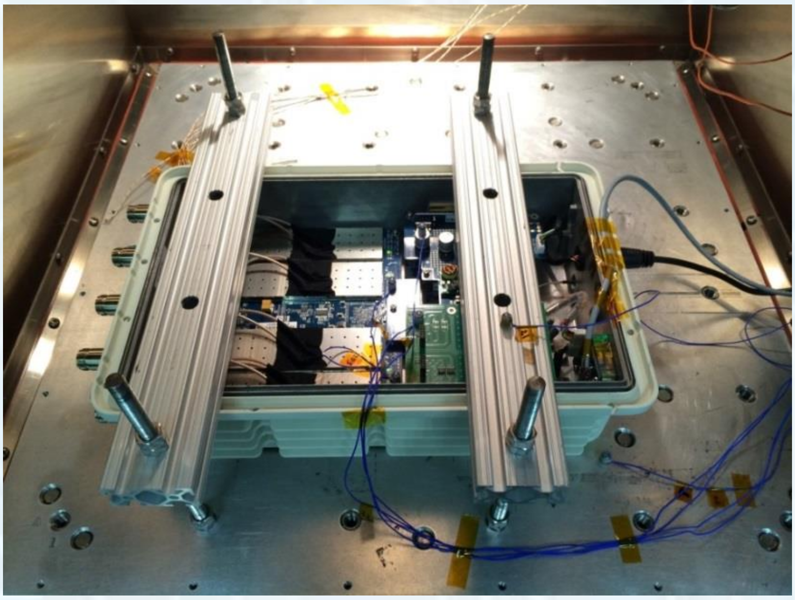


Figure 30 – The Unit Under Test is Mounted on the Test Platform with Aluminum Bars

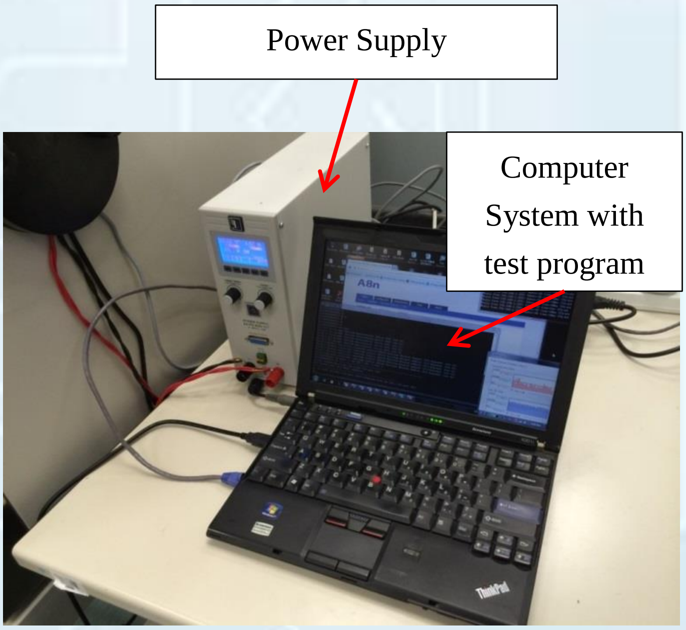


Figure 31 – The Function Checking is Supported by Power Supply and Computer System which Sends and Receives Signal from the Unit

6.4.1.2. Test Fixtures – Thermal Test (Case 3)

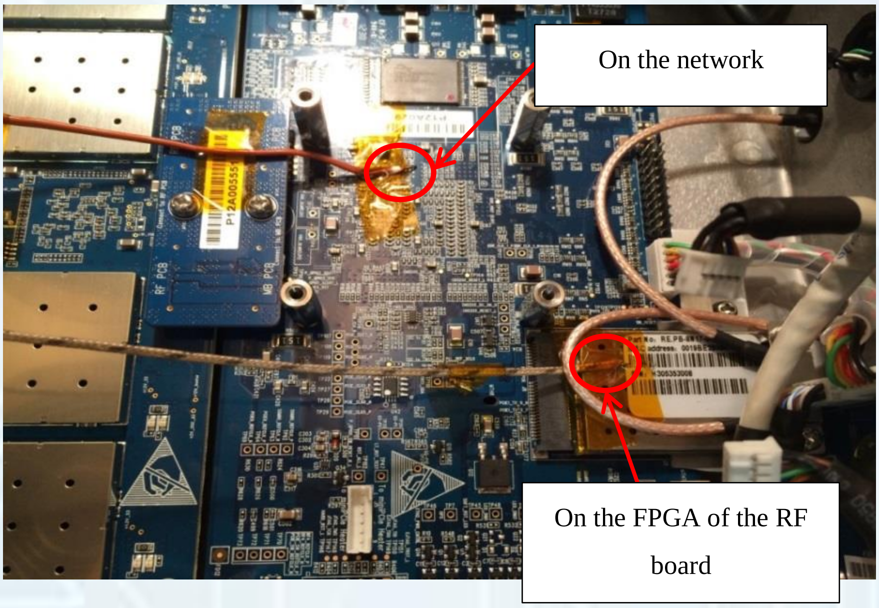


Figure 32 – Thermal Couple Mounting on the Unit Under Test (View 1)

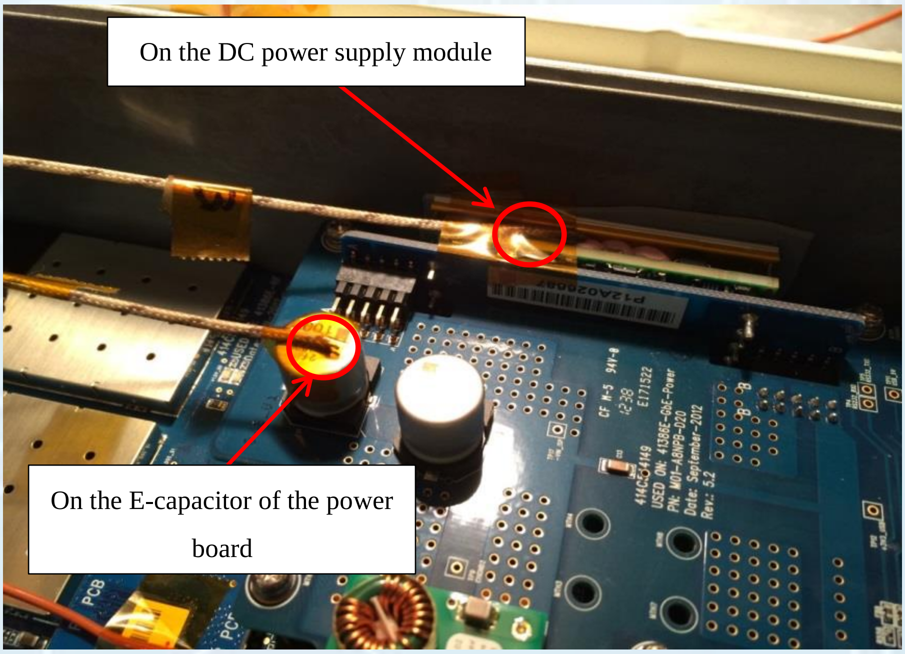


Figure 33 –Thermal Couple Mounting on the Unit Under Test (View 2)

Test Fixture –Thermal Test for Case 3 (Cont'd)

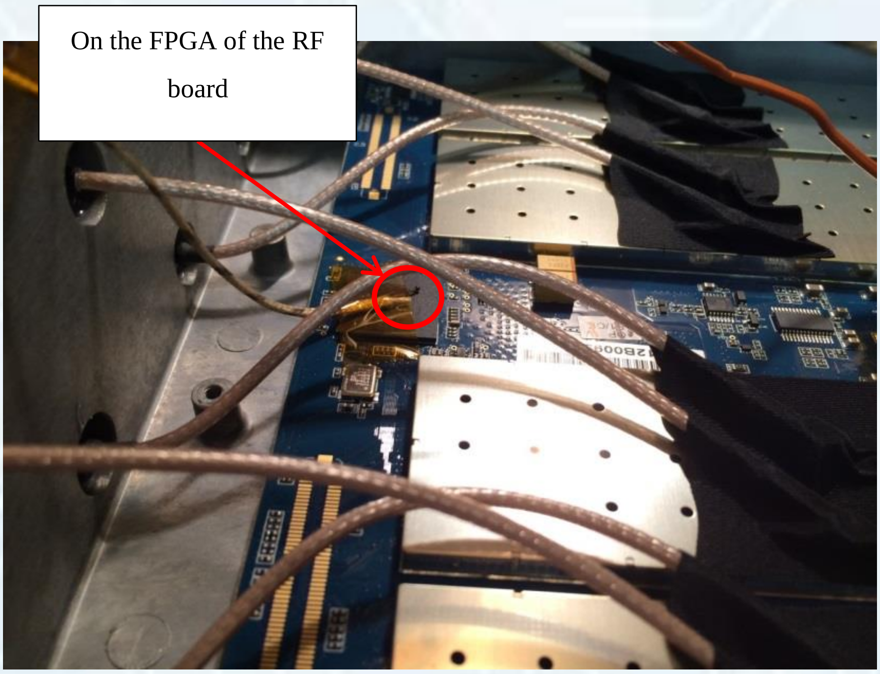


Figure 34 –Thermal Couple Mounting on the Unit Under Test (View 3)

Thermocouples were attached to the network processor, 5GHz module, FPGA of RF board. DC power supply module and E-capacitor of the power board.

Mounting of Thermo-couple is important in this case because the temperature rise is a critical factor which may cause electronic components breakdown due to overheat.

6.4.1.3. Test Fixtures –Vibration/ Combined Environment (Case 3)

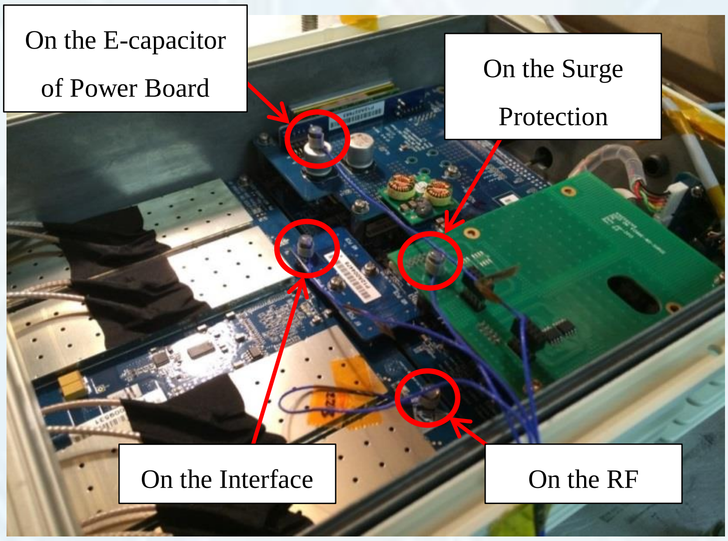


Figure 35 –Accelerometer Mounting on the Unit Under Test (View 1)

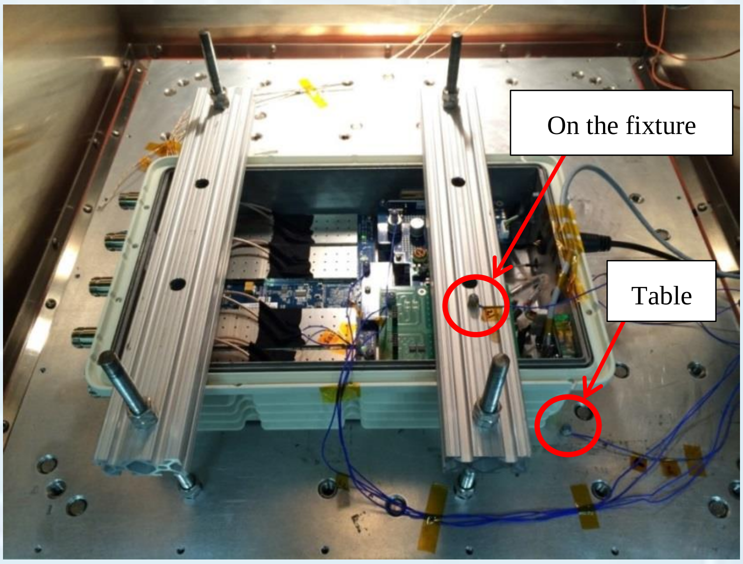


Figure 36 –Accelerometer Mounting on the Unit Under Test (View 2)

Accelerometer mounted on the Unit Under Test as per request by manufacturer provided that the PCB stack could be affected during vibration excitation.

6.4.2. Improvement Test (Case 3)

Compare to the initial HALT test, the following changes had been made for this improvement test:

- The complexity of the product had been reduced; with only one control board was retained.
- The size of the product had been reduced.
- Only two USB cables were retained to connect with the modem.

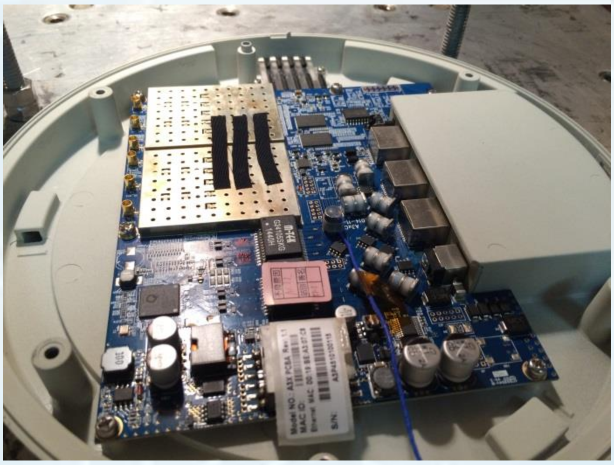


Figure 37 –Complexity of Product Reduced In The Resubmission (View 1)

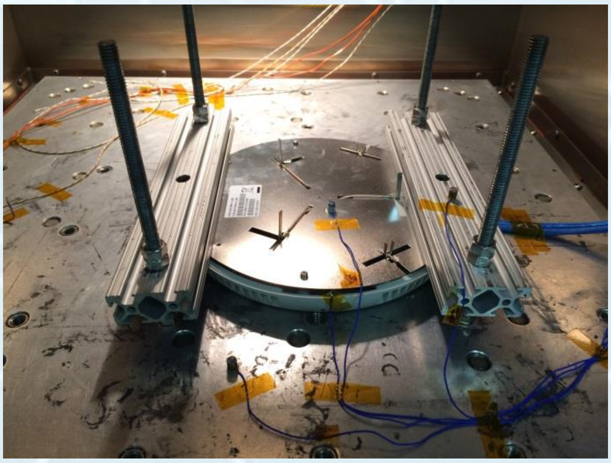


Figure 38 –Complexity of Product Reduced In The Resubmission (View 2)

6.4.3. Highlighted Quality Improvement Found from the Improved Test (Case 3)

Highlight on the result of the improvement test compare to the initial HALT test:

- The cold operating limit had been improved from -20℃ to -80℃.
- The vibration operating limit had been improved from 45 G-rms to 55 G-rms.
- The vibration destruct limit had been improved from 50 G-rms to 60 G-rms.

6.5. Case 4: LED Driver

Product Category: Home Appliances - HALT was performed on one LED driver of a LED light panel.

6.5.1. Initial Test (Case 4)

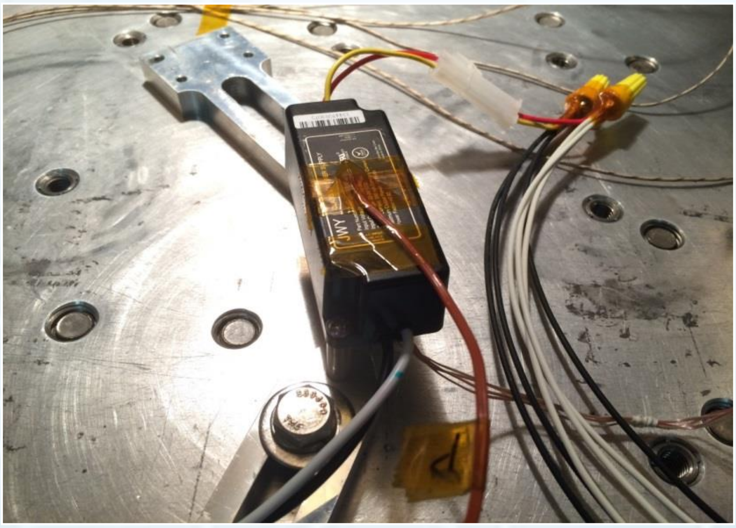


Figure 39 – Outlook of LED Driver (Overview)

Figure 40 – Outlook of LED Driver (PCBA View)

6.5.1.1. Test Setup and Functional Check (Case 4)

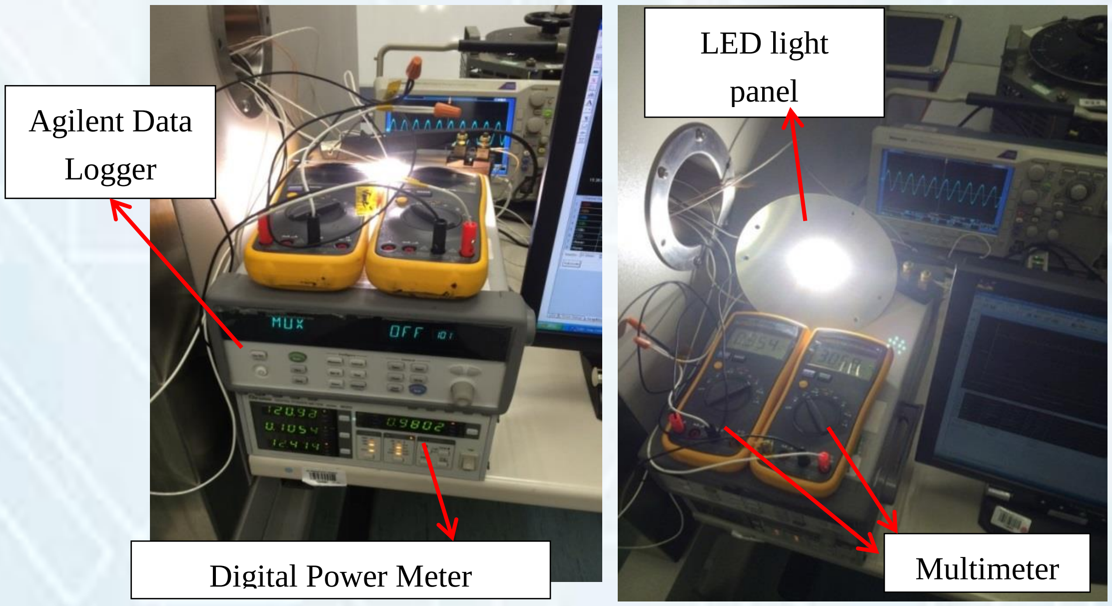
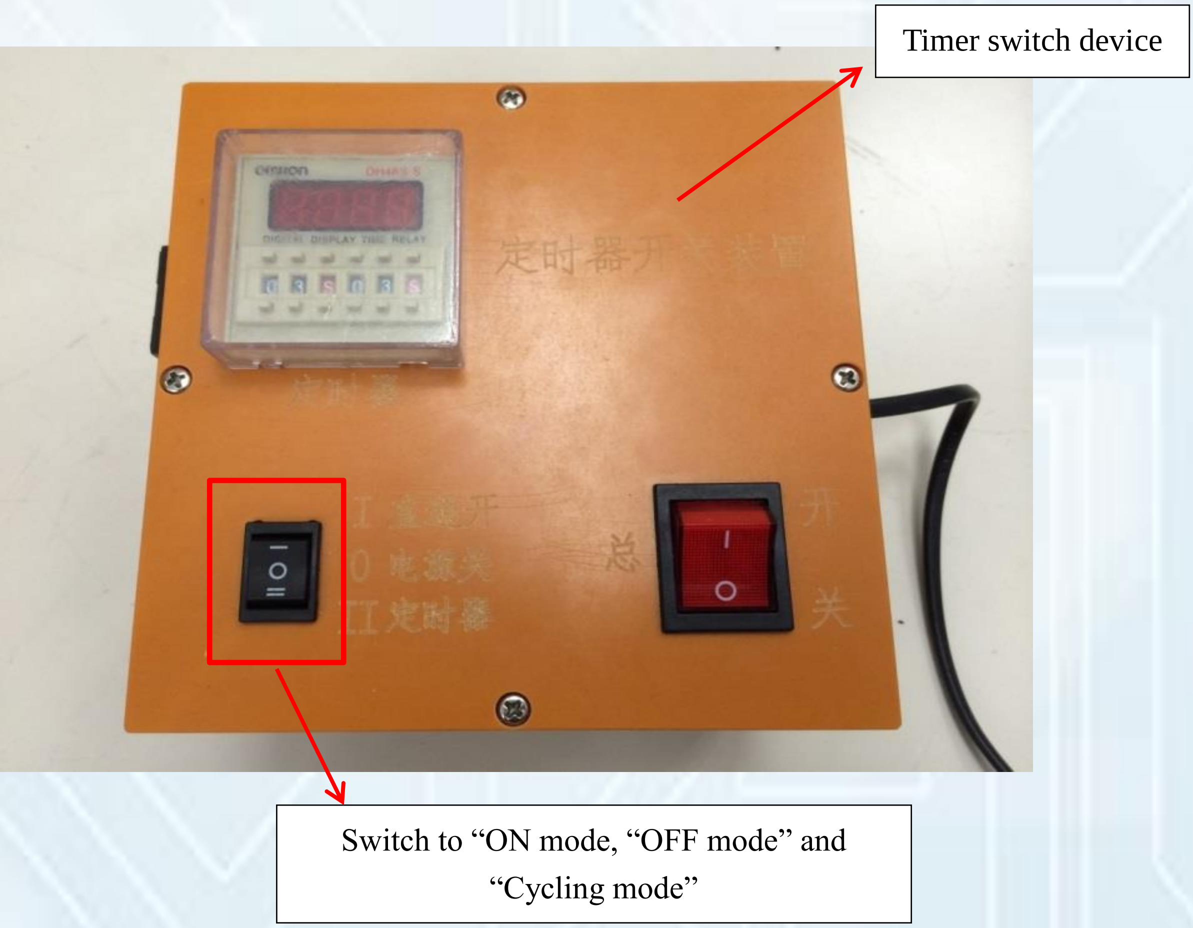


Figure 41 – Functional Test Setup of Case 4

Functional Test Items		Measuring Equipment	Pass/ Fail Criteria
1	Output Voltage	Multimeter	The pass or fail criteria depending on the lights up or not of the LED light panel.
2	Output Current	Multimeter	
3	The Peak to Peak Value of the Output Current Ripple	Digital Phosphor Oscilloscope	
4	Input Power	Digital Power Meter	
5	Power Factor	Digital Power Meter	
6	Switching Test	Timer Switch Device	

Table 6 – Functional Test Items of Case 4

Test Setup and Functional Check (Case 4)



<u>Figure 42 – Switching Test Kit Used for Function Checking</u>

For the switching test:

<u>"Cycling Mode"</u>

Automatically turn on and off in a time interval of around 3 seconds for 10 times.

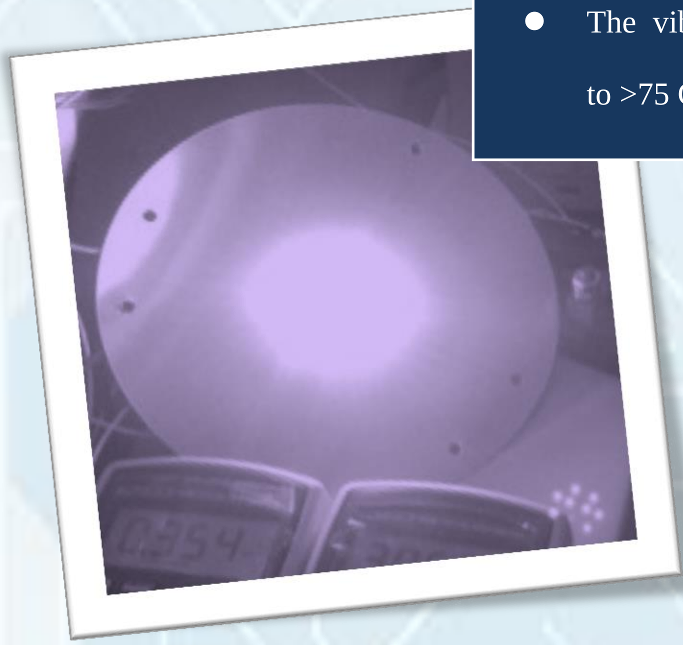
<u>"ON Mode"</u>

During the test, the timer switch device was set at the "ON mode" and the LED light panel was lights up during the dwell time.

6.5.2. Highlighted Quality Improvement Found from the Improved Test (Case 4)

Highlight on the result of the improvement test compare to the initial HALT test:

- The cold operating limit had been improved from 0℃ to -70℃.
- The cold destruct limit had been improved from -10℃ to < -100℃.
- The hot destruct limit had been improved from +160℃ to +180℃.
- The vibration operating limit had been improved from 60 G-rms to >75 G-rms.
- The vibration destruct limit had been improved from 65 G-rms to >75 G-rms.



6.6. Case 5: 7 Inch Tablet PC

Product Category: Portable Electronics - HALT was performed on one 7” Tablet which mainly consists of a touch screen, a PCB control board and a Lithium battery. The battery of the tablet was detached, wired to the tablet and placed outside the chamber. The casing on the back of the tablet was removed to facilitate the stresses experience by the product under test.

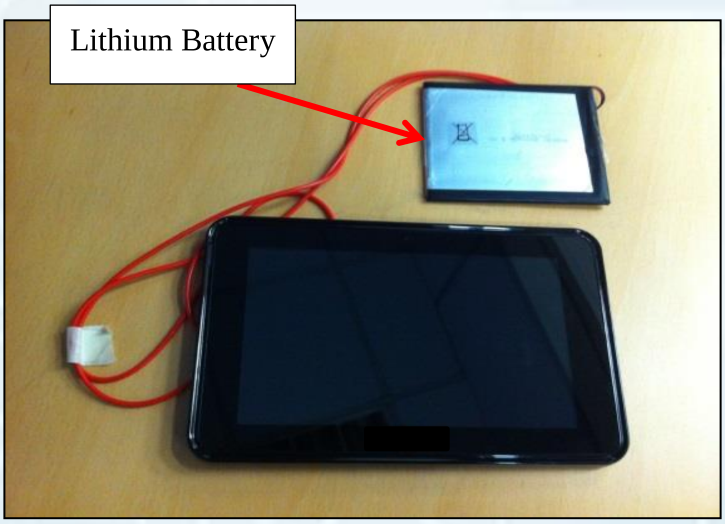


Figure 43 – Switching Test Kit Used for Function Checking

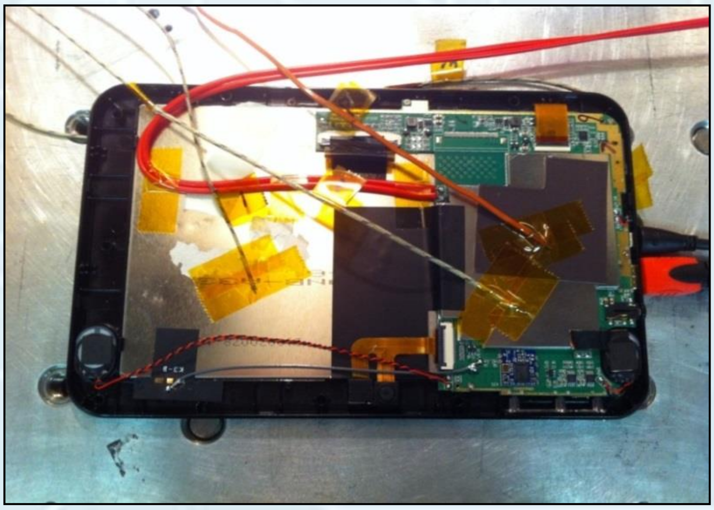


Figure 44 – Switching Test Kit Used for Function Checking

6.6.1. Initial Test (Case 5)

6.6.1.1. Setup Overview (Case 5)

The Lithium battery of the tablet was wired to the tablet and placed outside the chamber during test.

Screen outside the chamber to monitor the HDMI output.

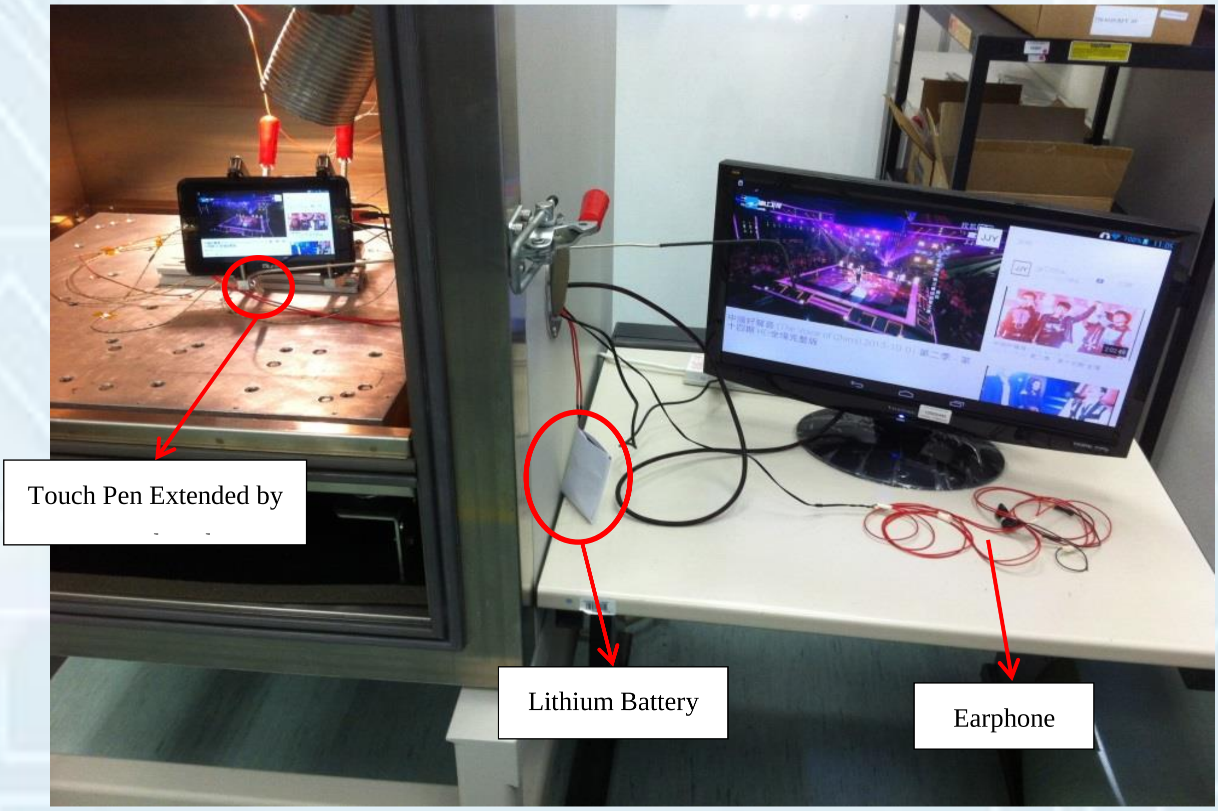


Figure 45 – Functional Test Setup of Case 5

6.6.1.2. Functional Test Setup (Case 5)

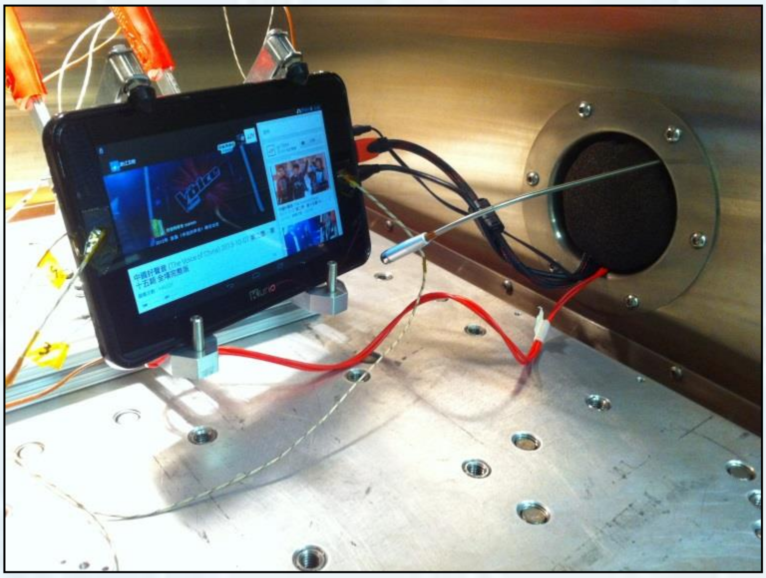
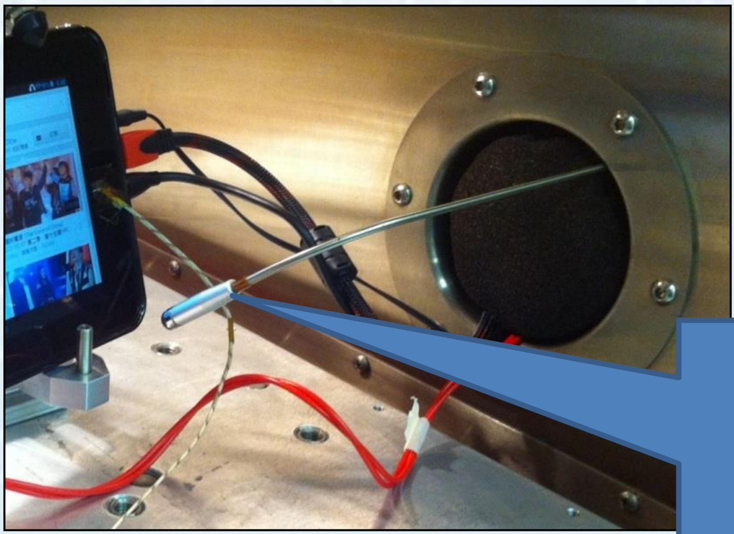


Figure 46 – Functional Test Setup of Case 5



A touch pen extended by a metal rod was used for touching the LCD display of the 7"tablet outside of the chamber during functional test.

Figure 47 – Functional Test Setup of Case 5

6.6.1.3. Functional Test Items (Case 5)

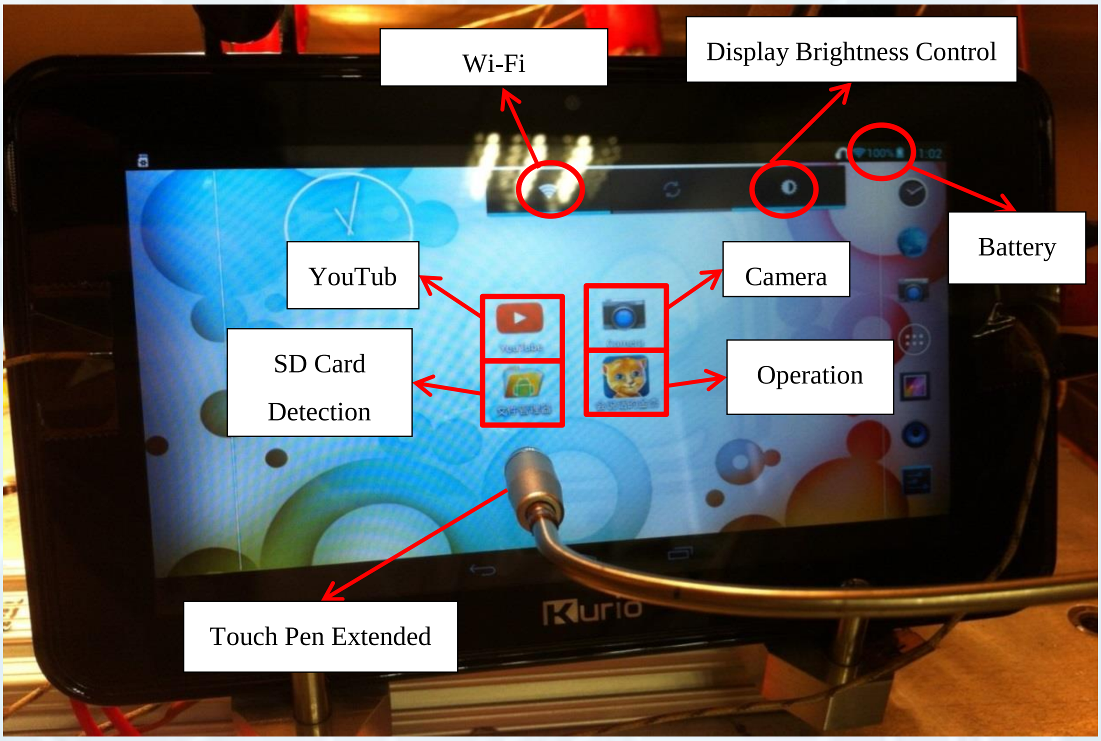


Figure 48 – Functional Test Buttons of Case 5

Functional Test Items		Pass/ Fail Criteria
1	Wi-Fi Connection	Working
2	HDMI Output	Working
3	Display Brightness Control	Working
4	Function of Camera	Working
5	SD Card Detection	Working
6	Charging	Working
7	Function of Earphone Output	Working
8	Operation of Apps	Working

Table 7 – Functional Test Items of Case 5

6.6.1.4. Test Fixtures – Thermal Test (Case 5)

Tilted at about 45 degree to the chamber table

Easier to observe the touch panel from the chamber door

Facilitate the use of extended touch pen

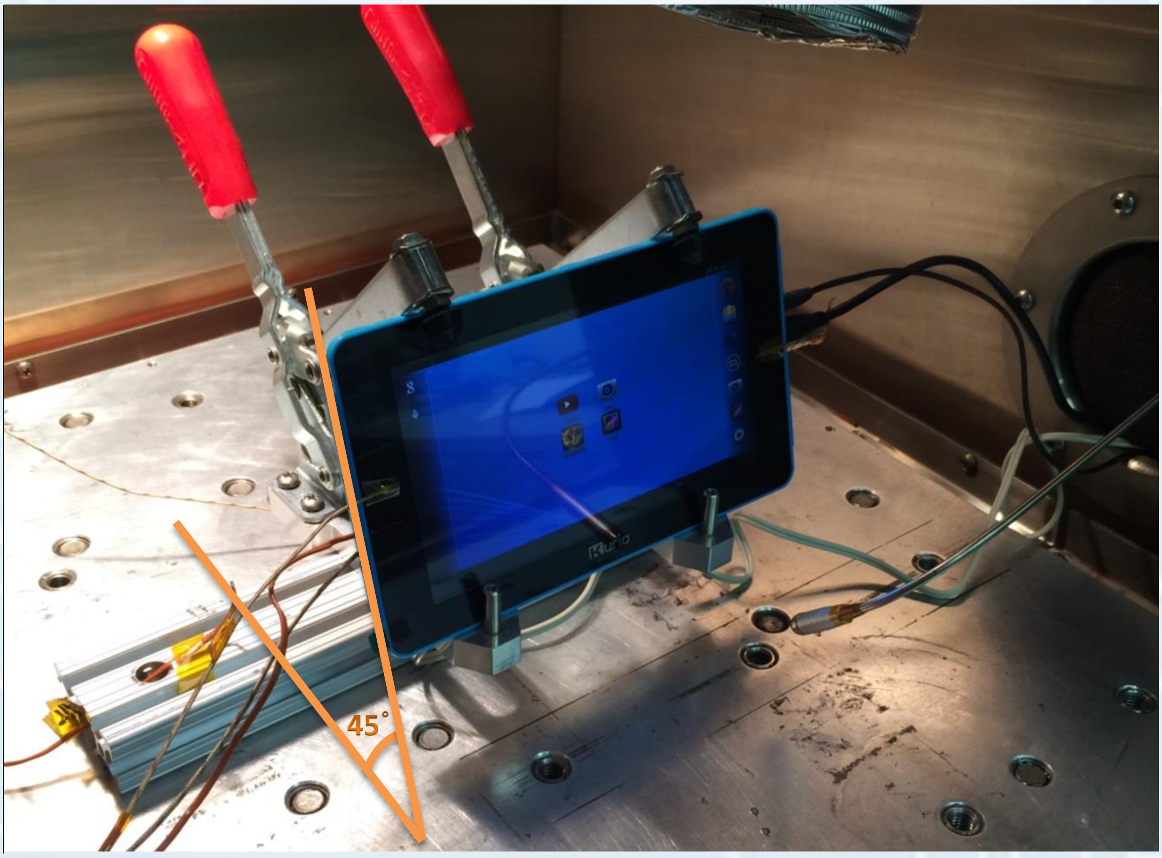


Figure 49 – Thermal Test Setup of Case 5

6.6.1.5. Test Fixtures – Vibration Test (Case 5)

Parallel to the chamber table

Facilitate vibration transfer

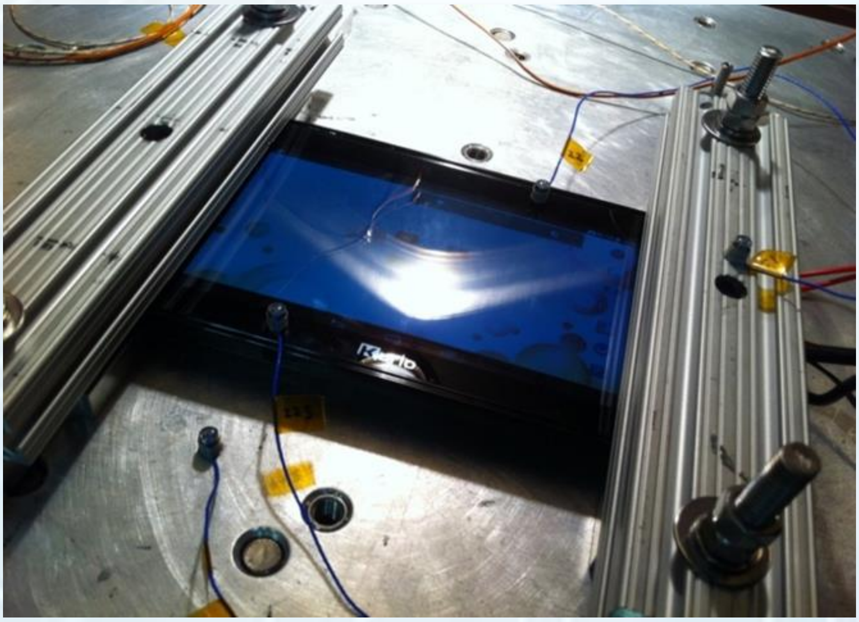


Figure 50 – Vibration Test Setup of Case 5

6.6.2. Improvement Test (Case 5)

Compare to the initial HALT test, the following changes had been made for this improvement test:

- Replaced the LCD display with a better quality one.
- Removed the HDMI port.

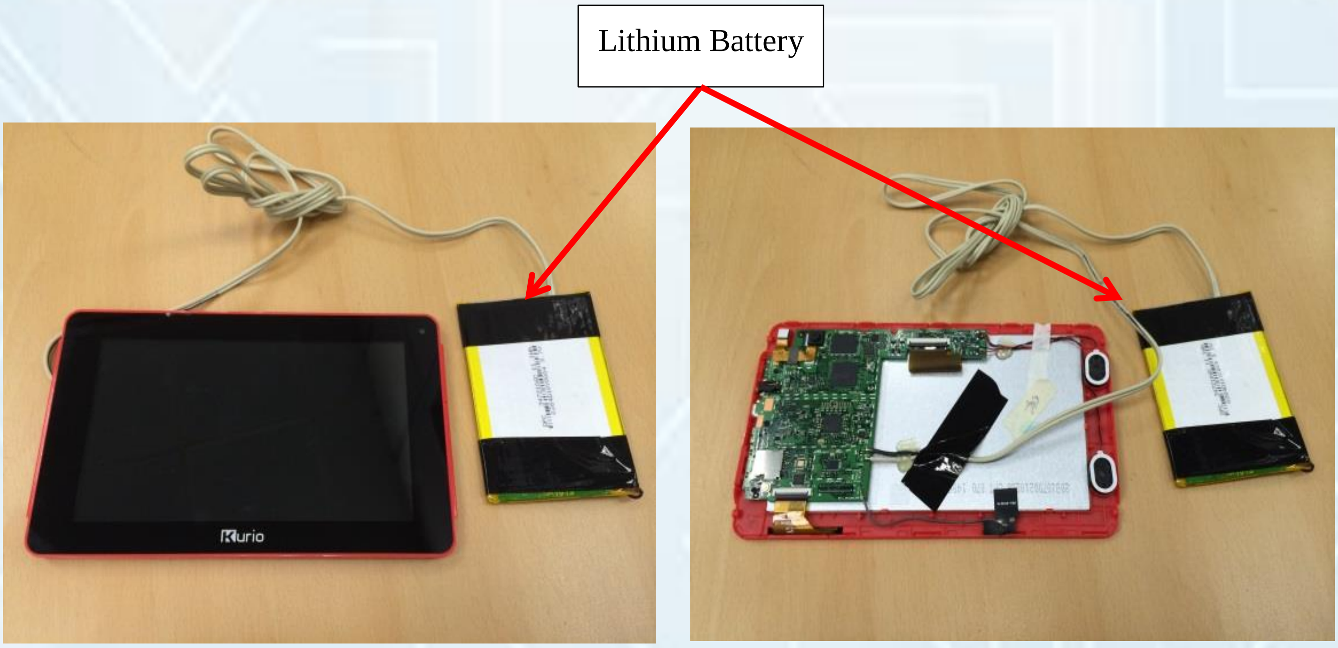


Figure 51 – Improvement of Case 5

6.6.3. Highlighted Quality Improvement Found from the Improved Test (Case 5)

Highlight on the result of the improvement test compare to the initial HALT test:

- The hot operating limit had been improved from +90℃ to +100℃.
- The hot destruct limit had been improved from +90℃ to +100℃.
- The hot destruct limit had been improved from +150℃ to +170℃.

6.7. Case 6: Outdoor Sprinkler Timer

Product Category: Portable Electronics - HALT was performed on one outdoor sprinkler timer which consists of one power board, one control board and one logic board.

Figure 52 – Outlook of Outdoor Sprinkler Timer for Case 6

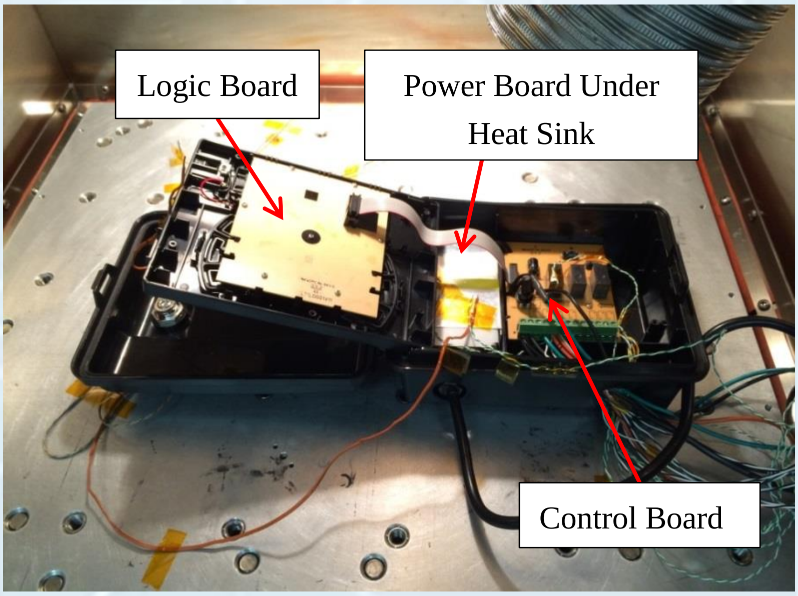


Figure 53 – Inside Components of Outdoor Sprinkler Timer for Case 6

6.7.1. Initial Test (Case 6)

6.7.1.1. Test Setup (Case 6)

Figure 54 – Mounting of Logic Board Inside the Chamber (Case 6)

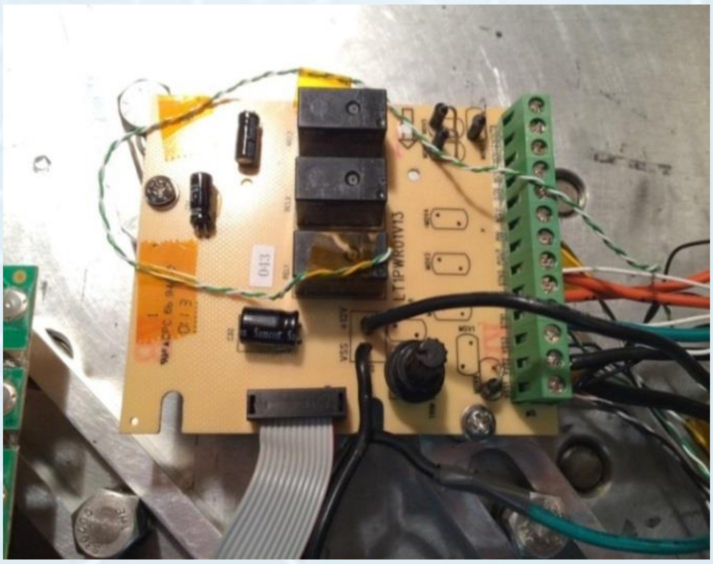


Figure 55 – Mounting of Control Board Inside the Chamber (Case 6)

Test Setup for Case 6 (Cont'd)

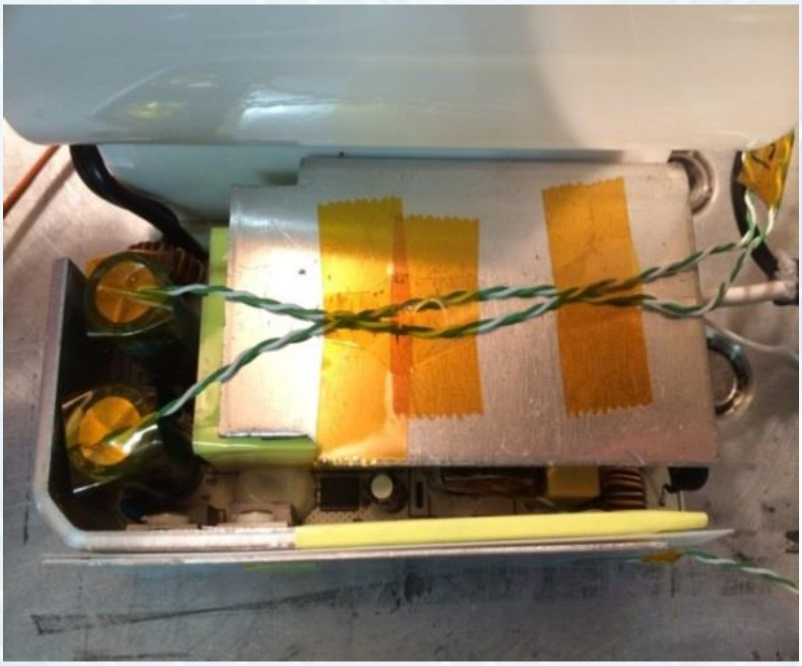


Figure 56 – Mounting of Power Board Inside the Chamber (Case 6)

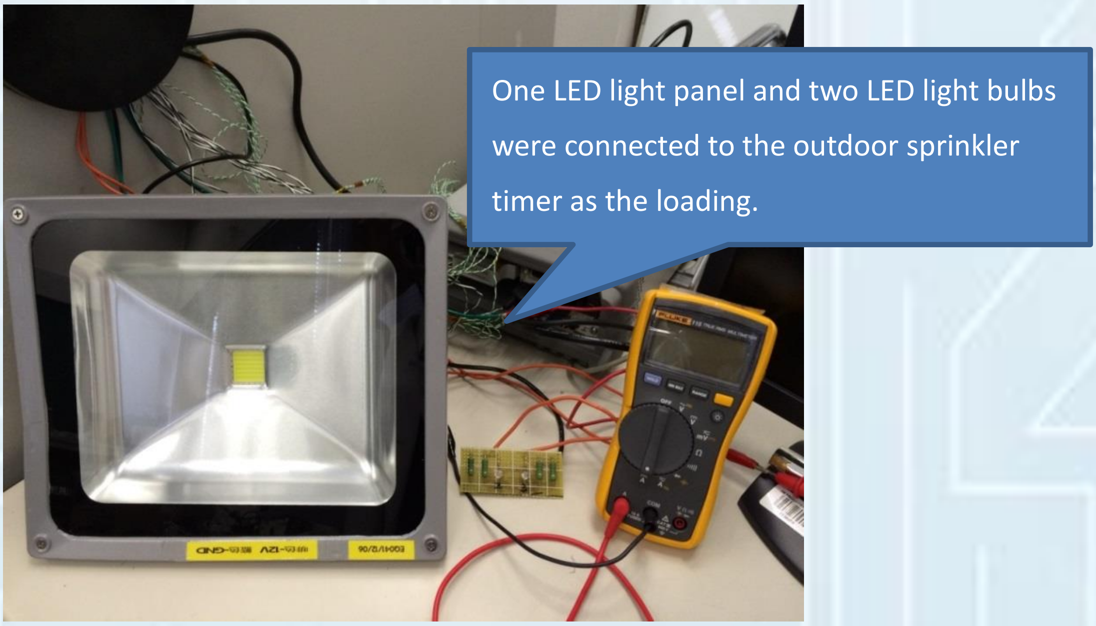


Figure 57 – Function Checking Setup (Case 6)

6.7.1.2. Functional Test Items (Case 6)

Totally 6 pairs of wires were soldered/connected to specific interest point of the logic board and control board, and connected to data logger to monitor the voltage value outside the chamber during test.

A multi-meter was connected to the control board to monitor the output current value.

The pass or fail criteria depending on the lights up or not of the LED light panel.

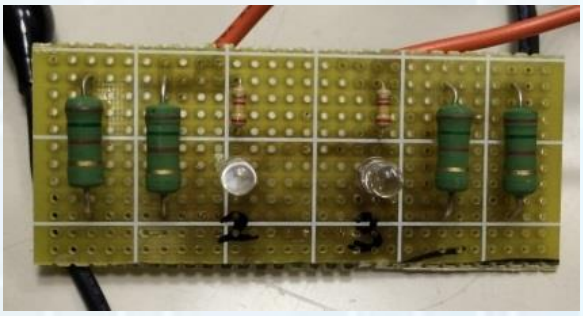
 

Figure 58 – Left: CH1 LED Function Checking Setup (Case 6)

Figure 59 – Right: CH2 and CH3 Function Checking Setup (Case 6)

Functional Test Items		Measuring Equipment	Pass/ Fail Criteria
1	SMPS Output Voltage +12V	Data Logger	The pass or fail criteria depending on the lights up or not of the LED light bulb.
2	DVCC for AC Detection		
3	VDD for MCU		
4	Ch1 Output Voltage		
5	Ch2 Output Voltage		
6	Ch3 Output Voltage		
7	SMPS Output Current	Multimeter	

Table 8 – Functional Test Items of Case 6

6.7.1.3. Test Fixtures – Thermal Test (Case 6)

Including the plastic case and the LCD display for saving the setup time.

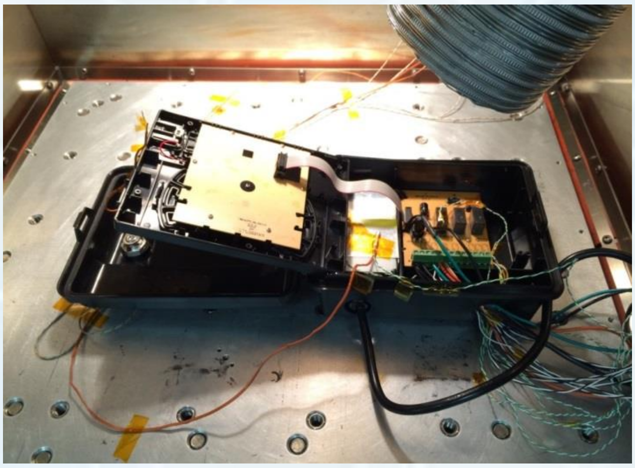


Figure 60 – CH2 and CH3 Function Checking Setup (Case 6)

6.7.1.4. Test Fixtures – Vibration Test (Case 6)

Removed the plastic case and the LCD display and mount the boards directly on the table to obtain better vibration transmission

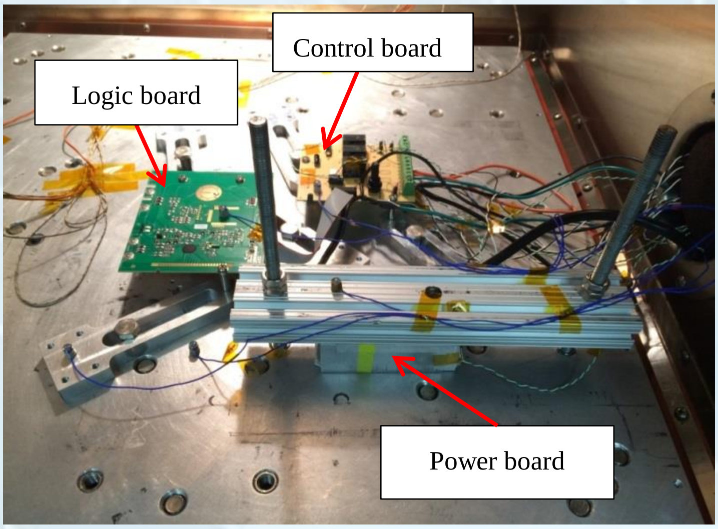


Figure 61 – CH2 and CH3 Function Checking Setup (Case 6)

6.7.2. Improvement Test (Case 6)

Compare to the initial HALT test, the following changes had been made for this improvement test:

Epoxy was potted on the power board

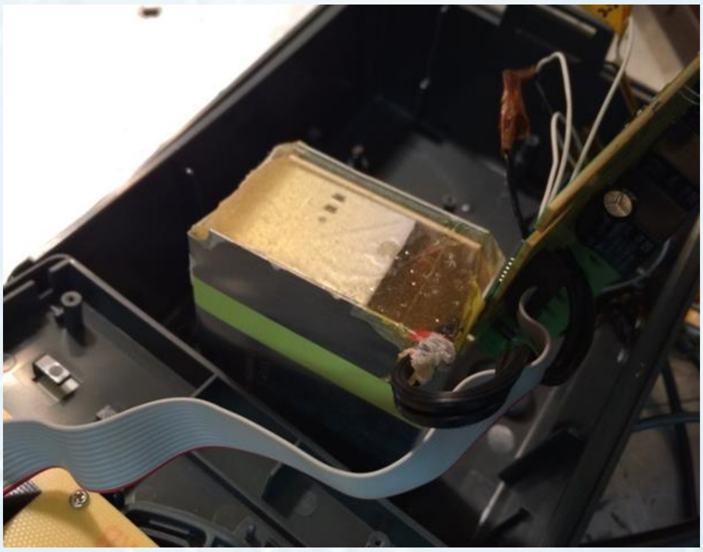


Figure 62 – CH2 and CH3 Function Checking Setup (Case 6)

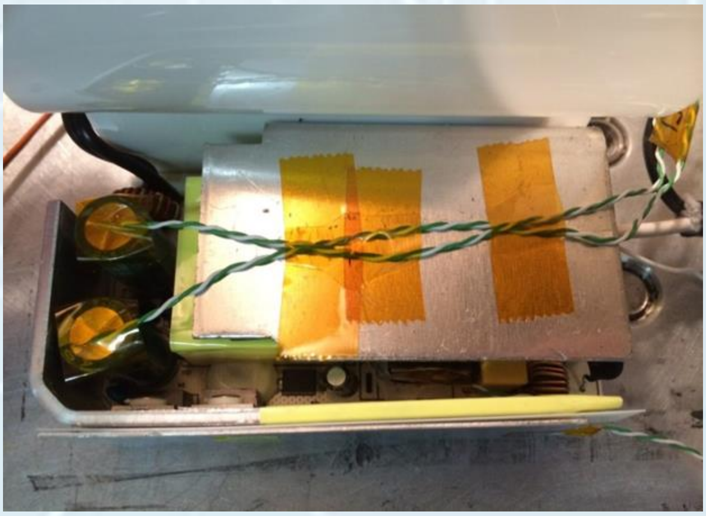


Figure 63 – CH2 and CH3 Function Checking Setup (Case 6)

6.7.3. Highlighted Quality Improvement Found from the Improved Test (Case 6)

Highlight on the result of the improvement test compare to the initial HALT test:

- The vibration operating limit had been improved from 25 G-rms to 35 G-rms
- The vibration destruct limit had been improved from 30 G-rms to 45 G-rms.

For the combined environment:

- In the initial test, the outdoor sprinkler timer could not recover and failed the functional test after five cycles.

6.8. Second Round Application

Case	Sample	Participating Company
7	Control Board of Portable Power Bank	GP Batteries International Limited
8	Industrial Wireless Sensor	Creaxon Limited
9	Smart Pressure Measuring Shoe Pad	AdvanPro Limited
10	Portable In-Circuit Tester	Concord Technology Limited
11	Wireless Embedded Module	Sierra Wireless Hong Kong Limited
12	LED Driver	Opulent Electronics Company Limited

Table 9 – Participant List of Second Round Application

***Remark:** Due to confidentiality considerations from participating companies, the test observations, including operating limit, destructive limit, and failure modes are not disclosed in this Handbook.

6.9. Case 7: Control Board of Portable Power Bank

Product Category: Portable Electronics - HALT was performed on one control board of portable power bank.

6.9.1. Initial Test (Case 7)

Figure 64 – Outlook of Portable Power Bank for Case 7

6.9.1.1. Test Setup (Case 7)

The digital circuit board of the power bank was placed inside the HALT chamber for evaluation. It should be noted that since the battery pack may explode under high temperature and vibration, the HALT could not be applied on this item. After communicating with the participating company, it was concluded that the battery pack shall be placed outside the chamber during the evaluation process. Similar cases apply to other components with potential hazards during test. The figure below shows the connection of the Unit Under Test inside the HALT chamber.

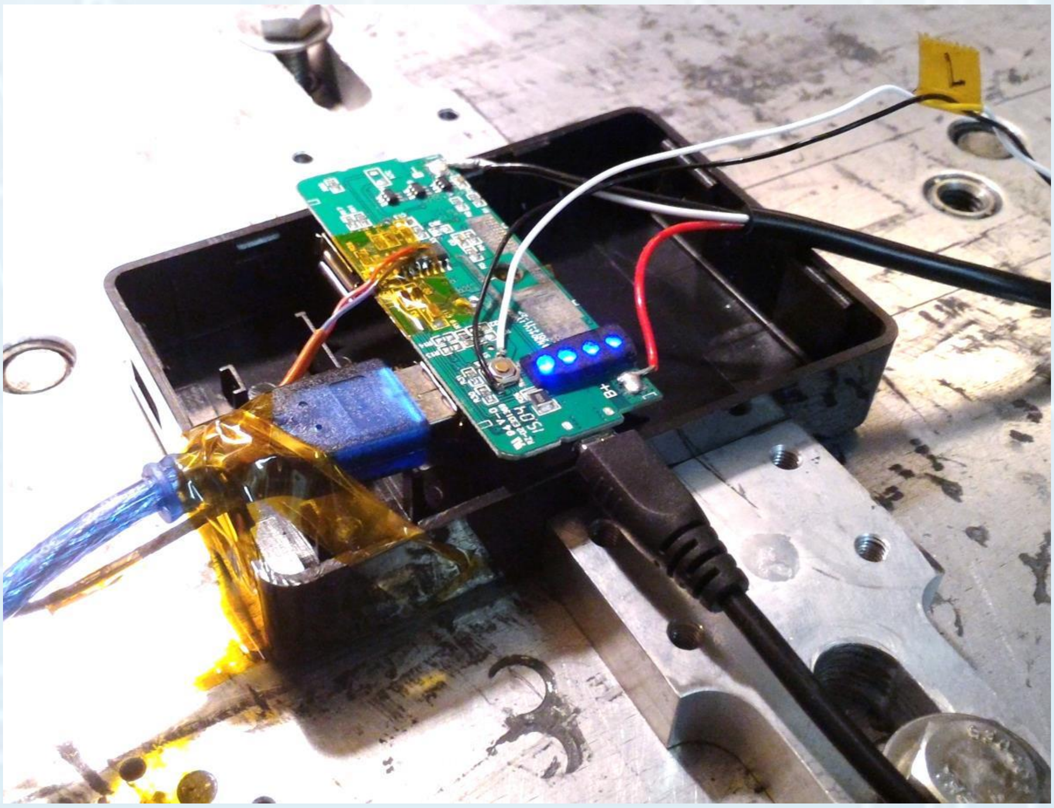


Figure 65 – Test Setup Overview for Case 7

6.9.1.2. Functional Check (Case 7)

As discussed per section 6.9.1.1, the battery pack was placed outside the chamber to prevent potential hazard of explosion due to unnecessary overstressing of product. The power board was connected with a resistive load for discharging operation. At the same time, adaptor was connected to the power pack to simulate the charging function of the Unit Under Test. The switching between charging mode and discharging mode was facilitated by a switch connected to the outside of the chamber. The current and voltage were monitored during the test process to ensure proper operation of the Unit Under Test. Figure below shows the connection setup outside the HALT chamber.

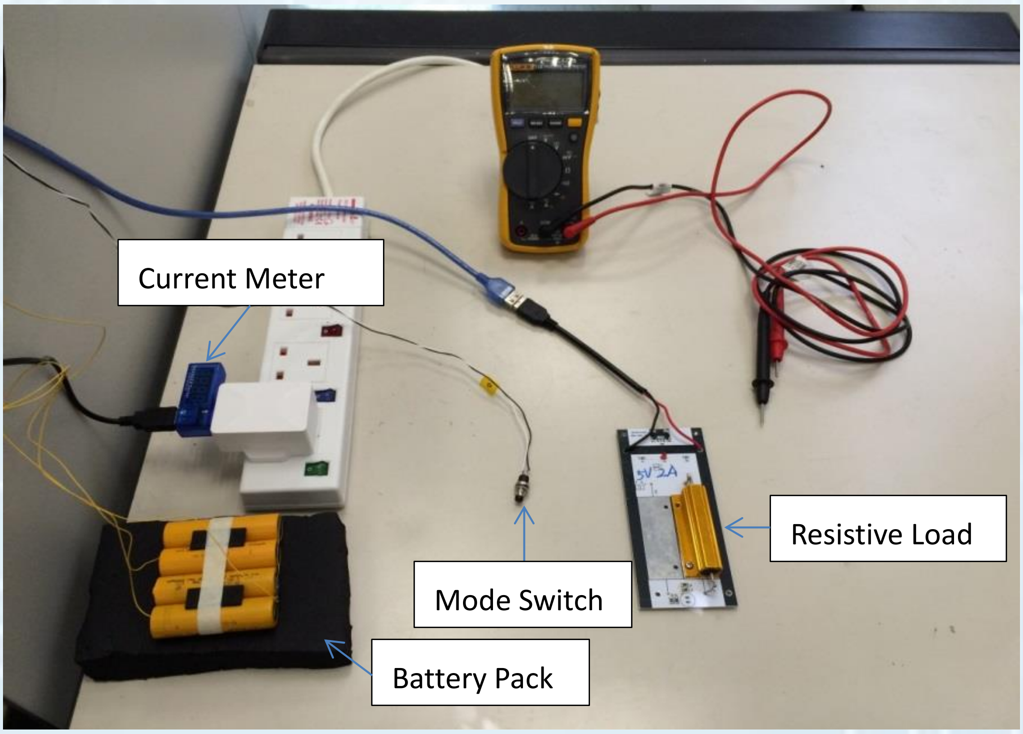


Figure 66 – Functional Checking Setup Overview for Case 7

Functional Check for Case 7 (Cont'd)

Functional Test Items		Measuring Equipment	Pass/ Fail Criteria
1	Charging Current	Current Meter	Ability of the control board of portable power bank for controlling the discharging process (the voltage across the loading should be higher than 2.8V) and charging process (non-zero current value if the batteries were not fully charged).
2	Supplying Voltage	Multimeter	

Table 10 – Functional Test Items of Case 7

6.9.1.3. Test Fixtures – Thermal Test (Case 7)

Thermocouples were attached on the MCU, the output coil (discharge) and the input coil (charge) of the control board of portable power bank.

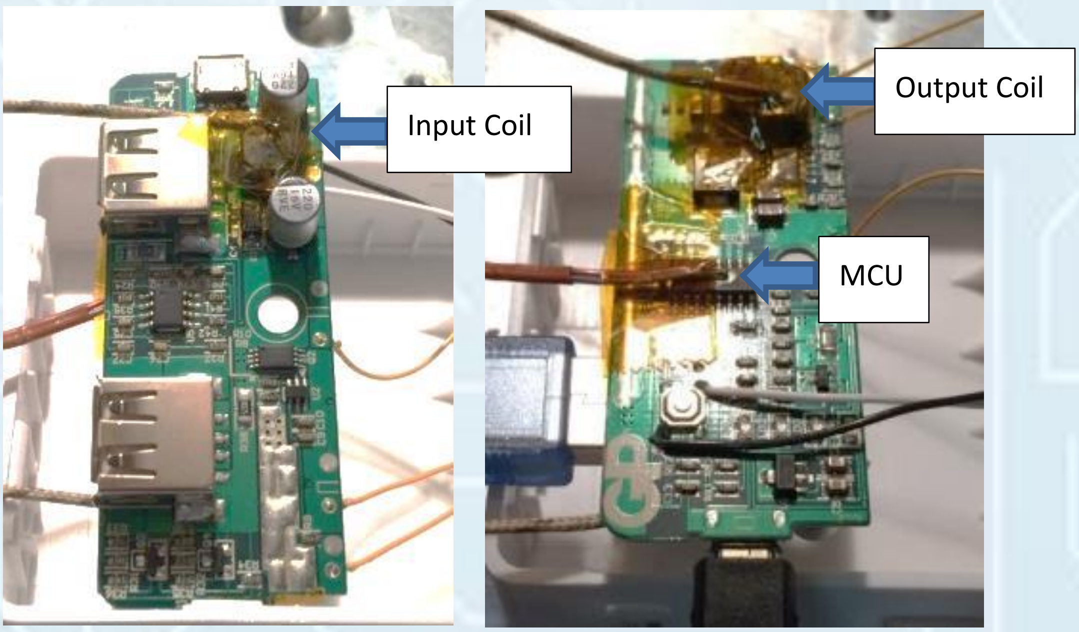


Figure 67 – Upper: Thermal Couple Monitoring Locations for Case 7 (View 1)

Figure 68 – Lower: Thermal Couple Monitoring Locations for Case 7 (View 2)

6.9.1.4. Test Fixtures – Vibration Test (Case 7)

Accelerometers were placed on the vibration table, the mounting fixture, and the control board of portable power bank during vibration step stress.

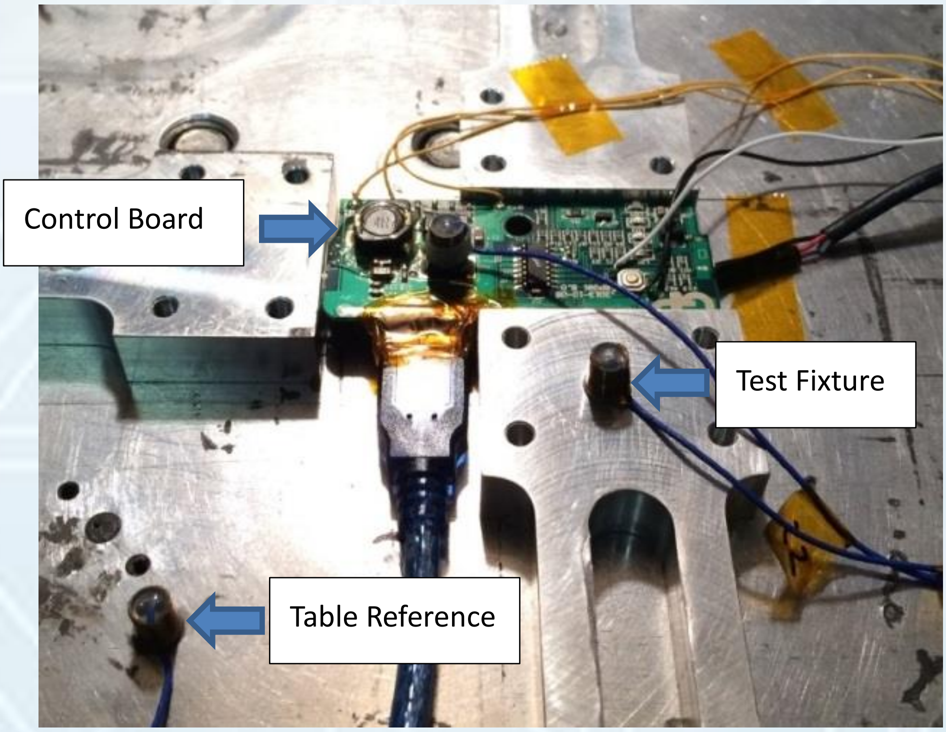


Figure 69 – Accelerometer Mounting Locations for Case 7

6.9.2. Improvement Test (Case 7)

Since the reliability performance after reviewed by the Participating Company was satisfactory. The Company decided to submit another test sample which was from a higher grading product to see if the reliability was of any better.

6.9.3. Highlighted Quality Improvement Found from the Improved Test (Case 7)

Highlight on the result of the improvement test compare to the initial HALT test:

- The hot destruct limit had been improved from +180℃ to >+180℃.
- The vibration operating limit had been improved from 70 G-rms to >75 G-rms.
- The vibration destruct limit had been improved from 70 G-rms to >75G-rms.

For Combined Environment:

- In the initial test, the control board of portable power bank failed the functional test after four cycles.
- In the improvement test, the control board of portable power bank passed the functional test after five cycles.

6.10. Case 8: Industrial Wireless Sensor

Product Category: Others - HALT was performed on one Industrial Wireless Sensor.

6.10.1. Initial Test (Case 8)

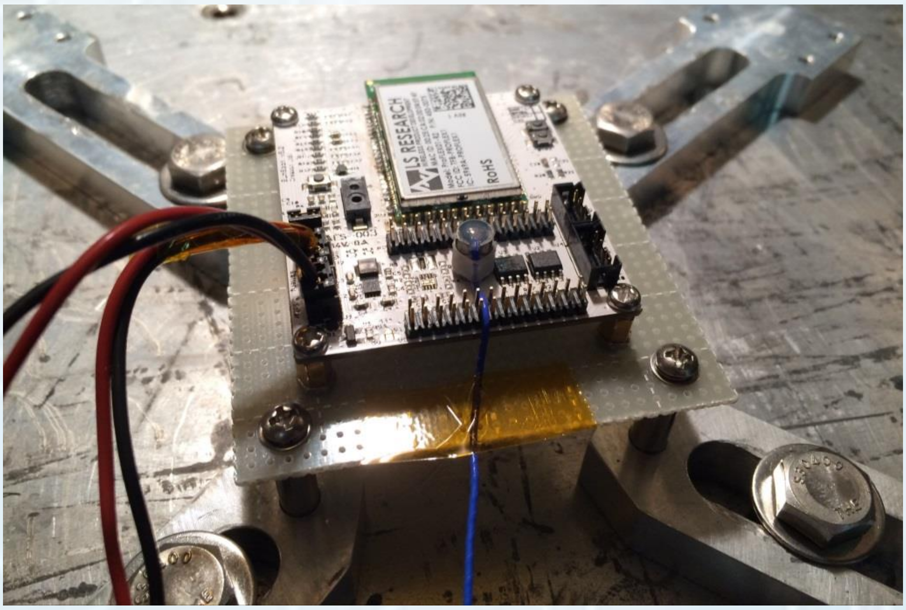


Figure 70 – Test Setup Overview for Case 8

6.10.1.1. Test Setup (Case 8)

The industrial wireless sensor was mounted on a dummy PCB and the dummy PCB was mounted on the chamber table by aluminum fixture.

The industrial wireless sensor was connected to a rechargeable battery which is located outside the chamber to provide power for the industrial wireless sensor. A solar energy panel which is illuminating by a lamp was connected to the rechargeable battery through the industry wireless sensor, in order to provide solar power for charging the battery.

6.10.1.2. Functional Check (Case 8)

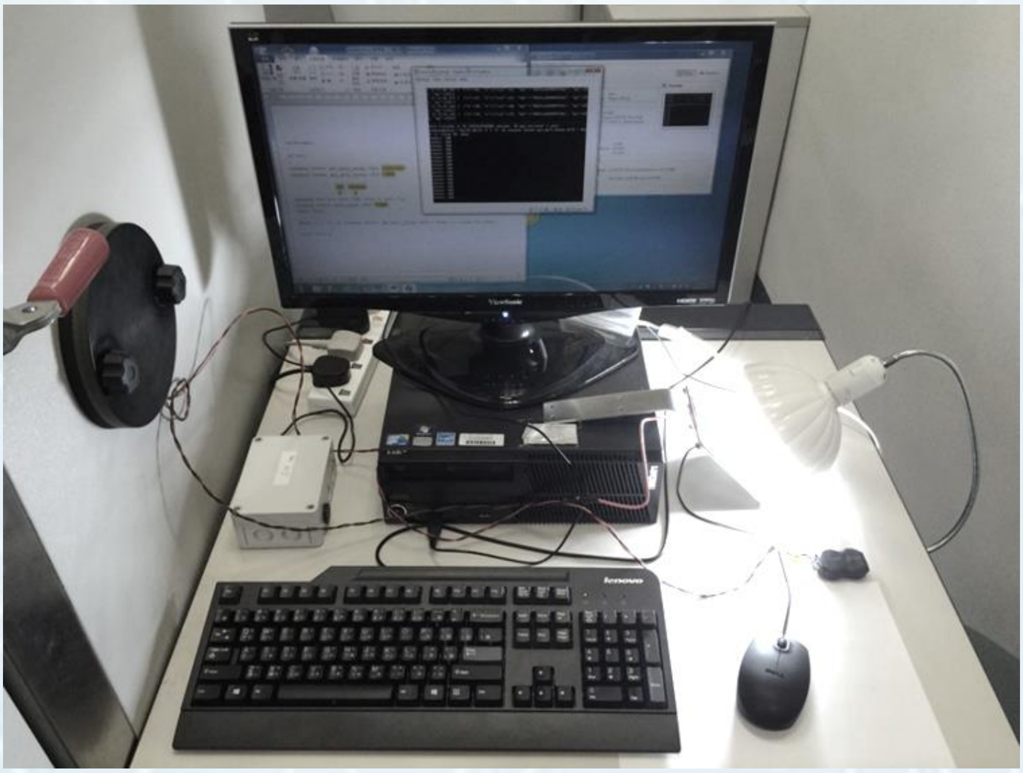


Figure 71 – Test Setup Outside HALT Chamber for Case 8

For the functional test, the industrial wireless sensor was connected to a gateway through wireless communication and a computer with testing programme is using for checking the communication among the industrial wireless sensor and the gateway.

The industrial wireless sensor was set into a monitor mode during test dwell time. The functional test consists of the board test and the radio test.

Pass/ Fail Criteria
Passing Board Test and Radio Test as defined by Participating Company.

Table 11 – Functional Test Items of Case 8

6.10.1.3. Test Fixtures – Thermal Test (Case 8)

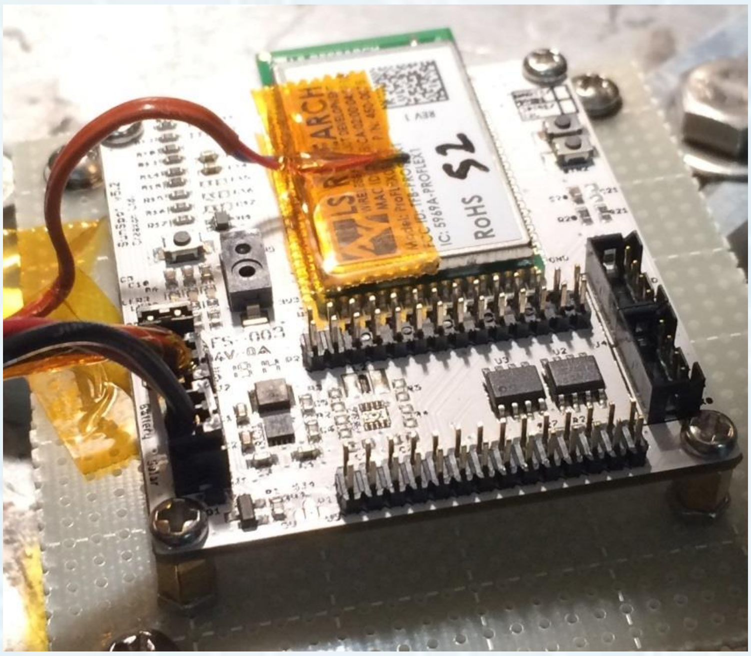


Figure 72 – Thermal Couple Monitoring Location for Case 8

6.10.1.4. Test Fixtures – Vibration Test (Case 8)

Figure 73 – Accelerometer Mounting Location for Case 8

6.10.2. Improvement Test (Case 8)

Compare to the initial HALT test, the following changes had been made for this improvement test:

The connecting wires were soldered directly on the substrate board and the connecting sockets were shifted away from the substrate board for this improvement test.

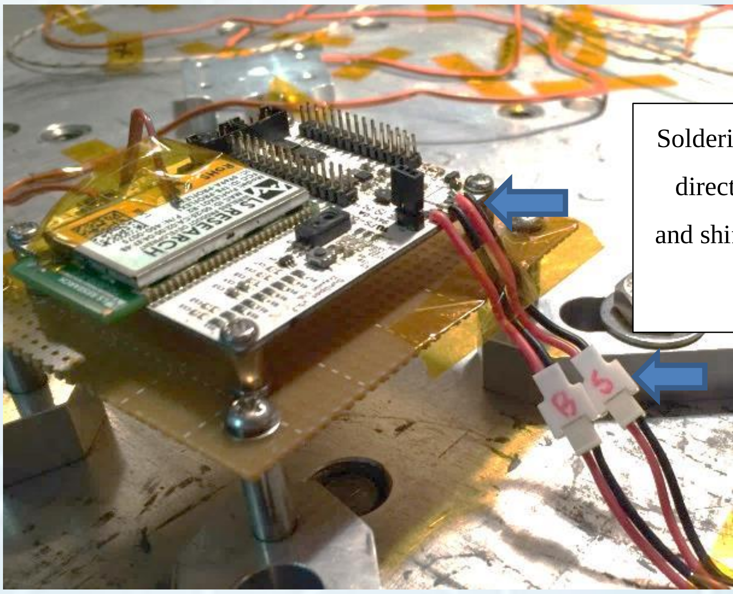


Figure 74 – Improvement Test for Case 8 (View 1)

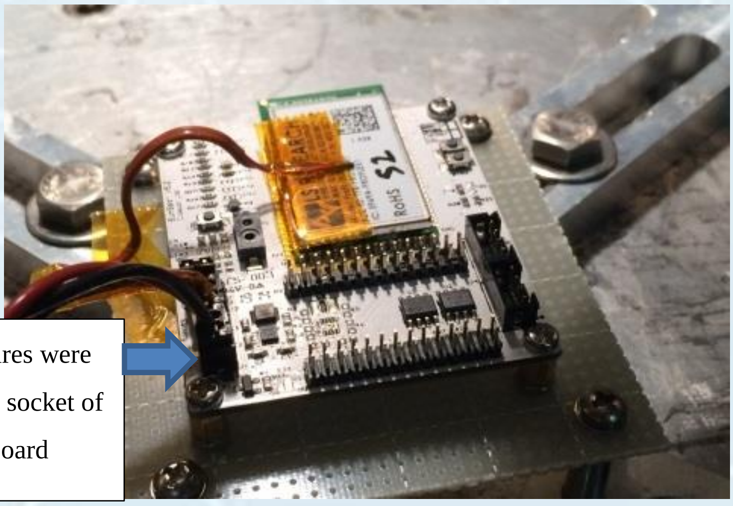
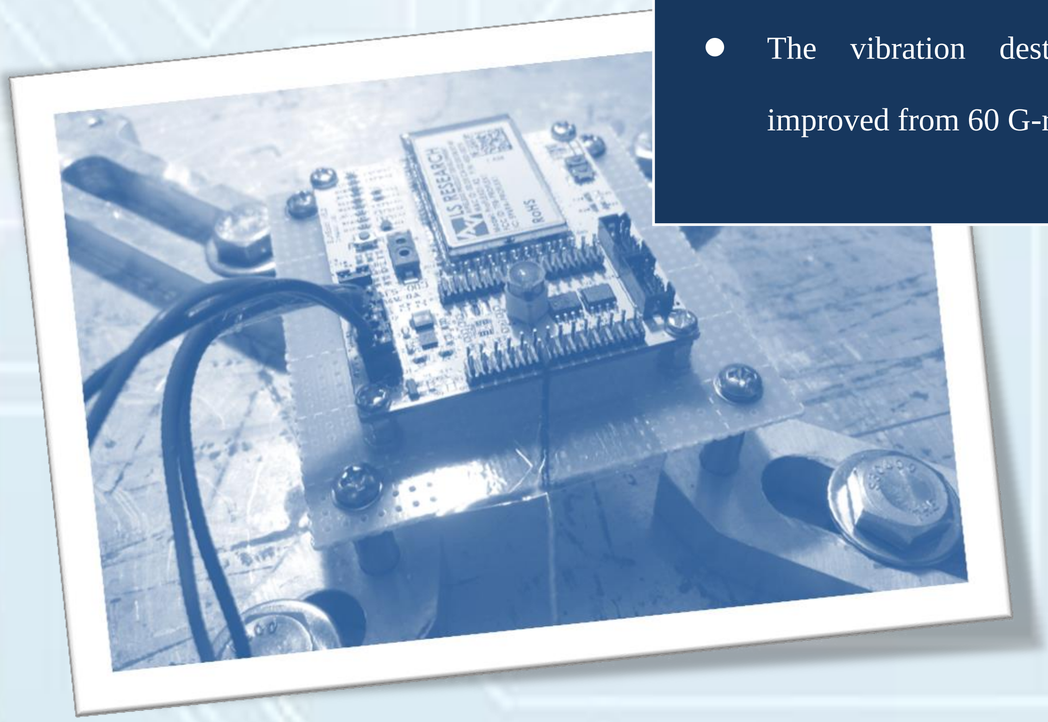


Figure 75 – Improvement Test for Case 8 (View 2)

6.10.3. Highlighted Quality Improvement Found from the Improved Test (Case 8)

Highlight on the result of the improvement test compare to the initial HALT test:

- The hot destruct limit had been improved from +200℃ to >+200℃.
- The vibration operating limit had been improved from 55 G-rms to >65 G-rms.
- The vibration destruct limit had been improved from 60 G-rms to 75 G-rms.



6.11. Case 9: Smart Pressure Measuring Shoe Pad

Product Category: Health Care Electronics - HALT was performed on one flexible printed circuit board which contains six pressure sensors and one Data Acquisition PCB board (DAQ board) of the smart pressure measuring shoe pad.

6.11.1. Initial Test (Case 9)

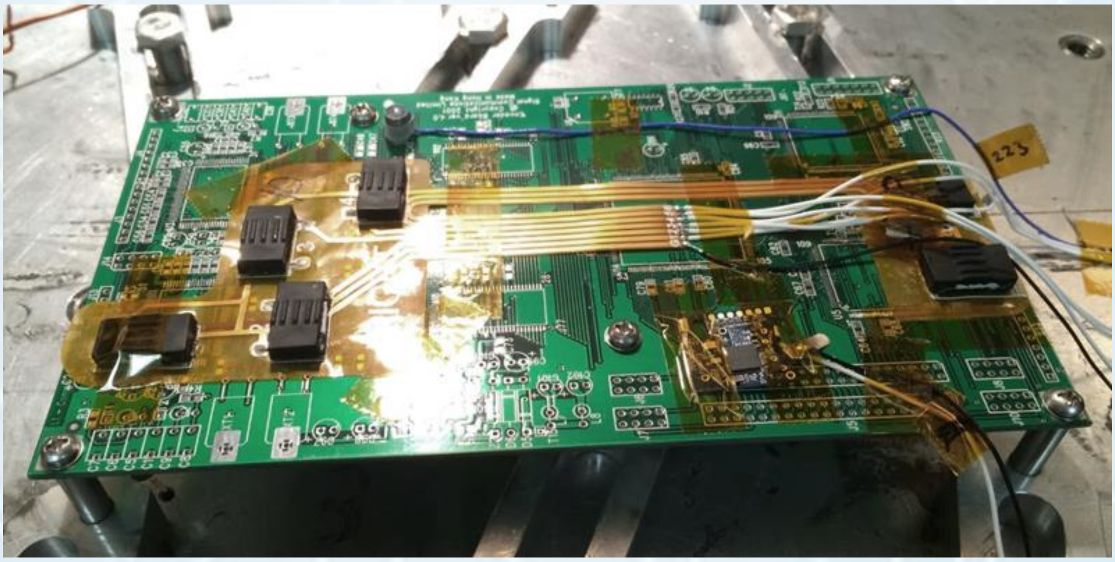


Figure 76 – Test Setup for Case 9

6.11.1.1. Test Setup (Case 9)

The flexible printed circuit board and the DAQ board were fixed on a dummy PCB by Kapton tape and the dummy PCB was mounted on the chamber table by aluminum fixture.

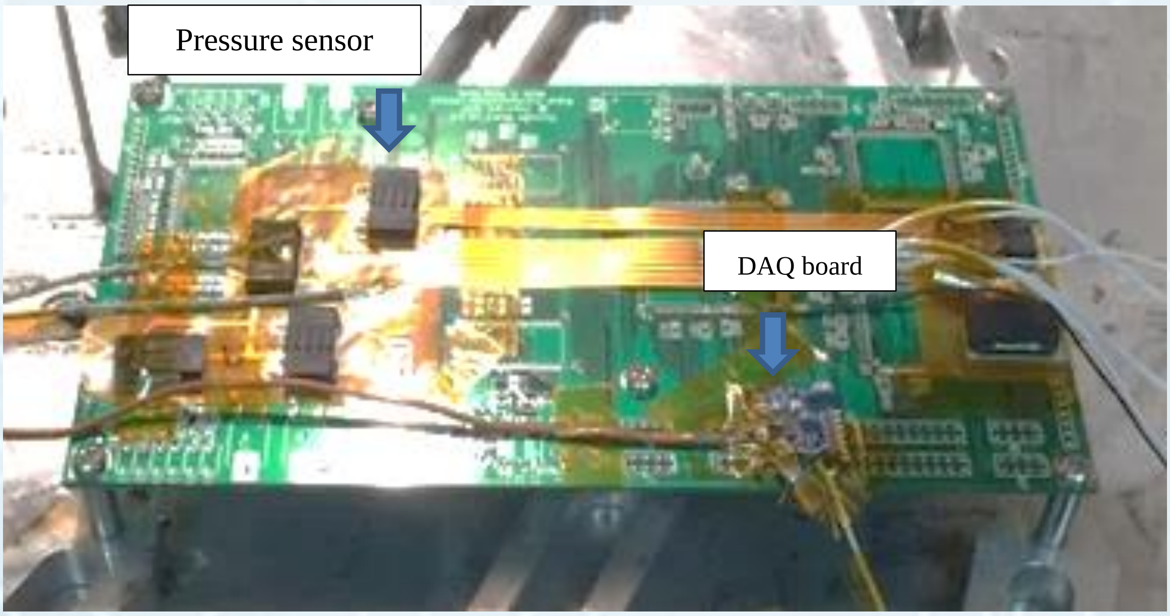


Figure 77 – Test Setup for Case 9

6.11.1.2. Functional Check (Case 9)

The functional test was divided into two parts. The first part is the measurement of the resistance value of the six pressure sensors by the Agilent data logger 34970A. The passing criteria of resistance values are below100kΩ.

The second part is to conduct the Bluetooth communication test of the DAQ board with the table tablet which is provided by the client, a program of the table tablet was used to determine the Bluetooth communication ability of the DAQ board. The passing criteria depend on the successful of the Bluetooth communication.

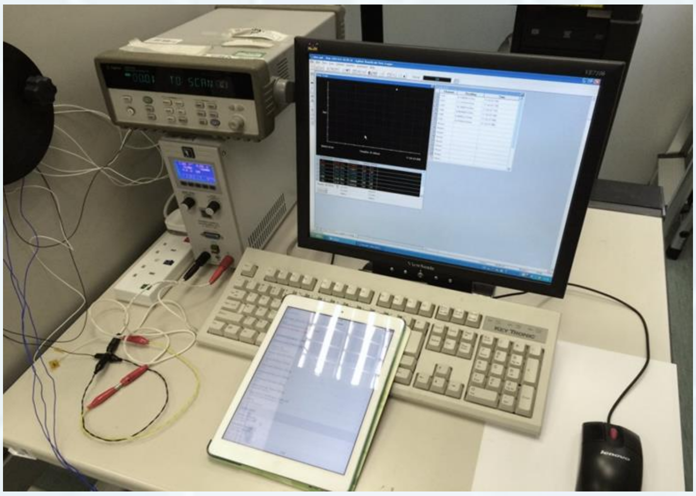


Figure 78 – Function Checking Setup Using iPad Outside HALT Chamber for Case 9

Function Checking	Pass/ Fail Criteria
Resistance Value	<100kΩ
Bluetooth Communication Test	Successful Bluetooth Communication with Tester

Table 12 – Functional Test Items of Case 9

6.11.1.3. Test Fixtures – Thermal Test (Case 9)

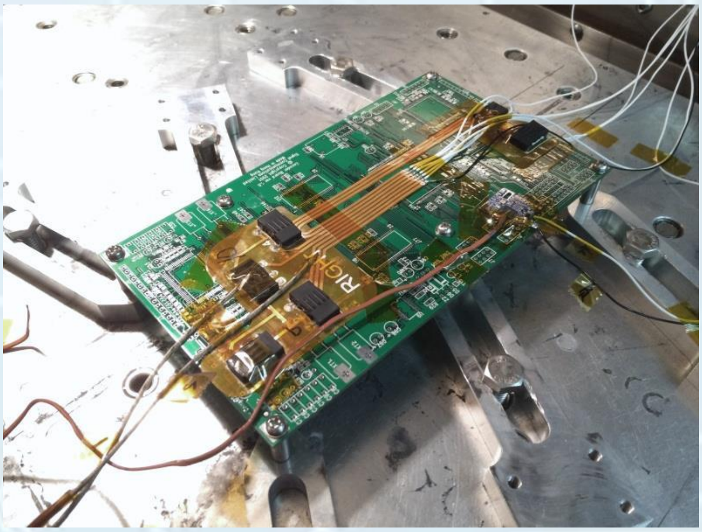


Figure 79 – Locations of Thermal Couples on Unit Under Test for Case 9

6.11.1.4. Test Fixtures – Vibration Test (Case 9)

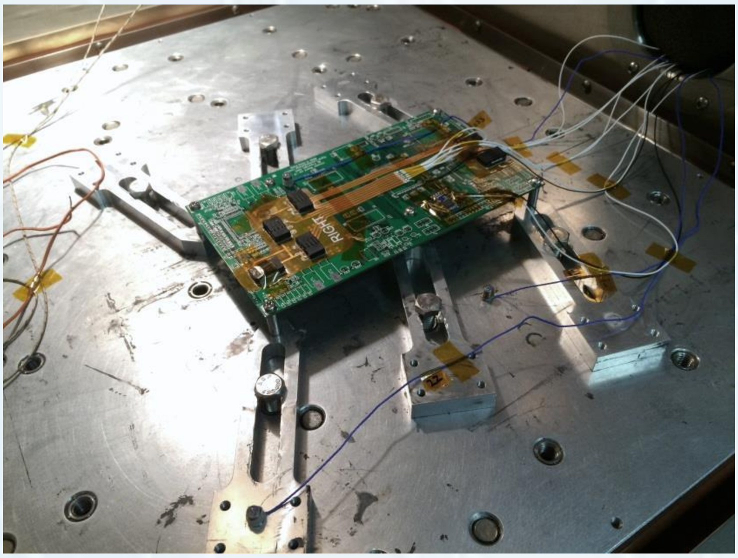


Figure 80 –Locations of Vibration Sensors on Unit Under Test for Case 9

6.11.2. Improvement Test (Case 9)

Since the reliability performance after reviewed by the Participating Company was satisfactory. The Company decided to submit another test sample which was from a higher grading product to see if the reliability was of any better.

6.11.3. Highlighted Quality Improvement Found from the Improved Test (Case 9)

Highlight on the result of the improvement test compare to the initial HALT test:

- The cold operating limit had been improved from -90℃ to <-100℃.
- The hot operating limit had been improved from +140 ℃ to +160℃.
- The hot destruct limit had been improved from +160℃ to +170℃.

6.12. Case 10: Portable In-Circuit Tester

Product Category: Portable Electronics - HALT was performed on one portable in-circuit tester, which consisted of a PCB module (one main control board and three application boards) and a power supply module.

6.12.1. Initial Test (Case 10)

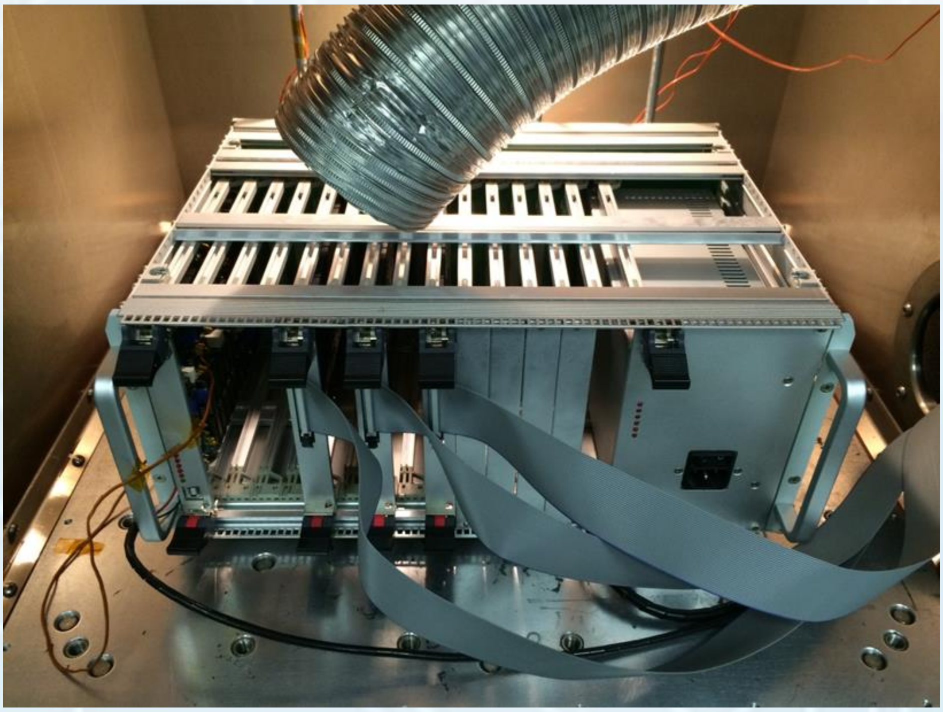


Figure 81 – Test Setup for Case 10

6.12.1.1. Test Setup (Case 10)

The Portable In Circuit Tester was in a size that was not easy to be mounted on the test platform inside the HALT chamber. For this case, the Participating Company had to specially design a test fixture which could mount the Unit Under Test to the test platform. Figure 82 shows how the test fixture worked as a part of the test setup.

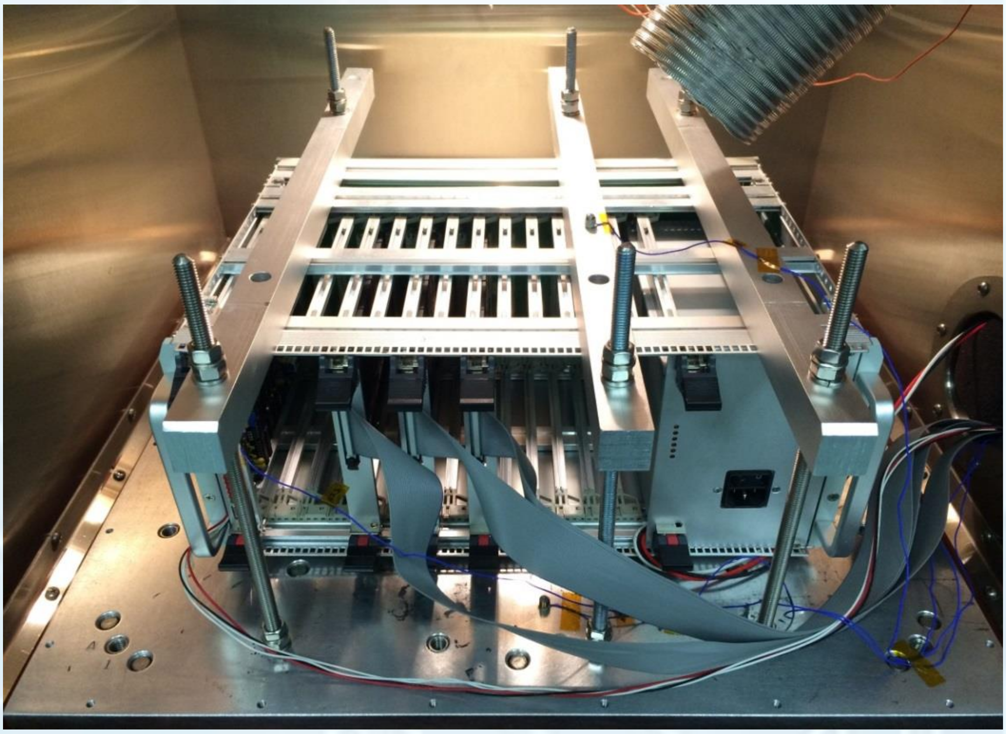


Figure 82 – Test Fixture Prepared by Participating Company for Case 10

6.12.1.2. Functional Check (Case 10)

Figure 83 – Function Checking Setup for Case 10

The portable in-circuit tester was connected to a demo board by flexible cables and a computer with testing programme by USB cable.

The demo board acts as a media to provide measurable such as resistance, capacitance, voltage and current for the testing process of the portable in-circuit tester.

Function Checking	Pass/ Fail Criteria
Communication of the portable in-circuit tester and the computer programme to provide a reasonable range of checked data value.	Function test verified by Participating Company and report to the project team.

Table 13 – Functional Test Items of Case 10

6.12.1.3. Test Fixtures – Thermal Test (Case 10)

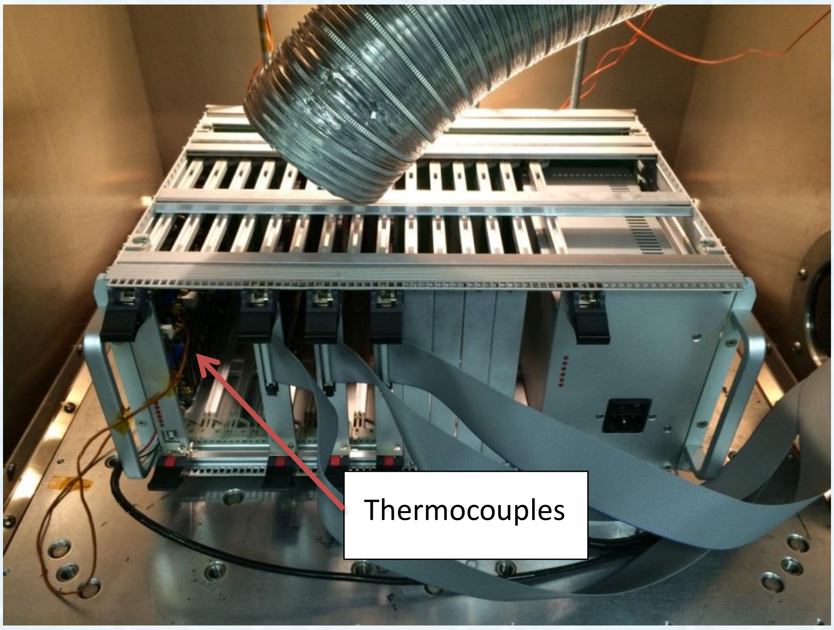


Figure 84 – Test Setup of Thermal Test for Case 10

6.12.1.4. Test Fixtures – Vibration Test (Case 10)

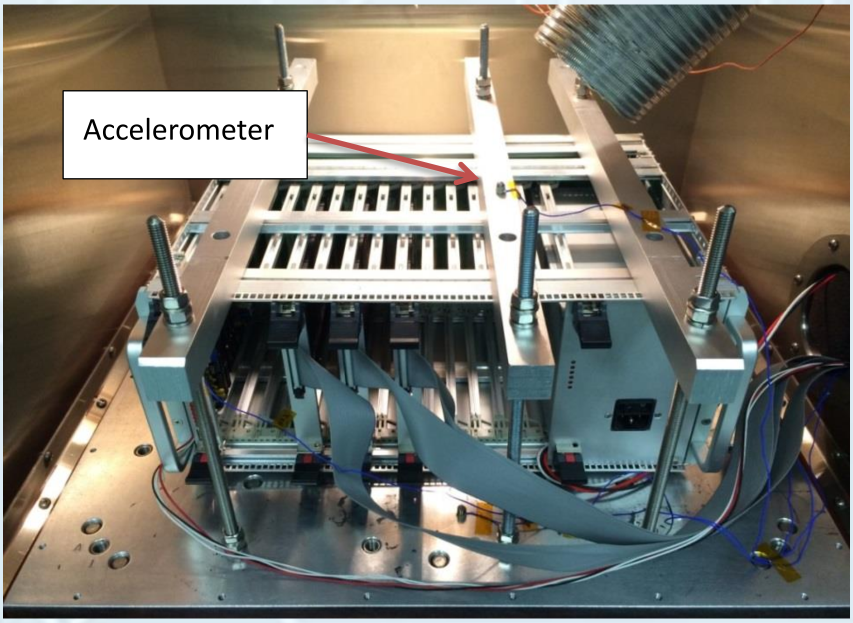


Figure 85 – Test Setup with Fixture of Vibration Test for Case 10

6.12.2. Improvement Test (Case 10)

Compare to the initial HALT test, the power supply module was extracted from the test and located outside the chamber for this improvement test, since it was acceptable by the participating company that the function of the power supply should be count outside the reliability consideration. The failure mode of the power supply was agreed and acknowledged by the participating company.

The test setup is updated as shown in the below figures.

Figure 86 – Power Supply Module Being Taken Out From the Chamber as a Second Reliability Trial for Case 10

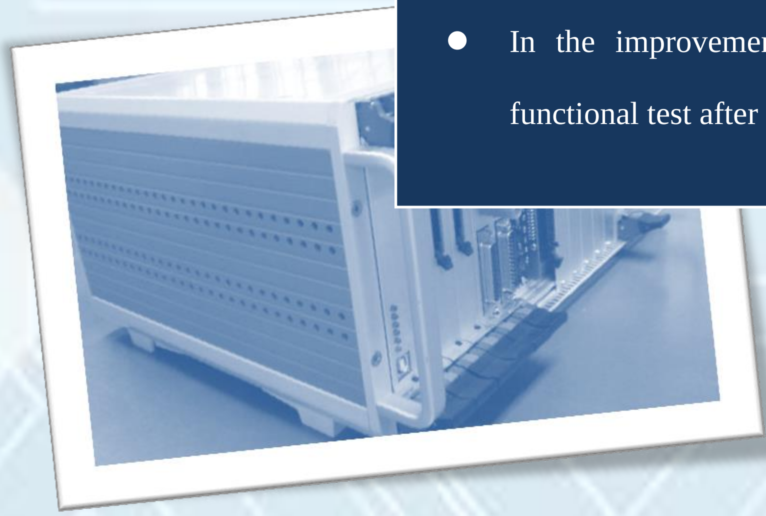
6.12.3. Highlighted Quality Improvement Found from the Improved Test (Case 10)

Highlight on the result of the improvement test compare to the initial HALT test:

- The cold operating limit had been improved from -50℃ to < -70℃.
- The cold destruct limit had been improved from < -60 ℃ to < -80℃.
- The hot operating limit had been improved from +120℃ to +150℃.
- The hot destruct limit had been improved from >+130℃ to >+160℃.
- The vibration operating limit had been improved from 45 G-rms to 50 G-rms.

For the combined environment:

- In the initial test, the portable in-circuit tester failed the functional test after four cycles.
- In the improvement test, the portable in-circuit tester passed the functional test after five cycles.



6.13. Case 11: Wireless Embedded Module

Product Category: Others - HALT was performed on 3 wireless embedded modules in each part of test.

6.13.1. Initial Test (Case 11)

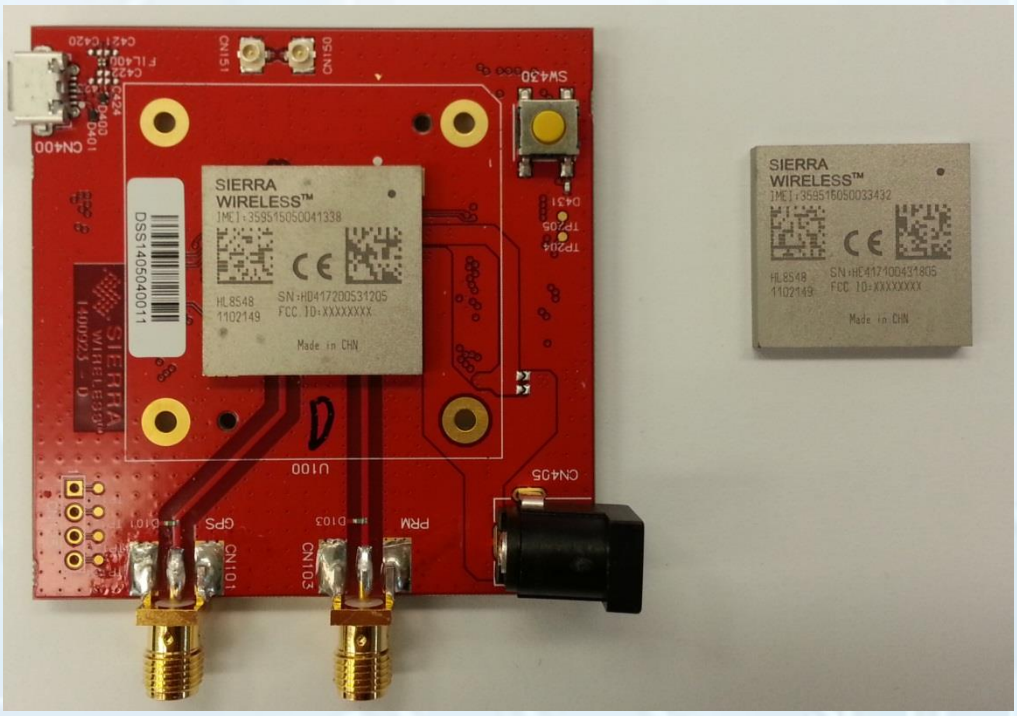


Figure 87 – Outlook of Wireless Embedded Module for Case 11

6.13.1.1. Test Setup (Case 11)

In this scenario, 3 Units Under Test were placed in the HALT Chamber the same time to provide more technical data for the Participating Company. This could be achieved when the sample dimensions were small and temperature evenness on all 3 units was well taken care of.

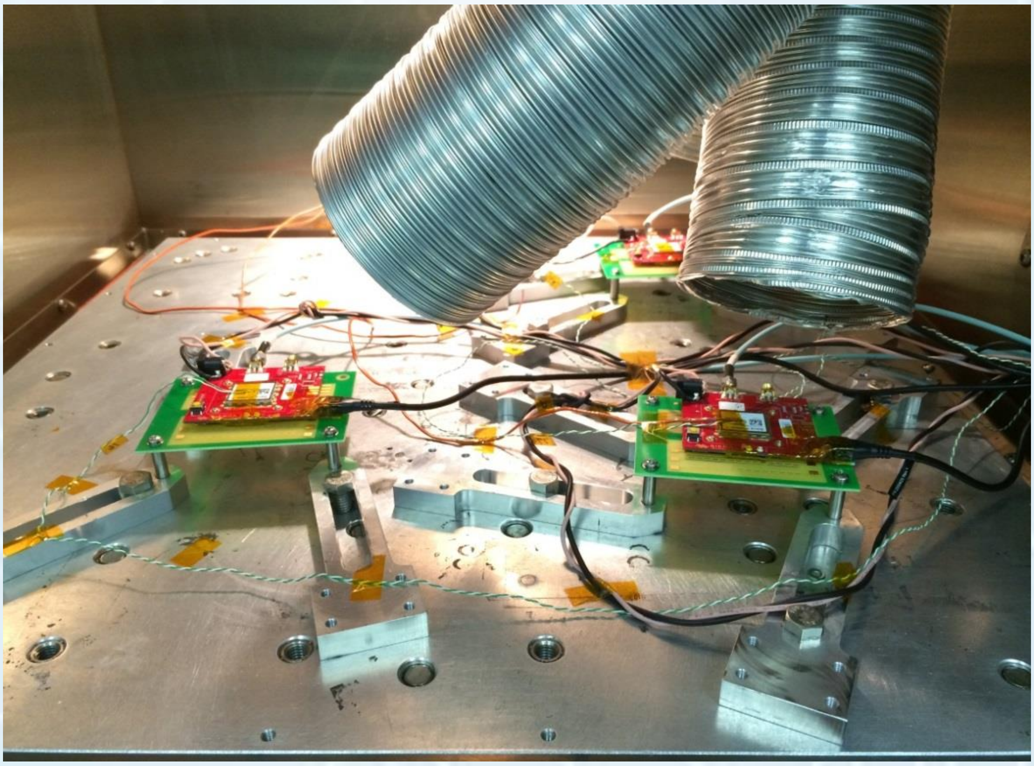


Figure 88 – 3 Modules Mounted on the Test Platform for Case 11

6.13.1.2. Functional Check (Case 11)

For measuring the functional test items, the three wireless embedded modules were connected to a computer with testing programme by USB cables, and to a wideband radio communication tester by RF cables. Radio communication of channel WCDMA band I, WCDMA band II, WCDMA band V, WCDMA band VI, WCDMA band VIII, GSM 850, GSM 900, GSM 1900 and GSM 1800 were checked for the functional test.

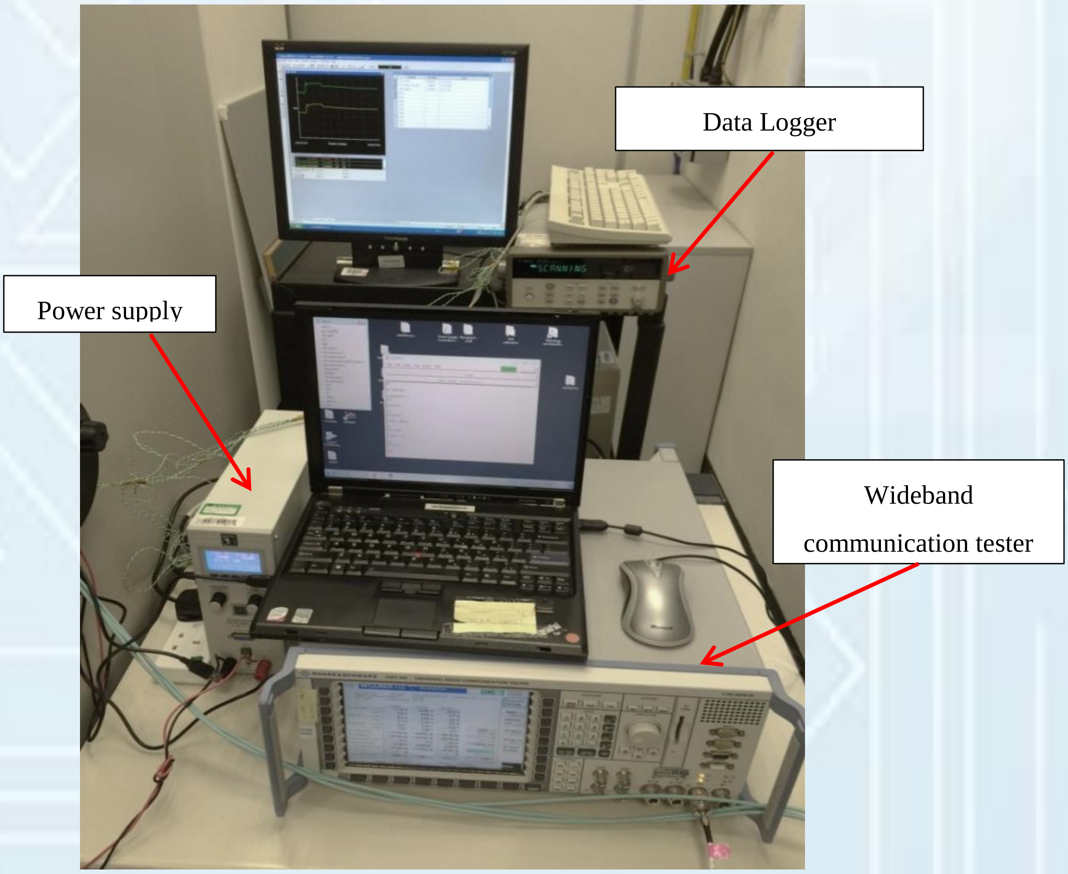


Figure 89 – Functional Checking Setup for Case 11

Function Checking	Pass/ Fail Criteria
Communication of the wireless embedded modules and making with the wideband radio communication tester.	Function test verified by Participating Company and report to the project team.

Table 14 – Functional Test Items of Case 11

6.13.1.3. Test Fixtures – Thermal Test (Case 11)

For hot step and rapid thermal transition, specially designed high temperature resist SIM cards were used.

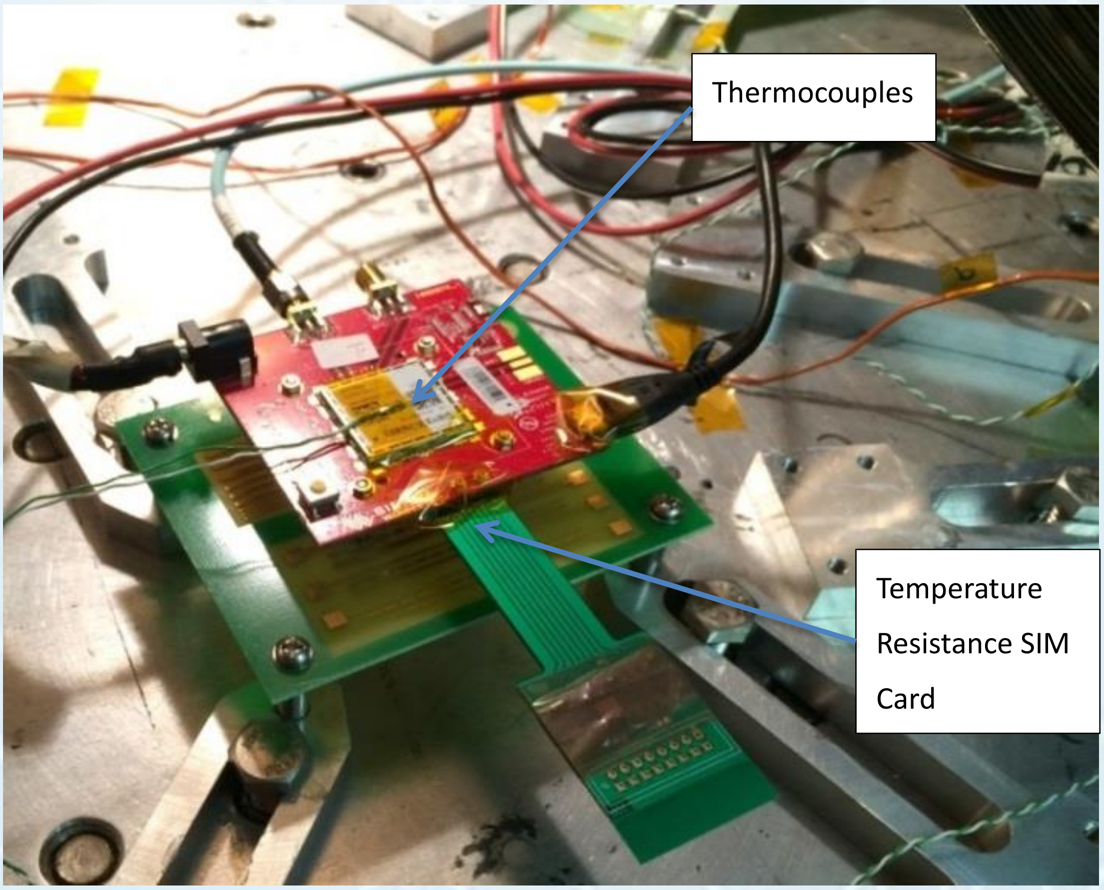


Figure 90 – Test Setup of Thermal Test for Case 11

6.13.1.4. Test Fixtures – Vibration Test (Case 11)

For combined environment, specially designed high temperature resist SIM cards were used and directly soldered on the samples.

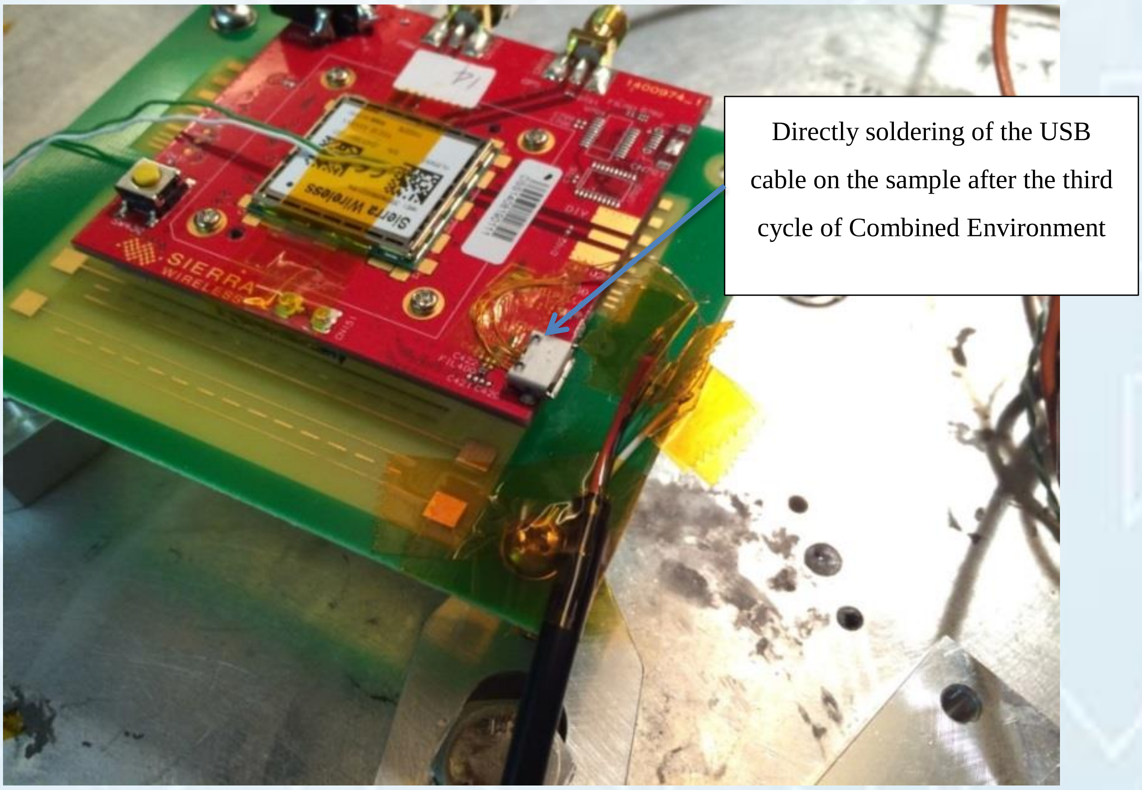


Figure 91 – Test Setup of Vibration Test for Case 11

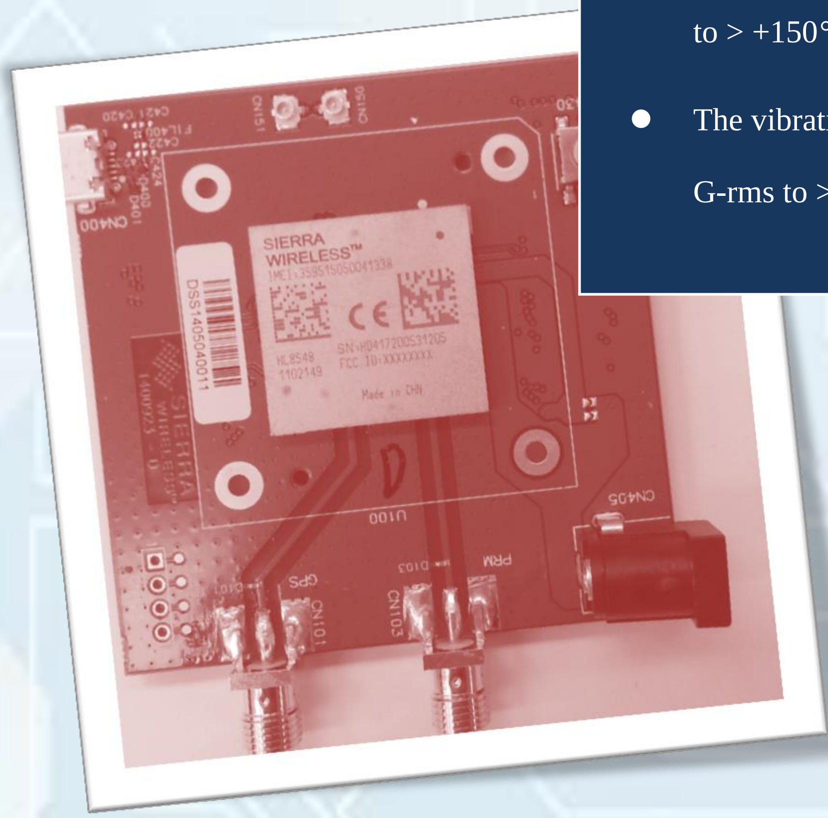
6.13.2. Improvement Test (Case 11)

Due to confidentiality considerations from the Participating Company, the improvement items were not disclosed in this report.

6.13.3. Highlighted Quality Improvement Found from the Improved Test (Case 11)

Highlight on the result of the improvement test compare to the initial HALT test:

- The hot destruct limit had been improved from > +140℃ to > +150℃.
- The vibration destruct limit had been improved from > 70 G-rms to > 75 G-rms.



6.14. Case 12: LED Driver

Product Category: Home Appliances - HALT was performed on one LED Driver.

6.14.1. Initial Test (Case 12)

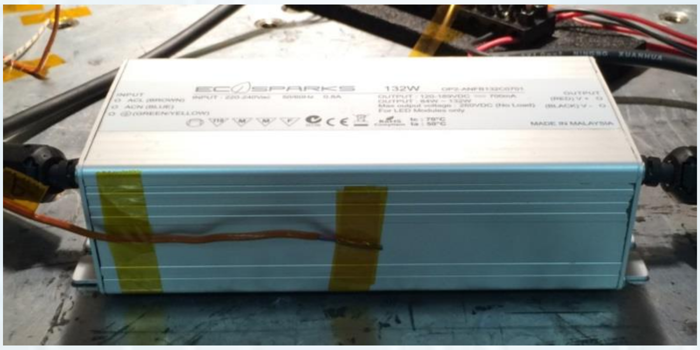


Figure 92 – Outlook of LED Driver for Case 12

6.14.1.1. Test Setup (Case 12)

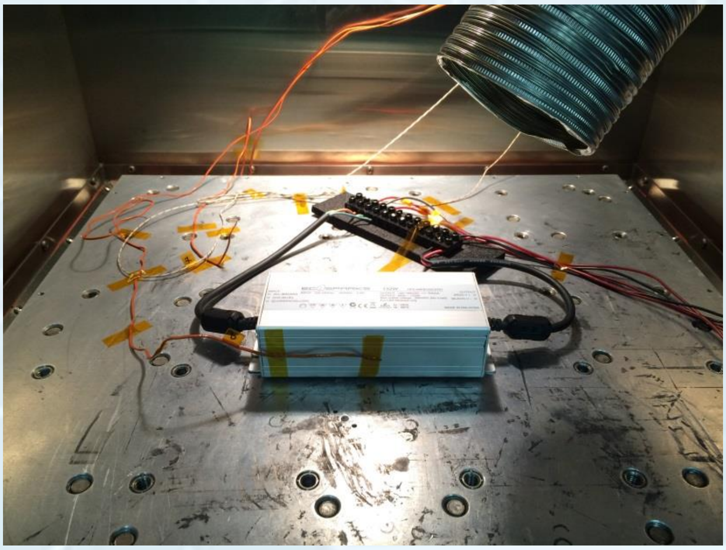


Figure 93 –LED Driver Inside HALT Chamber for Case 12

6.14.1.2. Functional Check (Case 12)

A 240V AC voltage was applied to the LED driver, and five pieces of 6 inch LED light source were connected to the LED driver as loading. The LED light loadings were placed outside the chamber during test.

Two digital power meters were connected to the LED driver, and the input voltage, input current, power factor, output voltage, output current and output power were measured for the functional test.

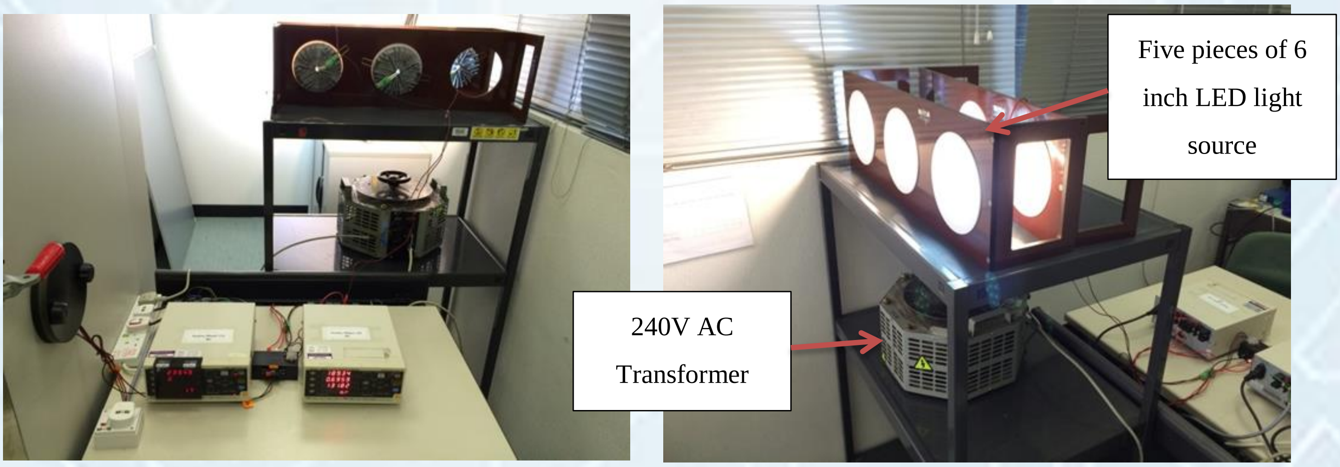


Figure 94 – Upper: Functional Checking (Power Supply Monitoring) Setup for Case 12

Figure 95 – Lower: Functional Checking (LED Function) Setup for Case 12

Function Checking	Pass/ Fail Criteria
Input Voltage, Input Current, Power Factor, Output Voltage, Output Current and Output Power	The flashing or lights off of the LED light loadings.

Table 15 – Functional Test Items of Case 12

6.14.1.3. Test Fixtures – Thermal Test (Case 12)

For thermal test (i.e. cold step stress, hot step stress and rapid thermal transition), the LED driver was placed on the chamber table directly.

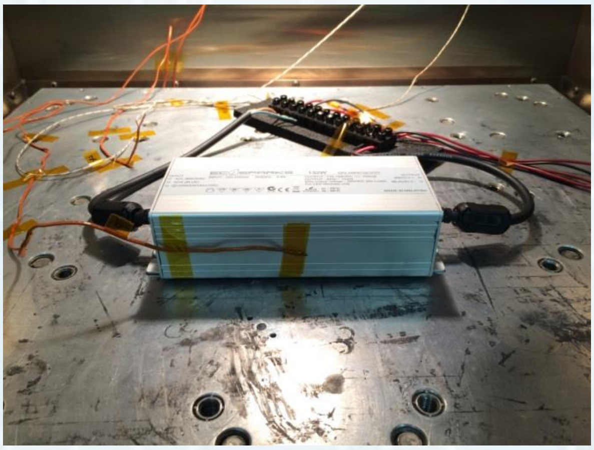


Figure 96 – Test Setup of Thermal Test for Case 12

6.14.1.4. Test Fixtures – Vibration Test (Case 12)

For the vibration test (i.e. vibration step test and combined environment), the LED driver was mounted to the chamber table by aluminum fixture.

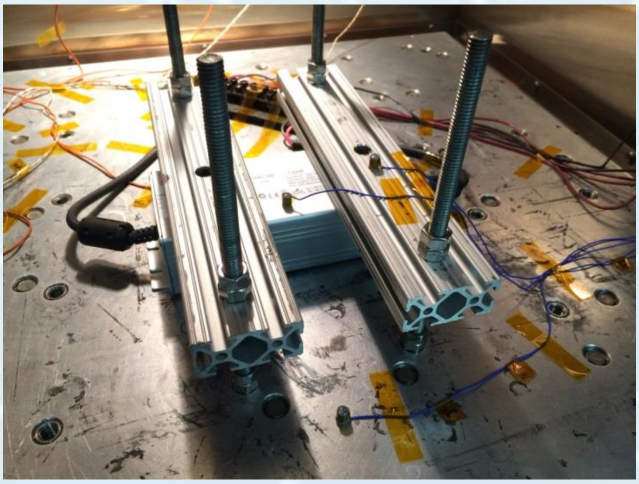


Figure 97 – Test Setup of Vibration Test for Case 12

6.14.2. Improvement Test (Case 12)

Compare to the initial HALT test, the following changes had been made for this improvement test:

Adding of solidified glue before potting glue for better heat transfer. The solidified glue will also improve on the week structure between vertical sub-board that mount onto main board.

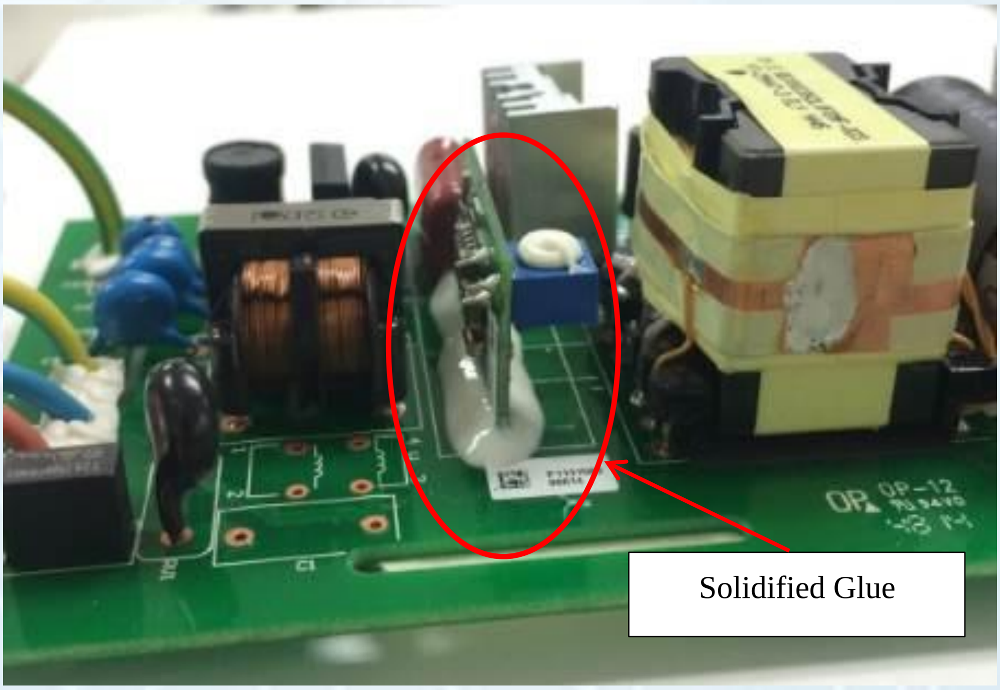


Figure 98 – Modification for Improvement Test for Case 12

6.14.3. Highlighted Quality Improvement Found from the Improved Test (Case 12)

Highlight on the result of the improvement test compare to the initial HALT test:

- The cold operating limit had been improved from < -70℃ to < -100℃.
- The cold destruct limit had been improved from < -90 ℃ to < -100℃.
- The hot operating limit had been improved from +120℃ to +150℃.
- The hot destruct limit had been improved from >+170℃ to >+180℃.

For the combined environment:

- In the initial test, the LED driver failed the functional test after four cycles.
- In the improvement test, the LED driver failed the functional test after five cycles.

7. Project Information

7.1. Project Background

This project is organized by Hong Kong Electronics & Technologies Association Limited (HKETA), collaborating by the Hong Kong Critical Components Manufacturers Association (HKCCMA) and implemented by Hong Kong Productivity Council (HKPC) and with the funding provided by SME Development Fund from Trade and Industry Department of the HKSAR.

7.1.1. Project Title:

To Enhance the Competitiveness of Hong Kong's Electronics Industry by Improving Product Reliability in a Short Product Development Cycle.

7.1.2. Applicant:

Hong Kong Electronics & Technologies Association Limited (HKETA)

7.1.3. Collaborating Organization:

The Hong Kong Critical Components Manufacturers Association (HKCCMA)

7.1.4. Implementation Agent:

Hong Kong Productivity Council (HKPC)

7.1.5. In-kind Sponsors:

Qualmark Corporation and Hong Kong Productivity Council (HKPC)

7.1.6. Project Period

1 July 2013 to 31 October 2015

7.3. Project Introduction

The purpose of the project is to help Hong Kong companies in the electronics industry to have a better understanding of the highly accelerated life testing (HALT) technology to improve the quality and reliability of their products. Ultimately, this will help to build up brand reputation of “made-in-Hong Kong” products.

This project was started in July 2013 and will last till end of October 2015. It is divided into two parts; each part will allow six SMEs (Small & Medium size Enterprises) companies to participate in the program for a total of twelve companies. Each selected company can submit their product for two rounds of HALT testing. The first round is a preliminary test, the purpose is to identify under what circumstances the product will fail and for what reason. Then the company will need to submit revised samples which corrective actions have been taken to remedy the problem. Then the revised sample will be subject to a second HALT test to make sure the corrective action is effective ad this will help to improve the reliability of the product.

7.4. HALT Project Introduction

This program was sponsored by Concord Technology, TQM consultants and Qualmark Company. These companies will send senior speakers to make detailed presentation of the program during the seminars which will be organized by HKPC. and these companies will have to perform free training during the functions organized by HKPC.

The Steering Committee members will help to select companies from the applications of the program. The companies selected will be from one of the four categories listed below:-

i. Consumer electronics,

ii. Products for medical use,

iii. Portable electronic products and

iv. Automotive electronics.

7.5. The Steering Committee

To administer the HALT project, a steering committee was formed which consists of the following parties:-

- HKETA - Mr Victor NG, Chairman of the Association
- HKETA – Ir Dr Aaron TONG, Deputy Chairman of the Association & Managing Director of TQM Consultants Co. Limited
- HKETA – Mr Lawrence LI, Chairman of the Technology Sub-committee & Managing Director of Concord Technology Ltd. Mr. Lawrence LI is also the Project Coordinator of this Project
- HKPC – Dr Lawrence CHEUNG, General Manager of the Automotive & Electronics Division of HKPC. HKPC is the Implementation Agent of this Project
- Professor H.C. MAN, Dean of Engineering and Chair Professor of Department of Industrial and System Engineering, The Hong Kong Polytechnic University
- Professor Michael TSE, Chair Professor of Department of Electronic and Information Engineering, The Hong Kong Polytechnic University
- Ir Dr C.K. LI, Former Associate Professor, The Hong Kong Polytechnic University
- Dr Henry LAU, Former Head, Department of Industrial and Manufacturing System Engineering, The University of Hong Kong

7.6. Seminar and Training

Seminars	Dates
Electronics Product Reliability Improvement	16 August 2013
如何利用測試技術提升電子產品可靠性—計劃簡介及經驗分享研討會	7 August 2014
「提升電子產品可靠性」計劃—成果及經驗分享會	25 September 2015
Trainings	**Dates**
「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(一)	4 March 2014
「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(二)	3 December 2014

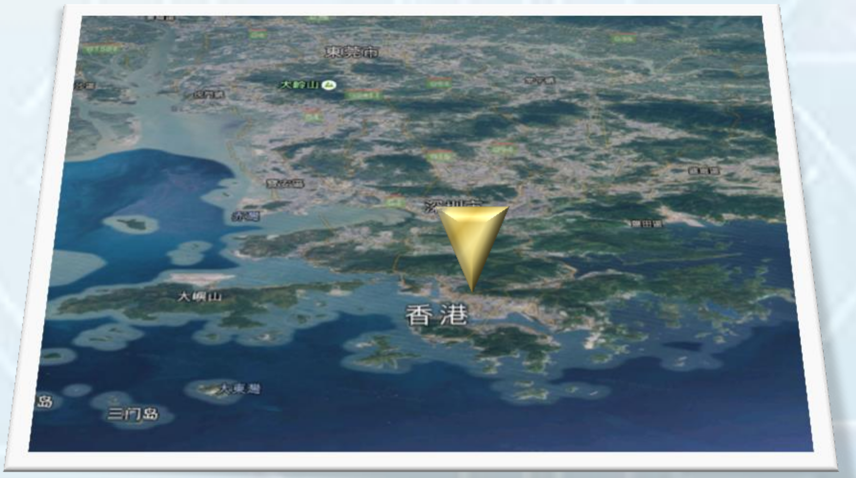
7.6.1. Electronics Product Reliability Improvement

First Seminar (Project Launch & Technical Seminar)

Date: 16 August 2013

Topic: "Electronics Product Reliability Improvement"

Venue: 1F Function Room, HKPC Building, Kowloon Tong, HK.



Electronics Product Reliability Improvement (Cont'd)

Electronics Product Reliability Improvement (Cont'd)

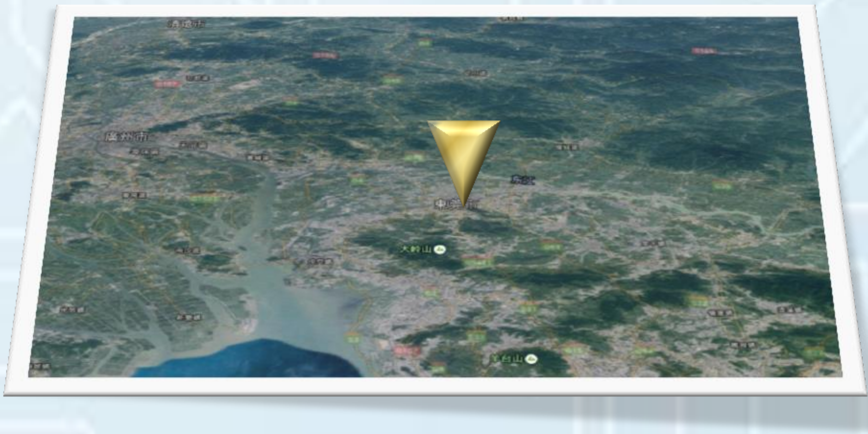
7.6.2. 「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(一)

First Training

Date: 4 March 2014

Topic: 「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(一)

Venue: 東莞會展國際大酒店會議廳.



「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班 (一) (Cont'd)

「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班 (一) (Cont'd)

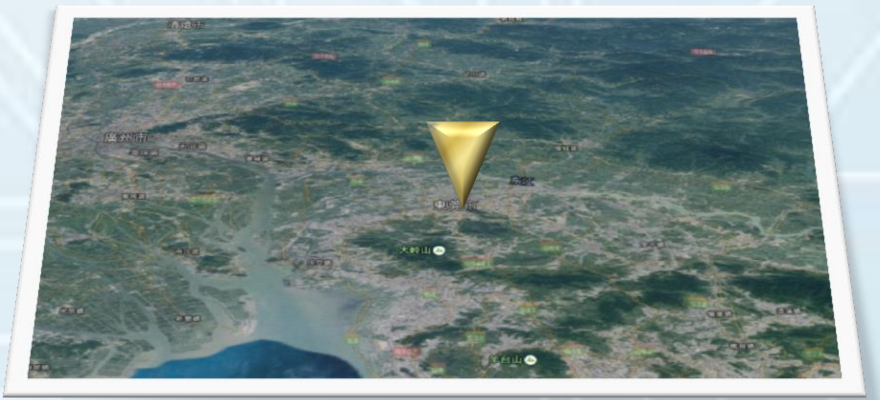
7.6.3. 如何利用測試技術提升電子產品可靠性—計劃簡介及經驗分享研討會

Second Seminar

Date: 7 August 2014

Topic: 如何利用測試技術提升電子產品可靠性—計劃簡介及經驗分享研討會

Venue: 東莞宏遠酒店



如何利用測試技術提升電子產品可靠性—計劃簡介及經驗分享研討會 (Cont'd)

如何利用測試技術提升電子產品可靠性—計劃簡介及經驗分享研討會 (Cont'd)

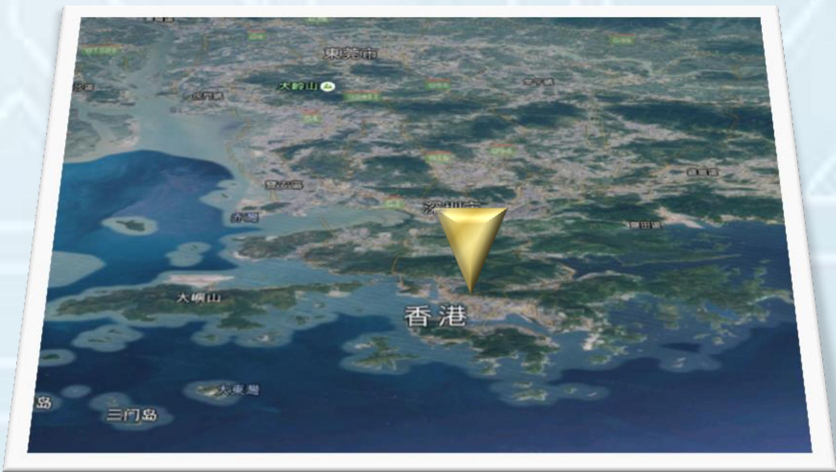
7.6.4.「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(二)

Second Training

Date: 3 December 2014

Topic:「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(二)

Venue: 生產力大樓 4/F The Terrace



「提升電子產品可靠性」計劃─高加速壽命測試技術專題培訓班(二) (Cont'd)

「提升電子產品可靠性」計劃—高加速壽命測試技術專題培訓班(二) (Cont'd)

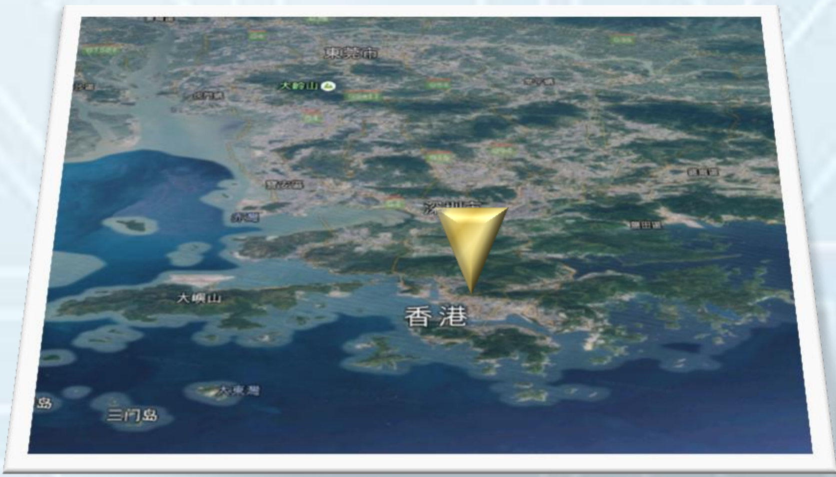
7.6.5. 「提升電子產品可靠性」計劃—成果及經驗分享會

Third Seminar

Date: 25 September 2015

Topic:「提升電子產品可靠性」計劃—成果及經驗分享會

Venue: 生產力大樓 1 樓多功能會議廳



「提升電子產品可靠性」計劃—成果及經驗分享會 (Cont'd)

「提升電子產品可靠性」計劃—成果及經驗分享會 (Cont'd)

「提升電子產品可靠性」計劃—成果及經驗分享會 (Cont'd)

「提升電子產品可靠性」計劃—成果及經驗分享會 (Cont'd)

8. Reference

i. Qualmark HALT Testing Guidelines Document 933-0336 Rev. 04.

ii. HALT, HASS, And HASA Explained Accelerated Reliability Techniques, Harry W. McLean

9. List of Figures

10. List of Tables

支持機構:

Hong Kong Critical Components Manufacturers Association
香港關鍵性零部件製造業協會

贊助機構:

Qualmark